UVA Decarbonization Academy 2022:
Synthesis Report and Summary of Key Outcomes

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0. Executive Summary

Preliminary feedback suggests that the pilot offering of UVA's Decarbonization Academy (DA) was a rewarding experience for all participants. Two factors seem to have been especially important in achieving deep engagement: 1) recurrent in-person interactions with individuals from diverse disciplines and perspectives across UVA; and 2) hands-on exposure to an urgent global problem, while helping UVA be as good and great as it can be.

The first conclusion from the Academy's collective work is that UVA's aggressive 2030 and 2050 goals, coupled with the long-range vision of Facilities Management (FM) and Office of Sustainability (OFS), have positioned UVA as a climate leader relative to its peers. FM and OFS have multiple planning initiatives underway to reduce the climate impact of the University's operations; e.g., the *Strategic Thermal Energy Study* (STES), roadmaps for prioritizing building energy upgrades, etc. Achievement of the planned initiatives will require significant financial investments. In addition, it is widely anticipated that UVA will need to purchase external carbon offsets to reach its net carbon neutrality goal by 2030. Findings from the Academy projects suggest that offsets should <u>not</u> be a significant part of UVA's decarbonization strategy.

The second conclusion from the Academy's collective work is that UVA should spend the resources that would have gone into buying offsets aggressively pursuing on its own initiatives. Examples include: heat recovery chillers, thermal engagement, geoexchange, building retrofits, green roofs, mini-forests, solar PV, etc. UVA should implement demonstration projects for these technologies in a way that intersects sustainability education and research; i.e., using the Grounds as a "living lab" and leveraging strong partnerships among students, faculty, and FM and OFS staff. This work is already taking place, but the visibility and quality could be enhanced with additional resources and thoughtful intentionality about how to structure the work such that it delivers multiple stacked benefits – emissions reductions, hands-on learning (tours, class projects, student internships, etc.), place-based research (seed funding, NSF broader-impacts, etc.), and continued visibility for UVA as a leader in this space. It would be valuable for "living lab" work to have a well-defined academic home. Aligning UVA's efforts to reduce its own climate footprint with the core teaching and research missions will ultimately yield decarbonization benefits far beyond achievement of the 2030 and 2050 goals – by creating knowledge and training future climate leaders and sharing both with the rest of the world.

1. Inception, Goals, and Structure

In 2021, the UVA Sustainability Committee comprised three sub-committees: Civic Engagement, Environmental Stewardship, and Teaching & Research (T&R). All three committees had the same charge: recommend or implement initiatives that would deliver meaningful contributions to UVA's dual sustainability goals of being carbon-neutral by 2030 and fossil-fuel free by 2050.

The T&R committee initially found it challenging to identify initiatives that would contribute to meaningful carbon reductions at UVA via research and/or teaching activities. However, over time, there was growing consensus that it would be valuable for faculty to supervise various experiential learning activities conducted by students, such as:

- Internships (at UVA) or externships (with partner entities)
- Academic research contributing to knowledge creation
- Small-scale demonstration projects or proof-of-concept analyses
- Evaluating relevant curricula at UVA and peer institutions

There was also shared anticipation that a network structure loosely collecting the related projects would be valuable for facilitating interaction among stakeholders and enriching the students' learning experiences. The UVA Decarbonization Academy (DA) was therefore envisioned as a loose assemblage of projects working towards the common goal of identifying strategies to decarbonize UVA, with ample opportunity for exchange of ideas and shared learning experiences. It was agreed that T&R members would organize the activities of the DA and supervise the constituent projects. The committee then established a shared set of goals and desired outcomes/deliverables (Table 1).

Table 1. Goals and desired deliverables for the pilot Decarbonization Academy.

STAKEHOLDERS	GOALS	OUTCOMES/DELIVERABLES
Committee, UVA	• Engage relevant stakeholders • Create and strengthen relationships • Crowdsource knowledge + best practices • Showcase progress, identify path forward (portfolio of ideas)	• Accessible archive or clearinghouse for existing resources • Synthesis of ongoing work that may be useful for defining next steps
Student Participants	• Learn about decarbonization via immersive project-based experiential learning ("learn by doing") • Enhance awareness • Build community	• Enhanced working knowledge of decarbonization • Engagement leading to long-term relationships • Poster presentation and final project report

The structure of the program encompassed two signature components:

I. Hands-on decarbonization learning experiences ("projects")
II. Group-based shared learning activities ("content and connectedness activities")

The planned duration of the program was eight weeks, the same as the longer UVA Summer Session. The timeframe was set for June 13 – August 5, 2022. The following paragraphs provide more detail about the finalized two-part program structure.

