THE HONG KONG
UNIVERSITY OF SCIENCE
AND TECHNOLOGY

HKUST Net-Zero Action Plan 2045

Setting Out the Strategies for the University to Reach Net-Zero Emissions by 2045

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CHAPTER 1

POLICY CONTEXT AND THE CASE FOR ACTION

Climate Leadership at HKUST

To enable the strategic development of the University in the long run, we place dual emphasis on achieving best-in-class sustainability of our operations as we pursue best-in-class quality practices.

HKUST's Net-Zero Action Plan ("Action Plan") is the strategic guide to realize our commitment to achieving net-zero greenhouse gas (GHG) emissions by 2045. Not only is this work critical to our University, but it will also be a guiding light for future growth, decision-making, and strategic planning in our schools and departments. This is a bold step, and many more bold steps lay ahead. Yet, we have a hope that this roadmap can serve as one example for other universities to align their research, operational, and investment focus to aggress this global, generational, grand challenge.

This Action Plan builds on the University's 2020 and 2028 Sustainability Challenges by offering an essential framework that harnesses the University's core capabilities in a way that ensures that we mitigate climate change while pursuing the University's strategic objectives.

Climate Leadership at HKUST

As a leading global university, HKUST stands at the forefront of the collective efforts of reducing carbon footprint through knowledge advancement, technology transfer, and integrating sustainability education with learning. Government and society are relying on HKUST to provide leadership, bridge-building, and real-world demonstration that can help the region meet ambitious decarbonization targets and transform the economy within the next 30 years.

The Intergovernmental Panel on Climate Change (IPCC) confirms in unequivocal terms that the growing physical risks from climate change are caused by human action, and the outlook is alarming. There is still a small window of opportunity for effective action to avert the worst of climate change. UN Secretary-General António Guterres called the August 2021 IPCC report a "code red for humanity".

In response to this mounting scientific evidence, economically damaging natural disasters and growing public concern, many governments around the world have announced target dates for achieving net-zero GHG emissions. Along with China, Japan, South Korea, the EU, and several other nations, together representing more than 70% of global emissions, have now announced net-zero target dates. Their message is clear: the task is urgent, and the work starts now.

Why We Pursue Net-Zero Carbon

In simple terms, "net-zero" means a country or an organization has set a target to reduce carbon emissions to as close to zero as possible. Then, using carbon removal and sequestration methods, the remainder of their emissions is balanced by GHGs that are actually removed from the atmosphere. In order to keep global warming within safe limits—recognized by the mainstream scientific community to be 1.5°C compared to pre-industrial era—the net-zero target must be reached by no later than 2050. [1]

There is a lot of discussion over the distinction between the terms carbon-neutral and net-zero carbon. While many use the two interchangeably, there is a significant difference; carbon-neutrality accepts the use of "avoided" in reduction calculations, and net-zero allows only "removal" in reduction calculations. It may be illustrative to see how both work, and why HKUST has embraced the net-zero carbon approach.

- **Avoided carbon:** refers to how a technology might replace a higher carbon emitting technology. A renewable energy facility can help avoid new carbon emissions because an equal amount of fossil fuels no longer are needed to create the same amount of electricity.
- **Carbon removal:** refers to actually taking carbon dioxide out of the atmosphere. If the removal is permanent (e.g. if the carbon is pumped underground and mineralized) then an equal amount of carbon can be safely released with no net-increase in overall emissions.

In the short-term, both methods are important tools for slowing the release of GHGs into the atmosphere. However, over the long-term, it is clear that avoided carbon strategies cannot reduce GHGs to a level of net-zero if we are still emitting GHGs. In Hong Kong, utility company projections suggest that while the region will phase out coal powered energy generation, there will still be some level of fossil fuels dependence even in 2050. Therefore, removing carbon is the only long-term option that can succeed.

By adopting a net-zero target rather than "carbon neutral" target, HKUST seeks a more comprehensive and ambitious approach to addressing climate change. As illustrated in Figure 1.1 below, unlike "carbon neutrality," net-zero aims to achieve climate stability in the long term, hence simply offsetting emissions or only pursuing carbon neutrality may not be sufficient to prevent the worse of climate change.

Figure 1.1: Key Comparisons of Carbon Neutral vs. Net-Zero [2]

	Carbon Neutral	Net-Zero
Definition	Sum of GHG emissions produced are balanced or 'offset'—no requirement to reduce absolute emissions	GHG emissions are reduced in line with the latest climate science and 1.5°C trajectory, offsetting any hard to abate residual emissions
Emissions Covered	Scopes 1 & 2 (Scope 3 encouraged)	Scopes 1, 2 & 3
Applicable Offsets	Carbon avoidance/reduction credits, and removal credits	Carbon removal credits only
Application of Definition	Company, product, or service-level	Global, national, or company-level

GHG Energy and Emissions Sources

As part of our commitment to transparent and comprehensive GHG emissions accounting, we adopt the World Resources Institute GHG accounting methodology. Under this methodology, the University takes the equity approach to define our emissions boundary, taking responsibility for the emissions from facilities owned by the University.