PROJECTS – A list of possible project topics was assembled by members of the T&R sub-committee, with expectation that members would supervise the work or share co-supervision responsibilities with a UVA staff member (e.g., Facilities Management [FM], Office for Sustainability [OFS], etc.) Applicants would indicate their preferred project topics or suggest an alternative topic Participants would be expected to work on their projects approximately 30-35 hours per week. Initially it was expected that students would work one-on-one with their mentors, but this was later changed to a team structure, to better accommodate very strong student interest and make use of the increased budget. Additional project topics from FM and OFS came to light after the application period opened.

CONTENT & CONNECTEDNESS ACTIVITIES – Participants also engaged in two shared learning experiences per week. The first was a 90-minute "lunch and learn" session introducing important concepts and methodologies/frameworks relevant to decarbonization. These sessions were presented in hybrid mode (i.e., in-person and via Zoom). The second was a "connectedness" event, constituting a field trip, tour, or other outing with significant emphasis on having fun and learning about UVA. Table 2 summarizes the schedule of topics and activities by week.

The application circulated to students in mid-April (see Appendix B). Third-years, fourth-years, and graduate students in all academic units were eligible to apply. There was some concern that qualified individuals would already have summer plans by that late date; however, more than 75 applications were received, despite the late start date and the short application window. This was an unexpectedly high number of applications, and the quality of the applicants was excellent. Figure 1 summarizes the breakdown of application by academic unit and student year.

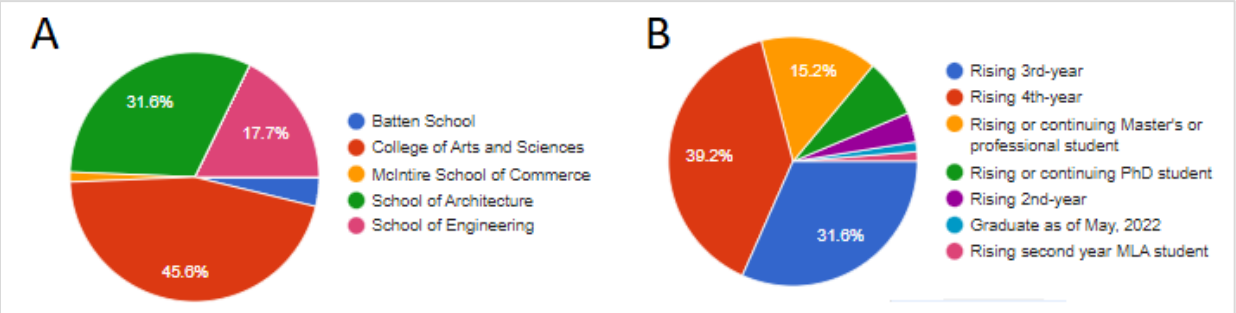

Figure 1. Breakdown of applicant pool by: A (left) academic unit; and B (right) student year.

Table 2. Schedule of DA topics and programming by week. The content for the first four weeks wasdefined in advance. Thereafter, the schedule was more open-ended, in anticipation that the students would take an increasingly active role over time in charting the course of the academy's work.

Week	Tuesday Lunch-and-Learn Topic	Thursday Activity
1 (Jun 13)	DECARBONIZATION 101: A GLOBAL PERSPECTIVE WHAT, WHY, HOW MUCH? [Lead = Lisa]	WELCOME SOCIAL (Popsicles in Darden Court) [Lead = Lisa]
2 (Jun 21)**	HEAT PLANT TOUR** [Leads = Paul, Peter Kowalzik]	DECARBONIZATION 101: A UVA PERSPECTIVE** WHAT, WHY, HOW MUCH? [Leads = Paul & Andrea Trimble]
3 (Jun 27)	BUILT ENVIRONMENT & ENGINEERED APPROACHES [Leads = Ethan, Lisa]	ALDERMAN RENOVATIONS TOUR [Leads = Dana, Kit Meyer]
4 (Jul 5)**	NATURE-BASED APPROACHES [Lead = Tim]	DELL WALKING TOUR & DATA COLLECTION [Student Leads = Logan, Jake, & Lily]
5 (Jul 11)	INTERMEDIATE PROGRESS REPORTS I (ORAL) [Lead = Lisa]	GROUP OUTDOOR SOCIAL (THURS) [Student Leads = Maddie, Michelle] RECYCLING FACILITY TOUR (FRI) [Leads = Ethan, Dana, Fiona]
6 (July 18)	ECONOMICS OF DECARBONIZATION [Lead = Bill]	OFFSETS EXERCISE OR GAME [Student Leads = Maddie, Holly]
7 (Jul 25)	INTERMEDIATE PROGRESS REPORTS II (ORAL) [Lead = Lisa]	MORVEN FARMS TOUR [Leads = Alex (Student), Rebecca Deeds]
8 (Aug 1)	FINAL PROGRESS REPORTS (e-POSTERS) [Lead = Lisa]	CHILLER PLANT TOUR (THURS) [Leads = Paul Zmick, Paul Stevens, Justin Callihan]]