Figure 1.2 below provides a representative breakdown of HKUST's Scope, 1, 2, and 3 GHG emissions:

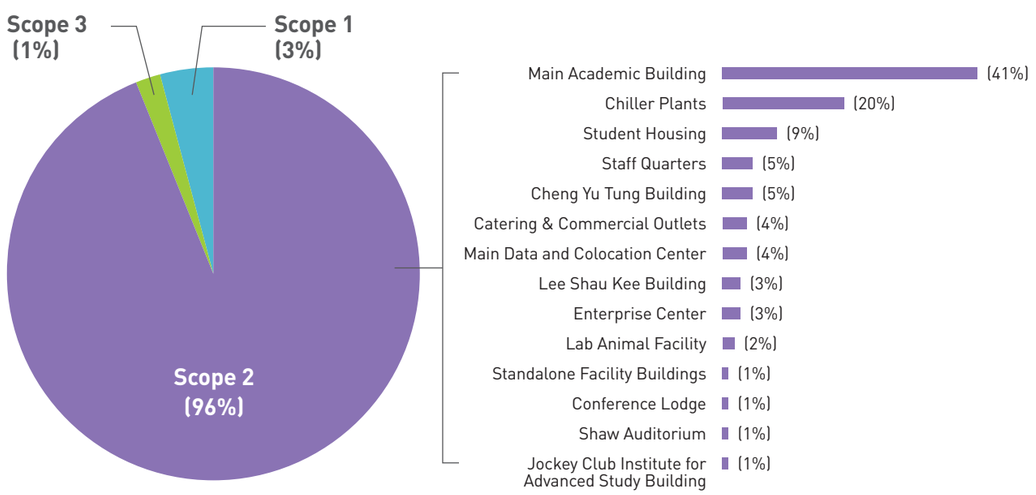
Figure 1.2: HKUST's Representative GHG Emissions Footprint

Scope	% of Total GHG Emissions	Description
1	3%	Emissions generated on campus: gasoline for HKUST vehicles, gas for cooking, and leaked refrigerants from air conditioning
2	96%	Emissions generated by off-site power plants from where we consume electricity
3	1%	Emissions emitted by other parties, but are influenced by our actions, such paper waste, fresh water, and sewage discharge

When setting science-based targets, HKUST has elected to include selected Scope 3 emissions in our GHG emissions targets, in addition to our direct Scope 1 emissions and indirect Scope 2 emissions from purchased electricity. In Chapter 2, we will discuss our plan for expanding the range of Scope 3 emissions items measured over time.

As illustrated below in Figure 1.3, Scope 2 emissions—the electricity we purchase from the grid for our buildings—make up 96% of our total GHG emissions. Of these emissions, the majority goes towards research labs in the Main Academic Building, Cheng Yu Tung Building, and Enterprise Centre Building; our central chiller plants represent the next largest source of GHG emissions on campus.

Figure 1.3: HKUST GHG Emissions Breakdown (Metric Tons CO_2e)



Key Areas for Action

Starting with a strong understanding of our GHG emission profile, this Action Plan has been developed to build on the unique strengths of the University while providing flexibility and room to grow in the future. This Action Plan organizes our efforts into five key areas for action related to how we operate our campus, leverage our academic research, and advance teaching and learning opportunities. Each strategy contains short-term goals and KPIs that are consistent with long-range targets and timelines.

Figure 1.4: Five Key Areas for Action

These areas will be continuously renewed to reflect updates in University growth.

Chapter 2 This chapter will establish the best estimates for growth and emissions in the next decades, and place that growth within an overall emissions reduction curve. The chapter will explain the essential elements of the costs of carbon and how we intend to use it as a core piece of the overall net-zero strategy.

Chapter 3 This chapter will clarify how to address new buildings from now through 2045 and how we can neutralize the emissions from these buildings from the construction process onward. By neutralizing these new buildings, we will free ourselves to focus on the existing building stock.

Chapter 4 This chapter will aim at several strategies to reduce emissions from current buildings by improving their performance during the renewal process. The chapter will also examine other opportunities to utilize the existing buildings and campus landscape for experimental technologies that can remove carbon from the atmosphere or generate renewable energy in creative ways.

Chapter 5 This chapter will address the risks and vulnerabilities that the campus might face as the climate changes weather patterns in the region. The chapter will highlight strategies for mitigating the risks to the campus, and adapting to new conditions where necessary.