*** Jun 20 and Jul 4 were holidays. The lunch-and-learn and engagement sessions were swapped in Week 2.*

2.0 Projects and Participants

The DA comprised 13 students working on seven topics. Projects were supervised or co-supervised by seven UVA faculty members and staff. The projects topics were as follows:

1. Carbon Accounting and Offsets
   - Student Fellows: Madelyn Davis, Politics + Economics [BA, 2023]
     Holly Sims, Environmental Science [BS 2023], Batten [MS]
   - Mentor: Professor William Shobe, Weldon Cooper Center

2. Thermal Energy Meta-Decarbonization Study
   - Student Fellow: Eva Massarelli, Engineering Science [BS, 2024]
   - Mentors: Mr. Paul Zmick, UVA FM: Director of Energy & Utilities
     Professor Andrés Clarens, School of Engineering

3. Building and Plant Thermal Engagement
   - Student Fellows: Valerie Michel, Systems Economics [PhD]
     Flimon Kesete, Mechanical Engineering [BS, 2025]
   - Mentors: Mr. Paul Zmick, UVA FM: Director of Energy & Utilities
     Professor Lisa Colosi Peterson, School of Engineering

4. Geoexchange
   - Student Fellow: Cameron Murie, Civil Engineering [BS, 2023]
   - Mentors: Mr. Paul Zmick, UVA FM: Director of Energy & Utilities
     Professor Lisa Colosi Peterson, School of Engineering

5. Building Decarbonization
   - Student Fellows: Viswajith Govinda Rajan, Computer Engineering [MS]
     Michelle Tran, Architecture [BS, 2023]
     Alex Yang, Global Sustainability + Economics [BS, 2023]
   - Mentors: Mr. Ethan Heil, UVA FM: Office for Sustainability
     Professor Lisa Colosi Peterson, School of Engineering

6. Building Occupant Behavior Change
   - Student Fellow: Krysten Kuhn, English + Environ. Thought & Practice [BS, 2023]
   - Mentor: Ms. Dana Schroeder, UVA FM: Office for Sustainability

7. Nature-Based Solutions
   - Student Fellows: Logan Ende, Urban & Environ. Planning + Public Policy [Dual MS]
     Jake Hecker, Urban Planning [BS, 2023]
     Lily Menzin, Architecture [BS, 2023]
   - Mentor: Professor Timothy Beatley, School of Architecture

3. Summary of Decarbonization Outcomes

The following paragraphs provide brief summaries of each DA project, with emphasis on actionable recommendations and possible next steps. The ordering of the projects is somewhat arbitrary; however, *Accounting and Offsets* is intentionally listed first. **The outcomes of this project highlight the relative merits of UVA investments in UVA-led initiatives (on its own or with local partners) given the lack of credible external offsets.** The summaries of all other projects highlight possible initiatives that could be supported using the resources that would otherwise have gone into buying offsets.

3.1 Carbon Accounting and Offsets

Summary. Accurate carbon accounting is a foundational underpinning of the University's decarbonization goals, and there is widespread expectation that the University will need to purchase carbon offsets to meet its 2030 goal. However, a key outcome of this project was that widely used accounting and offsetting practices have significant flaws such that they will not help UVA meaningfully reach its climate goals. In the absence of local, verifiable carbon uptake initiatives, it is anticipated that UVA would have to buy offsets a ratio of at least 2:1. Therefore, instead of suggesting external offsets that could be purchased to meet specific carbon reduction targets, this work focused on: 1) reevaluating sustainability accounting standards within higher education (e.g., the Association for the Advancement of Sustainability in Higher Education [AASHE]) to better focus on climate change mitigation; and 2) exploring courses of action that would allow UVA to signal its serious commitment to climate action without relying on commercially available offsets, while also setting the standard for a "great and good" university.

Recommendations:

- UVA should advance the ongoing discussion about decarbonization vis-à-vis sustainability (more broadly) in higher education by highlighting inconsistencies in AASHE's *Sustainability, Tracking, Assessment, and Rating System* (STARS) framework.
- UVA should consider opting out of AASHE's *Sustainability Tracking, Assessment, and Rating System* (STARS) framework – consistent with select peer institutions.
- UVA should make targeted investments across three broad categories to signal its seriousness about climate action while also upholding its teaching and research missions and affirming its role as a "beacon on the hill" (Table 3). By design, all three categories focus on <u>local</u> action, which will make it easier for UVA to ensure that carbon reduction targets are being achieved. They also have strong potential to deepen relationships with the surrounding community and leverage Charlottesville's rich collection of up-and-coming alternative energy firms. Future analyses could dig deeper into the cost-effectiveness of the proposed (i.e., computing $ per kg CO-equivalent avoided) compared to commercially available offsets.

Table 3. Three classes of investments UVA could pursue as more meaningful alternatives to buying external offsets. All proposed investments support UVA's research and/or teaching mission and would deepen relationships with local stakeholders. [Courtesy: Madelyn Davis, '23]

CATEGORIY	POSSIBLE FUNDING	PARTNERS	GOALS
GOOD NEIGHBOR Sponsoring renewable energy infrastructure in Albemarle County (e.g., installing solar PV at local schools or public housing)	Community Strategic Investment Fund ($15M)	City and county schools Charlottesville Renewable Energy Alliance (CvilleREA)	Building bridges through collaboration Community-based teaching and research (e.g., platform for NSF broader impacts)
GOOD STEWARD Accelerating achievement of UVA's decarbonization goals (e.g., investing in STES initiatives, outcomes from other DA projects)	General Operating Budget	CvilleREA Facilities Management	Pilot new technologies, using UVA as "living lab" and/or "model city" and disseminate best practices Educate and train technology leaders (research, class tours)
GREAT RESEARCH Prioritizing Research on Decarbonization Technologies	Grand Challenges Research Investment [earmark for decarb.] ($60)	Morven PI's; e.g., Gunnoe, Loth, Zheng, etc. ERI	Achieve 2030 and 2050 goals ahead of schedule Develop high-impact technologies Educate and train technology leaders

3.2 Thermal Energy Meta-Decarbonization Study

Summary. The goal of the *Meta-Decarbonization Study* was to synthesize and contextualize results from two engineering analyses, conducted by external consultants, which together constitute UVA's *Strategic Thermal Energy Study* (STES). Phase I results from this work were delivered in early 2022 in the form of a 648-page report delineating three possible pathways (scenarios) for decarbonizing UVA's district heating and cooling systems. Achievement of the STES targets will be critical for UVA to reach its 2030 and 2050 goals insofar as heating and cooling account for most of UVA's Scope 1 and Scope 2 emissions (>80%). However, the report is very dense and highly technical. Accordingly, a DA fellow was charged with synthesizing and extending the results in four ways: 1) creating Sankey diagrams to illustrate future fuel mixes, energy flows, and use locations (by facility) under each STES scenario; 2) developing visual timelines for changes in fuel use and adoption of other lower-carbon technologies under each STES scenario; 3) highlighting key similarities and differences among all three scenarios in a single summary infographic that will be accessible and meaningful for key decision-makers (Figure 2); and 4) estimating the magnitude of Scope 3 fugitive methane emissions under the various STES

scenarios, although Scope 3 is currently excluded under UVA's accounting. The DA fellow also compiled a comprehensive summary of sustainability plans for peer universities. Results from this work were very well-received by the Office for Energy and Utilities.

Recommendations:

- UVA should continue to pursue the recommendations of the STES, reevaluating the anticipated costs and benefits of specific initiatives in light of the findings from the *Carbon Accounting and Offsets* team. Even if candidate projects would have longer payback periods than would usually warrant immediate implementation, they may constitute appealing initiatives under the *Good Steward Plan* (Table 1), whereby UVA makes additional investments in accelerating the decarbonization of its own operations, as a more meaningful alternative to purchasing external offsets.

- UVA should allocate additional funds to support faculty-mentored student research evaluating the various *Good Steward* initiatives (above). The work funded this way would then also uphold the *Great Research Plan* (Table 1). A key outcome of the DA projects mentored by the Division of Energy & Utilities was deepening collaboration between students/faculty (most notably in Engineering) and FM. These partnerships benefitted FM by giving them enhanced capacity to evaluate (in a research mode) the technologies they are test-bedding and write up the results for dissemination outside parties. In turn, the students are engaged in cutting-edge research (implementing new technologies in a "model city" or "living lab"), which will train them to take decarbonization leadership jobs after they graduate. These activities are already happening, but creation of a designated fund would accelerate the pace of this work and enhance its quality. The University could also publicize the existence of the fund as a way to signal its serious commitment to pursuing decarbonization in a way that aligns with our teaching and research missions.

- UVA should revisit its current carbon accounting and reporting framework, including the decision to exclude Scope 3 emissions. The *Accounting and Offsets* team articulated several possible flaws or ambiguities in the current tiered system (Scopes 1, 2, 3). The *Metadecarbonization Study* suggests that fugitive methane emissions (currently excluded from UVA's accounting) may contribute an additional 15-27% to overall emissions under the various STES scenarios. This high magnitude means the University must take urgent action to remedy the current ambiguities.