Chapter 6 This chapter will explain how we can take advantage of our teaching and research capabilities to help solve some of the challenges of climate change. Building on the success of the Sustainable Smart campus as a Living Lab, the chapter looks into other ways in which the University can support climate-related research and foster better learning conditions for our students.

Chapter 7 This chapter will focus on the role of funding and investments in achieving the goals of the Action Plan, and clarify how our investments align with our vision and priorities.

Chapter 8 This chapter will demonstrate the governance and oversight structures in place to ensure success of the Action Plan over time. It will also expand on how the plan is designed to support and align with existing governing structures like the HKUST Strategic Plan.

CHAPTER 2

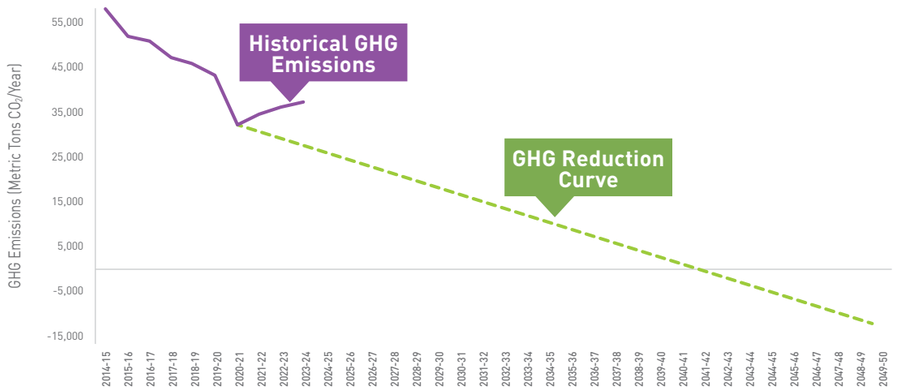
PROJECTIONS AND STRATEGY FOR CLOSING THE CARBON GAP

Greenhouse Gas Projections

Figure 2.1 below illustrates HKUST's greenhouse gas (GHG) historical annual emissions and the emissions reduction curve. The green line represents the annual targeted reduction that will gradually lead us to our net-zero goal in 2045. The GHG reduction curve is calculated using the Target Setting Tool prepared by The Science Based Targets initiative (SBTi) following the 1.5°C pathway, ensuring that emissions reduction efforts are in line with climate science and contribute to the global goal of mitigating climate change. The curve suggests continual progress of emissions reductions of around 5% per year in order to reach net-zero emissions by 2045, starting from 2021.

Figure 2.1: HKUST's GHG Reduction Target [3]

Net-Zero Emissions 2045

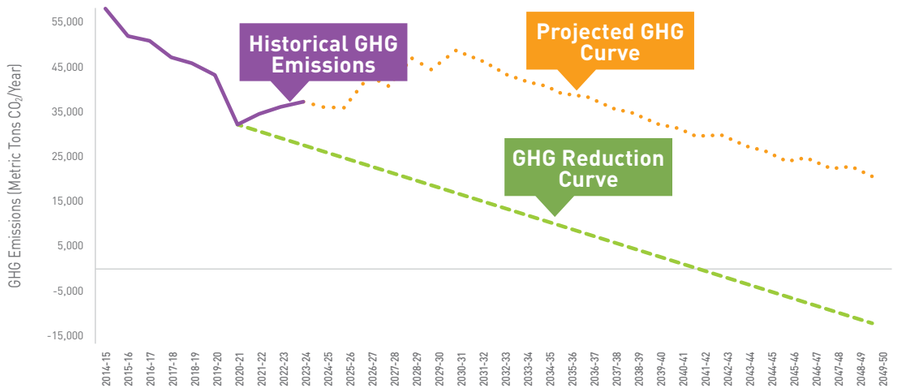


While our electricity grid will get progressively "greener" as coal-fired power generation is phased out of the CLP electricity grid, our campus continues to grow and consume more electricity. For instance, the planned construction of the HP5 Data Center and new laboratory buildings will approximately double the 2022-23 year of total electricity consumption, increasing GHG emissions by 30%. [4]

Figure 2.2 below illustrates our projected GHG emissions in comparison to the reduction target that leads us to net-zero 2045. This Action Plan enacts measures to "close the gap" between our projected GHG emissions and the GHG reduction target:

Figure 2.2: HKUST Projected GHG Emissions

Estimated to 2050



The Net-Zero Action Plan enacts measures to "close the gap" between our projected GHG emissions and the GHG reduction target that the University needs to achieve year to year in order to reach our net-zero 2045 goal.

Scope 3 Strategies

Global GHG protocols focus on three broad areas of emissions:

SCOPE 01 — Direct emissions from operations that are owned or controlled by an organization. At HKUST, Scope 1 emissions include gasoline for University-owned and operated vehicles, Towngas for cooking, and leaked refrigerants from air conditioning.

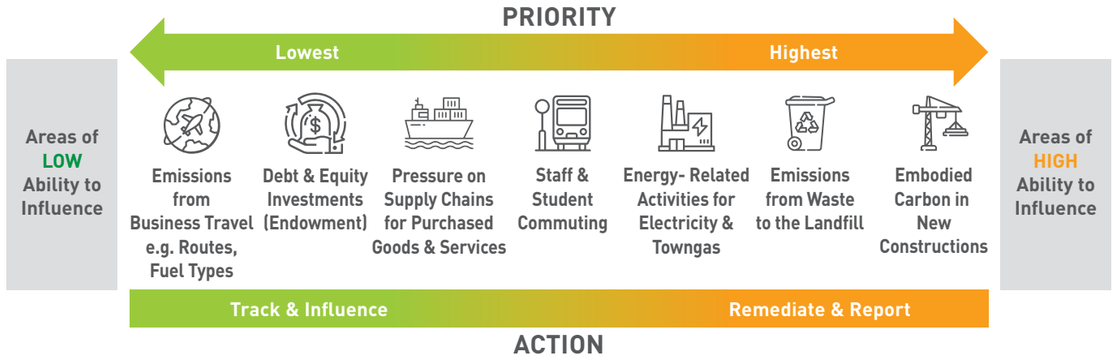
SCOPE 02 — Indirect emissions from the generation of purchased energy consumed by an organization. At HKUST, our Scope 2 emissions come from electricity we purchase from CLP.

SCOPE 03 — Indirect "value chain" emissions released by others to support an organization's upstream and downstream activities. Data for Scope 3 emissions can be difficult to obtain, so quantifying Scope 3 emissions is not as straightforward as it can be for Scopes 1 and 2. For HKUST, Scope 3 emissions tracked include paper and water waste.

HKUST's approach to measurement and target setting for Scope 3 emissions will be to focus on the areas of influence and placing efforts where they will be most effective, as illustrated in Figure 2.3 below:

Figure 2.3: HKUST Scope 3 Strategy

Differentiating Areas of Influence



Case-in-Point: Embodied Carbon in New Construction

When the University builds a new building, emissions are released by the production of steel and cement that will eventually go into the new building. Even though these emissions are Scope 1 for the manufacturer of the steel and cement, the protocols recognize that as a purchaser of these products, we have a degree of accountability.

This Action Plan considers seven areas of influence where HKUST can develop an effective role for addressing Scope 3 emissions. With plans for future growth, the highest priority will be to remediate the Scope 3 emissions from new construction, as addressed in our Net-Zero Building Standards (see Appendix 1). Strategies for waste to the landfill, fuel and energy-related activities, staff and commuter commuting are included in Chapter 4, investments in Chapter 7, and supply chains and business travel in Chapter 8.

Action Plan Key Feature: Internal Carbon Pricing

GHG emissions are what economists call "environmental externalities," meaning that the damage and harmful impacts caused are not paid for by anyone. These costs are real, though, as seen by the trillions of dollars of damage caused by extreme weather events, higher health impacts, and spread of diseases, droughts, and crop destruction. [5]

Holding ourselves accountable: this Action Plan recognizes the importance of placing the costs where they belong. This is referred to as the "user pays" principle and by self-imposing a cost for the emissions HKUST generates, we are taking responsibility for our actions. This level of accountability demonstrates our leadership in acknowledging our role in this climate crisis, and sets a good example for students, members of our community, and industry.

Net-Zero Aligned Decision-Making: there is a practical reason for imposing an internal carbon price; by assigning a monetary value to HKUST's carbon emissions, the environmental externalities associated with carbon pollution can be incorporated into economic decision-making.

This can be in the form of a shadow price, where the cost of carbon is not charged, but incorporated into economic assessment or trade-offs for things such as, green building features, new equipment, net present value of projects, and the cost-benefit of various initiatives.

The second form is an internal fee where a carbon price is charged to an activity or business unit based on the greenhouse gas emissions (these internal taxes or fees are similar to intracompany transfer pricing). [6]

By voluntarily adopting this mechanism we structurally align HKUST's ambitions to be a climate leader with the way we operate our campus, while generating a funding source for investments in cleaner technologies and innovative practices that can mitigate climate change and reduce our carbon emissions.

Carbon Price Setting in a Voluntary Market

While some regions have adopted mandatory carbon pricing regulations, Hong Kong has yet to adopt this approach. This may change in the near future, but for now, any pricing and collection of carbon fees is purely voluntary. In a voluntary carbon market such as Hong Kong, carbon pricing operates outside of a legally enforced regulatory environment, and pricing is established by referencing pricing and forecasts that have been researched and published by recognized global research organizations, and then ensuring adoption of credible standards and methodologies for review and reporting.