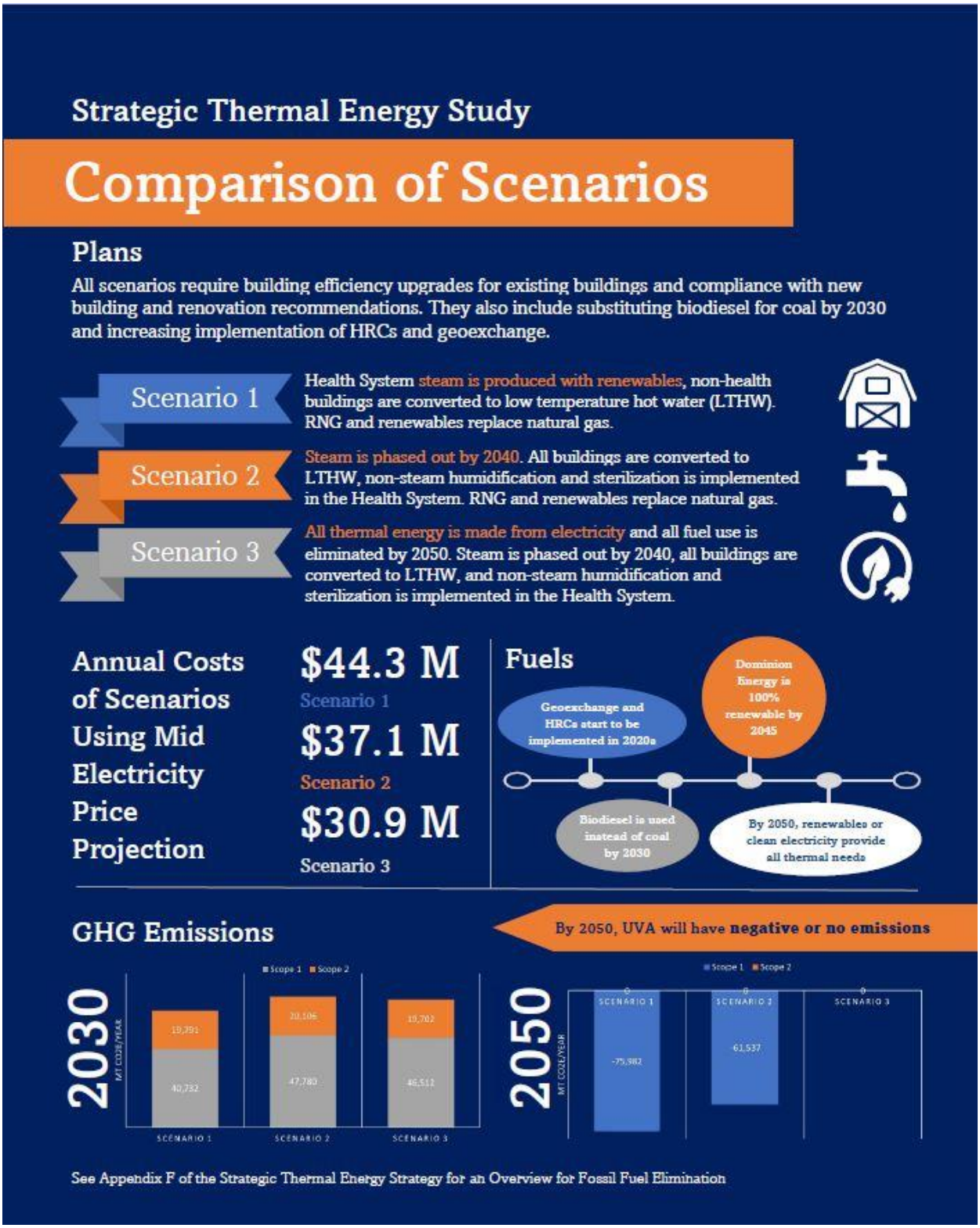

Figure 2. Infographic summarizing comparison among three STES scenarios. [Credit: Eva Massarelli, 2022]

3.3 Building and Plant Thermal Engagement

Summary. This study focused on one of the key technologies referenced in the STES and the *Meta-Decarbonization Study*, namely heat recovery chillers (HRCs). Implementation of HRCs is expected to significantly improve the efficiency of UVA's district heating and cooling by combining both processes together. HRCs can be operated using electricity only, which contributes to UVA's 2030 and 2050 in two additional ways: 1) immediately eliminating the need to combust fossil-based natural gas for heating; and 2) reducing the carbon intensity for both heating and cooling over time as the grid mix becomes more and more renewable-rich. UVA already has two small HRC installations in operation, which makes it a leader among peer institutions. This project used data from one HRC to estimate what emissions reduction is being achieved based on its current operation. A key outcome of the work was realization that the carbon savings of HRCs at UVA is currently undercut by the high carbon intensity of Dominion's electric grid, though this is expected to change over time. This project also sought to make recommendations about how HRCs could be better leveraged by "engaging" (connecting and operating together) existing UVA buildings in a way that makes the whole system much more efficient. This latter work is still underway since the project is so complex.