HKUST's carbon price references the International Energy Agency (IEA) analysis for carbon prices. Other organizations in Hong Kong that adopt this reference price include HKEX-listed companies Swire Group and CLP Holdings Group. [7,8]

Carbon Price from 2020-2050

HKUST's carbon price reference's IEA's Global Energy and Climate Model under the Net-Zero Emissions by 2050 scenario. [9]

Figure 2.4 on the right represents prices in emerging market and developing economies with net-zero emissions pledges, which includes China, India, Indonesia, Brazil, and South Africa. [10] The IEA report provides reference pricing forecasts at ten year intervals between 2020 and 2050.

See appendix documents for annual carbon price forecasts.

Figure 2.4: HKUST's Reference Carbon Price

Year	Carbon Price (HKD/Metric Ton CO_2)
2020	$235
2030	$700
2040	$1,250
2050	$1,560

Calculating and Allocating Carbon Costs

Through a chargeback mechanism guided by a "user pays" principle, we make the cost of carbon emissions felt across our University that results in direct operational efficiency benefits while also driving culture change in support of pursuing our science-based GHG reduction targets each year.

Calculating the Carbon Cost

As over 95% of the University's GHG emissions result from Scope 2 electricity consumption, the Net-Zero Action Plan uses electricity consumption as the basis for calculating the carbon costs that will be charged back to chargeable units such as schools, departments, and research facilities. [11]

New buildings built and owned by the University after 2024 will enact a chargeback model for users that will already recognize the cost of carbon. Therefore, the remaining carbon cost that need to be assessed is the "carbon gap" between the GHG emissions coming from the University's existing buildings built before 2024 and the GHG reduction target for that year, as illustrated in Figure 2.5 below. The costs based on the carbon gap will be assigned based on the calculation in Figure 2.6.

Figure 2.5: The "Carbon Gap"

Annual GHG Emissions

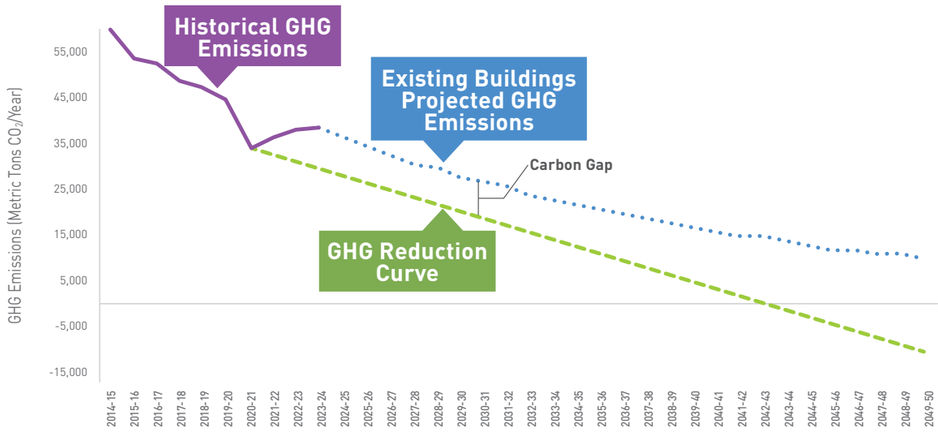


Figure 2.6: Sample Carbon Cost Calculation

Selected Year: 2025

Carbon Gap (Metric Tons GHG Emissions) X Carbon Price (HKD/Metric Ton CO_2) = Total Carbon Cost (HKD)

Carbon Gap = Net GHG Emissions from Existing Buildings − GHG Reduction Target

9,000 Metric Tons CO_2 (Carbon Gap) X HK$350 (2025 Cost/Metric Ton CO_2) = HK$3,150,000 (Total Carbon Costs to Chargeback)

36,000 Metric Tons CO_2 from Existing Buildings − 27,000 Metric Tons CO_2 Target

Note: Net GHG emissions from existing buildings refers to the emissions after accounting for reductions associated with renewable energy generated from these sites.

Allocating the Carbon Cost

Under the "user pays" principle, the GHG emissions for each chargeable unit is used to determine the allocation of the total carbon cost to be charged back.

New buildings are designed with the necessary submetering infrastructure to measure this electricity consumption (and subsequent GHG emissions) for individual chargeable units. The funding and strategies for new buildings is detailed in Chapter 3.

For existing buildings, the University will continue to invest in submetering infrastructure to support chargeback. The strategies for collecting costs and allocating towards mitigation efforts are detailed in Chapter 4.

While the necessary submetering infrastructure is being implemented, the University will assign each chargeable unit a carbon cost allocation percentage for existing buildings. The carbon cost allocation percentage is calculated based on a chargeable unit's total assigned space, weighted by the Energy Use Intensity (EUI) of the different space types, as illustrated in Figure 2.7 below:

Figure 2.7: Illustrative Carbon Cost Allocation Percentage Calculation

Step 1: Calculate total Assigned EUI-Weighted Space for each chargeable unit:

Chargeable Unit A	Assigned Space (m^2)	Space EUI (kWh/m^2/yr)	EUI Weighted (kWh/yr)
Faculty Office	500	158	79,000
Research Staff/RPG Area	1,000	158	158,000
Department Admin Area	1,000	158	158,000
Department Classroom Area	400	170	68,000
Wet Labs	2,000	900	1,800,000
Dry Labs	1,000	500	500,000
Study Spaces	500	170	85,000
Staff Housing	-	37	-
Student Housing	-	90	-

2,848,000
Assigned EUI-Weighted

Chargeable Unit B	Assigned Space (m^2)	Space EUI (kWh/m^2/yr)	EUI Weighted (kWh/yr)
Faculty Office	1,000	158	158,000
Research Staff/RPG Area	1,500	158	237,000
Department Admin Area	2,000	158	316,000
Department Classroom Area	400	170	68,000
Wet Lab	-	900	-
Dry Labs	-	500	-
Study Space	500	170	85,000
Staff Housing	-	37	-
Student Housing	-	90	-

864,000
Assigned EUI-Weighted

Chargeable Unit C	Assigned Space (m^2)	Space EUI (kWh/m^2/yr)	EUI Weighted (kWh/yr)
Faculty Office		158	-
Research Staff/RPG Area		158	-
Department Admin Area	2,000	158	316,000
Department Classroom Area		170	-
Wet Lab		900	-
Dry Labs		500	-
Study Space	3,000	170	510,000
Staff Housing	0	37	-
Student Housing	61,000	90	5,490,000

6,316,000
Assigned EUI-Weighted

Step 2: Determine proportion of total EUI Weighted-Space per chargeable unit. This becomes the cost allocation percentage:

Chargeable Unit	Assigned EUI Weighted Space (kWh/yr)	Cost Allocation %
A	2,848,000	28%
B	864,000	9%
C	6,316,000	63%
Total	**10,028,000**	**100%**

Step 3: Apply the cost allocation percentage to the Carbon Gap. In this example, the carbon gap is 9,000 metric tons CO_2 and the carbon price is HK$350 per metric ton CO_2:

Chargeable Units	Carbon Cost Allocation %	GHG Allocated (Metric Tons CO_2)	Carbon Cost Allocated (@HK$350/Metric Ton CO_2)
A	28%	2,520	$882,000
B	9%	810	$283,500
C	63%	5670	$1,984,500
Total	**100%**	**9,000**	**$3,150,000**

Note on Acceptable Offsets

HKUST adheres to the Oxford Principles for Net-Zero Aligned Carbon Offsetting that provides a framework for assessing the quality of offsets from the perspective of achieving a net-zero society. [12]

We adopt these best-practices to ensure our offsetting practices align with the Paris Agreement goals. These best-practices begins first and foremost by observing the following:

1. Strongly prioritizing reducing HKUST emissions and scaling up carbon removals, minimizing our need to purchase offsets to achieve net-zero
2. Using offsets that are verifiable and correctly accounted for, with a lower risk of non-additionality, reversal, and negative unintended consequences
3. Disclose our current emissions, accounting practices, and interim targets to reach net-zero

By participating in creating demand for high quality carbon offsets today, HKUST sends the necessary market signals to increase supply.