Recommendations:

- UVA should continue to pursue the technology recommendations put forth in the STES, again re-evaluating their anticipated financial costs with an eye towards upholding the goals of the *Good Steward* and *Great Research* plans; i.e., reallocating funds UVA would have spent on offsets to fund pilot installations on-Grounds.
    - One specific technology need is finding additional cold sinks to maximize use of HRCs to supplant natural gas boilers. The HRC "engagement" part of this study (which was not completed during Summer 2022) would be useful in this vein.
    - Geoexchange technology is also of interest as way to complement and extend the performance of HRCs, as noted in the STES (see Section 3.4).
- UVA should continue to assess its existing pilot HRC installations, potentially making additional investments in sensing, data cleaning, and other auxiliary system. These changes would improve the usefulness of the results to maximize benefits of the existing installations and inform decision making about future investments. With upgraded data collection capacities, UVA will also be well-positioned to disseminate findings and best practices, so that other institutions will benefit from our experience.
- UVA should evaluate to what extent achievement of its decarbonization goals will be contingent on the pace at which Dominion decarbonizes its electric grid. Investing in its own renewable energy systems (i.e., installing local solar) could accelerate UVA's achievement of its own 2030 and 2050 goals, and it is anticipated that such an initiative would be significantly more meaningful that buying external carbon offsets.

3.4 Geoexchange

Summary. This study focused on another key technology referenced in the STES and the *Meta-Decarbonization,* namely geoexchange. This technology increases the efficiency of district heating and cooling by using the ground's consistent temperature to heat and cool buildings. UVA is located atop a large graphite installation, which is particularly favorable for geoexchange. Facilities Management contracted a geoengineering firm to drill 7-8 test bores across Grounds, which will be evaluated for implementation within the existing heating and cooling network. It is anticipated that geoexchange deployment could enhance the performance of heat recovery chillers (Section 3.3) by helping to balance the demands for hot and cold water, especially during winter months. The overall scope of this project was impeded by delays to the drilling schedule. However, it was possible to compute a preliminary estimate of carbon savings for a hypothetical geoexchange installation. There was also preliminary assessment of how 1-2 test bores (the ones not selected for use in the installed system) could be donated to the School of Engineering for research and/or teaching purposes. Based on this work, it may be valuable to explore how UVA's geoexchange bores could be leveraged to support research into innovative energy storage technologies (e.g., compressed air energy storage, CAES) that will be critical for supporting the ongoing transition to increasingly renewable electricity.

Recommendations:

- Restating from Section 3.3, UVA should aggressively pursue the technology recommendations put forth in the STES, potentially reallocating funds it would have spent on offsets to fund pilot installations on-Grounds. Although geoexchange has a higher capital cost than some other suggested technologies, it may be of particular interest for installation on Grounds because the geological conditions here are uniquely favorable.
- UVA should establish a working group (likely in Engineering) to explore how one or more of the geoexchange bores could be used to conduct unique, high impact decarbonization or energy transitions research. Seed funding should be made available (potentially via the Grand Challenges investments) to support project teams, in the hopes that they will generate compelling preliminary data that would then attract larger federal demonstration projects (e.g, the US Department of Energy has supported CASE demonstration projects at the University of Arizona and elsewhere). Notably, there is at least one lab already conducting CAES research at UVA.

3.5 Building Decarbonization

Summary. All STES scenarios assume that UVA's buildings will continue to achieve appreciable reductions in energy consumption for heating and cooling, thereby contributing to reduced carbon emissions. This project focused on creation of a process by which individual UVA schools can formulate roadmaps to decarbonize their existing buildings. A key outcome of the work was delivery of a tool to integrate data streams from multiple sources, compute scores for each building's energy performance and overall condition, and then assign each building into one of

four priority tiers. Scores were computed based on six kinds of data: 1) energy summary metrics; 2) energy use index (EUI), which accounts for building type (e.g., lab or office); 3) life-cycle cost, as articulated using a "25-year Energy Deficiency Cost" metric; 4) condition assessment, based on deferred maintenance; 5) building systems indices, based on estimated costs of necessary upgrades; and 6) facilities performance index (FPI), which aggregates multiple energy criteria. Four of these metrics were already in use by FM. Two were newly created by the DA team. The four priority tiers were as follows: Tier I = Poor Performance, High Improvement Opportunity; Tier II = Moderate Performance, Moderate Improvement Opportunity; Tier III = Good Performance, Limited Improvement Opportunity; and Tier IV = Good to Excellent Performance, Low Impact Facilities. The team then used the building evaluation tool to prioritize which buildings are most urgently in need of upgrades within the School of Engineering (SEAS) and the School of Medicine (SOM). The *Building Decarbonization* also team helped finalize several case studies related to successful UVA building upgrades, for dissemination to internal and external audiences. All of this work was very well received by the Office for Sustainability.