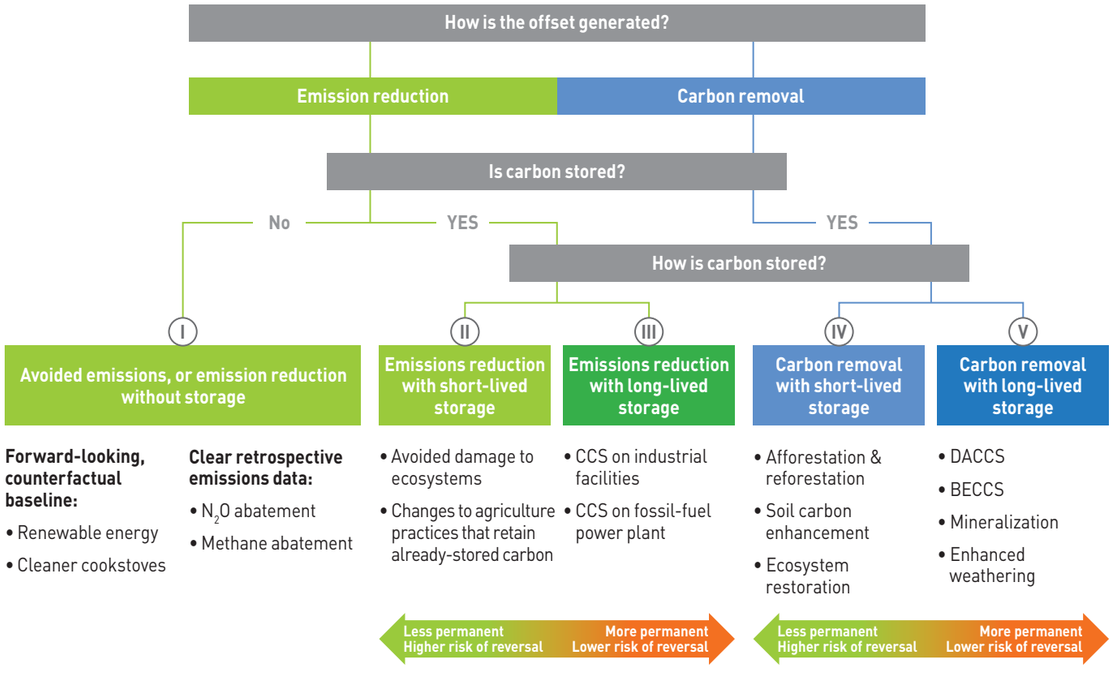
Over time, carbon offsetting emphasis should shift towards methods that directly remove carbon from the atmosphere and store carbon in forms that have a lower risk of reversal.

Shifting from Carbon Avoidance towards Carbon Removal Offsets

Carbon avoidance examples include the deployment of renewable energy projects, capturing methane from landfills to create energy, or (in theory) preventing a forest from being destroyed. While carbon avoidance offsets are necessary today, they are not sufficient to achieve global net-zero in the long run.

On the other hand, carbon removals extract carbon directly from the atmosphere. Carbon removal solutions eventually can help with stabilizing CO_2 concentrations in the atmosphere, and have the potential to keep reducing CO_2 levels after net-zero is achieved. Examples include biological carbon sequestration through tree planting, enhanced rock weathering, and direct air capture with storage.

Figure 2.8: Taxonomy of Carbon Offsets [13]



Acronyms:

CCS: Carbon capture and storage; DACCS: Direct air capture with geological storage; BECCS: Bioenergy with carbon capture and storage

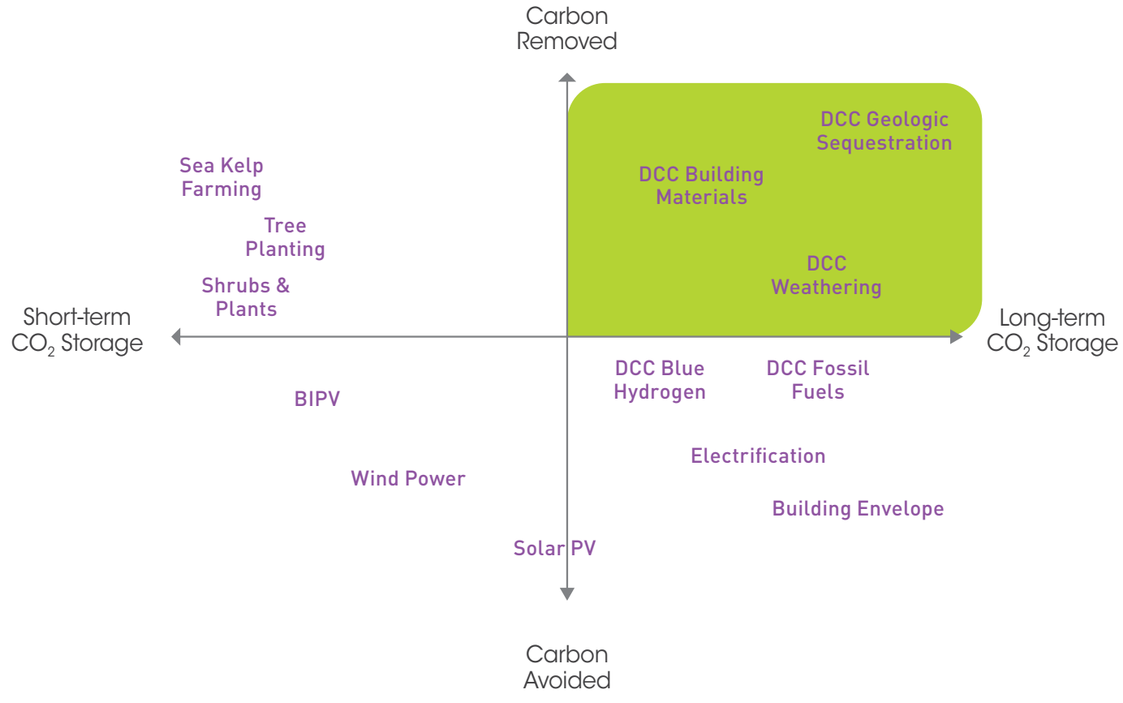
Shifting from Short-Term Storage towards Long-Term Storage Offsets