Recommendations:

- UVA should pursue recommended building upgrades for SEAS and SOM buildings. For SEAS: 5 out of 12 evaluated buildings are in Tiers I or II. Thornton and Wilsdorf Halls had the lowest scores overall. For SOM: 10 out of 12 evaluated buildings are in Tiers I or II. Pinn Hall, MR-4, MR-5, and MR-6 had the worst scores, all of which were worse than the worst SEAS building.
- UVA should direct other academic units to implement the building prioritization tool.
- UVA should contribute to disseminate building decarbonization case studies ("success stories") to internal and external audiences. Sharing this information could motivate units to pursue building upgrades and highlight the University's commitment to climate action.

3.6 Building Occupant Behavior Change

Summary. This study examined possible means of reducing building energy consumption arising from individual occupant behaviors. Influencing "small" decisions by many individual stakeholders is more challenging than influencing "big" decisions made by a few key stakeholders. In addition, building occupant activities account for a very small fraction of UVA's annual carbon emissions. Nevertheless, there was strong desire to include social sciences and humanities perspectives in the Decarbonization Academy insofar as human consumption constitutes the root cause of climate change and related environmental programs. UVA also has high credibility and robust activity in these disciplines. This project took inspiration from community-based social marketing and other research-based best practices to identify activities that would have highly likelihood of success. It was determined that effective plug-load management could have a high impact on carbon emissions reductions, and three initiatives were created, each targeting specific devices accounting for appreciable in-building energy use. The three initiatives were: 1) "Saving Loads of Energy", to promote sustainable laundry practices in

UVA residence halls; 2) “Kitchenette Reset”, to eliminate unneeded breakroom appliances; and 3) “Energy Hog Photo Contest” to update and streamline appliances and office space devices. The first initiative focuses primarily on students. The latter two initiatives focus primarily on faculty and staff and are especially timely given the ongoing changes to UVA work culture (e.g., the rise of remote and hybrid working, etc.). All initiatives contribute to creating a culture of sustainability at UVA and beyond, to the extent that building occupants may become more conscious of their consumption habits in other domains. The Office of Sustainability is working to implement these initiatives. This project did not have a formalized faculty mentor.

Recommendations:

- UVA should implement the three proposed initiatives.
- UVA should make additional investments in the Office for Sustainability. They have a huge portfolio of responsibilities, encompassing not only facilities management/operations but also teaching; e.g., supporting individual internships, projects, etc. and also influencing the attitudes and behaviors of the study body at large.
    - UVA should continue to explore the relative merits of different modes by which students are “educated” on topics pertaining to climate change mitigation. What is the appropriate balance of formal coursework (for some or all individuals) versus immersion in a “culture of sustainability” (i.e., regular exposure to sustainability and climate action initiatives intersecting daily life)?

3.7 Nature-Based Solutions

Summary. Nature-based solutions encompass a broad range of planning, design, and engineering practices that integrate natural features or processes into the built environment. These approaches seek to enhance human well-being and promote biodiversity in urban settings. This study evaluated how trees and forests on-Grounds can contribute to achievement of UVA’s 2030 and 2050 goals, while also delivering critical ecosystem services, promoting physical and mental health, and enhancing the beauty of our historic Grounds. This project was distinct from all other DA projects insofar as it explored not only *emissions reductions* but also CO2 *sequestration* as ways to reach net carbon neutrality by 2030. The project team started by documenting the 100 (or so) most “significant” trees on Grounds. They made multiple measurements for all trees and updated an incomplete earlier database. They used the revised information to estimate what amount of carbon is embodied in UVA’s existing tree stock and compute how much CO2 is taken up per year by trees. The also estimated what carbon savings is achieved by trees via shading of nearby buildings. Results from this analysis underscore the significant climate benefits delivered by UVA’s trees and highlight the importance of protecting them. The team also explored opportunities to increase carbon uptake on Grounds via afforestation, specifically installation of one or more Miyawaki mini-forests, which can deliver appreciable carbon uptake (plus other valuable ecosystem services and social benefits) per year despite their small areal footprint, low initial cost, and relatively minimal maintenance.

Recommendations:

- UVA should continue to pursue outreach efforts tied to “significant” landmark trees, as a way to emphasize how decarbonization aligns with other efforts to preserve and steward the UVA Grounds. Existing large trees must be protected from construction damage, removal, and natural threats.
- UVA should install a Miyawaki min-forest on Grounds or at Morven. The first installation should be used as a demonstration project, ideally with significant ties to teaching and research. Small amounts of funding should be allocated for faculty or staff to write proposals about how they will incorporate the installation into their courses or research.

4. Summary of Other Key Outcomes

In addition to the specific recommendations related to ongoing decarbonization initiatives (Section 3), there were several convergent outcomes from the 2022 Decarbonization Academy, pertaining to how achievement of the climate goals intersects with the University's teaching and research missions. These outcomes are grouped into three categories as described below.

I. Education and Training

The DA was a rich learning experience for all participants, especially students. This was evident from the progression of their intermediate reports over the 8-week timeline. Most of the projects were nicely framed (not too big to be overwhelming, not too small to be busywork), and the field trips, tours, and other hands-on activities were fantastic complements to the overall learning experience. Sustained direct interaction with FM and OFS staff was especially valuable.

It was striking how many excellent applicants were received despite the late deadline and short application window. From reading the application statements and talking with the fellows about why they applied, it is evident that UVA students are very concerned about climate change and they want to learn more about how they can be part of the solution. The very strong interest in the DA could be interpreted as indication that we need more climate-related coursework and curricula at UVA, or at least better advertising/publicity for what we do have already.

That said, the academy was an "expensive" means of educating 13 fellows – both with respect to the funds spent and the time and effort put forth by the mentors. It is difficult to imagine scaling the program to a much larger cohort size without compromising the educational quality.

II. Interdisciplinarity and Collaboration

The collection of related but distinct projects into a loose academy structure seems to have been a useful approach. Looking across all projects together made it possible to identify synergies and interconnections among initiatives. It was also very valuable to have representation from so many disciplines and perspectives (undergraduates, graduate students, faculty, staff). FM/OFS participants played an especially valuable role – both in suggesting meaningful initiatives to be evaluated, and by helping the students "learn by doing". Notably, it was often true that FM staff had to work much harder than the faculty to make time for the DA projects and fellows while also balancing their other responsibilities. It was also challenging to compensate FM and OFS personnel for their time. These difficulties highlight the need for FM/OFS to receive increased resources. Additional investments are required to ensure that they can implement the initiatives required to meet the 2030 and 2050 goals while also staying meaningfully engaged in training students and co-conducting "living lab" research with faculty.

III. Leadership, Reputation, and Virtue Signaling

Based on analysis of related initiatives at other universities, UVA's efforts compare well with its peers. It is commendable that UVA already has so many initiatives underway (via FM/OFS and others) and that it is prepared to invest significant resources in achieving the 2030 and 2050 goals. However, the full value of the formalized goals may not be in achieving them and "checking them off" per se, but rather in using them to catalyze meaningful teaching, research, and outreach activities that are aligned with our core mission and make sense for us based on our culture, location, and values. In other words, we should use the resources allocated for meeting the 2030 and 2050 goals to invest in UVA-led initiatives. UVA initiatives are as good or better than commercially available offsets. It will be exciting to have students, faculty, and FM/OFS and other staff work together to test-bed new technologies and approaches in a way that inspires and informs other entities (institutions, municipalities, etc.) to take urgent climate action.

5. Critique and Possible Next Steps

Despite the many successful outcomes of the academy, there were several shortcomings that should be acknowledged and potentially addressed.

- The DA was heavily skewed towards STEM disciplines, especially Engineering. This imbalance undermined the full potential of the work, and it should be addressed if the program is repeated in the future.
- The projects were selected in a haphazard way, without much strategic consideration of how they would fit together. This process should be improved
- As noted above, the DA was a relatively "costly" means of training students to work in decarbonization. It should be discussed whether other modes may be more scalable and/or cost-effective. On the other hand, the DA had other additional outcomes. It is difficult to weigh to what extent this was a good investment.
- It was challenging to administer the DA since it does not have a disciplinary home and participants were from so many units. FM staff were gracious and supportive, but continued implementation of proposed decarbonization initiatives in a way that meaningfully integrates teaching, student mentorship, and "living lab" research (Section 3) will likely require similar, intra-departmental coordination and administration. If UVA moves forward with the proposed initiatives, some provision should be made for how they will be administered (i.e., finding a formal "home" for this work).

Appendix 1 – Digital Repository of Full Reports

All seven final reports are maintained in a UVA Box folder.

They can be accessed using this link: https://virginia.box.com/v/DecarbFinalReports

Appendix 2 – Timeline and Budget

Table A2.1 - Important dates for the 2022 Decarbonization Academy

Milestone	Date
Applications open	April 14, 2022
Applications close	April 19, 2022
Participants are notified	May 9, 2022
Program begins	June 13, 2022
Midterm deliverables due	July 11, 2022
Program ends	August 5, 2022
Synthesis report delivered	September 16, 2022

Table A2.2 - Forecasted and actual budget for Decarbonization Academy 2022. Actual amounts are tentative pending delays caused by UVA's ongoing financial systems upgrade.

Item	Budget Forecast (May 2022)	Budget Actual (September 2022)
Project Costs (Students + Mentors)*	$86,000	$84,761
*Student Fellows**	*$50,000*	*$66,761*
Mentors	*$36,000*	*$18,000*
Director	$15,300	$7,801
Events (meals, social events)	$8,000	$2,001
Posters	$500	$0
Total *	$109,800	$94,563

*Values updated 9/19, after submission of final report to Megan and Collette.