Short-term carbon storage refers to methods that "lock away" carbon for shorter periods or are at a higher risk of being reversed within a few decades. Examples of short term carbon storage include afforestation, reforestation, and soil carbon enhancement. Standalone, these methods may store carbon for thousands of years, however, the results are highly dependent on land use and other environmental conditions, including emerging climate risks.

Conversely, long-term carbon storage encompasses methods with a minimal risk of reversal over centuries to millennia. Examples include storing CO_2 in geological reservoirs or transforming carbon into stable forms through mineralization. These storage methods are generally more inert and secure compared to biological storage approaches.

Figure 2.9: Examples of High Quality Offsets

Focus on Carbon Removal and Long-Term CO_2 Storage



Acronyms:

DCC: Direct carbon capture; BIPV: Building Integrated Photovoltaics; PV: Photovoltaics

While it is not feasible for HKUST to achieve 100% carbon offsets through long-term carbon removal today, the University commits to gradually increasing the proportion of these offsets purchased. The aim is to purchase this type of offsets exclusively by mid-century to ensure compatibility with the Paris Agreement goals.

These projections and strategies will be continuously renewed to reflect updates in University growth.

CHAPTER 3

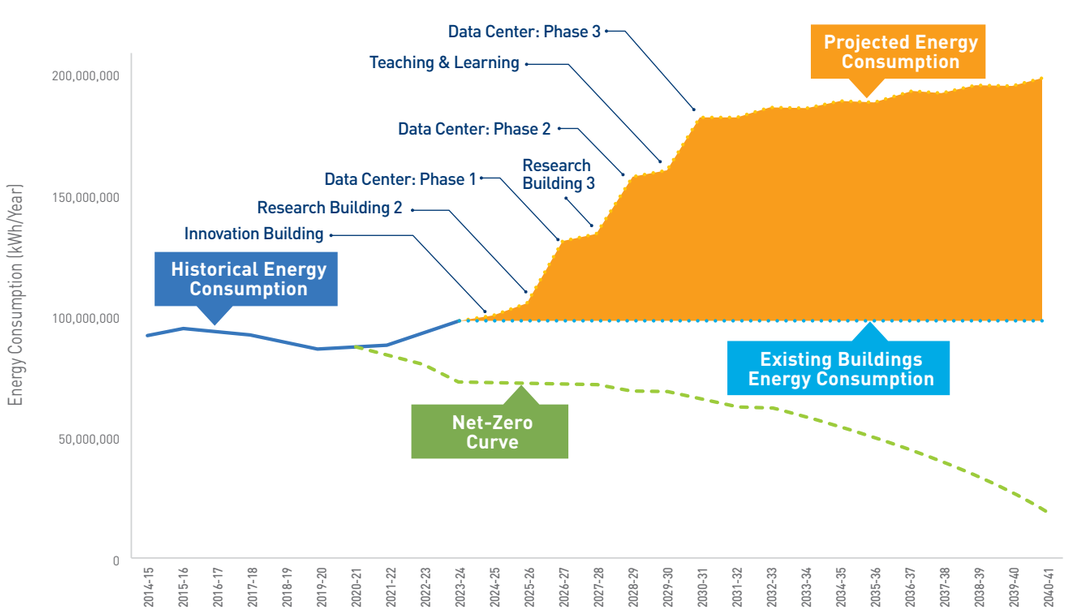
ADDRESSING NEW BUILDINGS

Growing Sustainably

HKUST is a thriving university that uses our core strengths in teaching, learning, and research to contribute to new decarbonization solutions that are of significant value to Hong Kong and our region. However, this growth requires additional resources and energy consumption that contribute to a growing greenhouse gas (GHG) footprint. The Net-Zero Action Plan aims to create a net-zero carbon pathway that anticipates the planned strategic growth of the campus.

A growing campus means the addition of new buildings, equipment, data centers, and other campus amenities. As seen in Figure 3.1, the projected growth of new construction will drive a corresponding increase in electricity consumption over the next two decades. Since electricity is the predominant source of GHG emissions for the campus, we can gauge the magnitude of carbon footprint growth over time by looking at expected electricity growth trends.

Figure 3.1: Projecting the Role of New Buildings in Electricity Consumption Growth



Addressing New Building Emissions

To address the emissions related to campus growth, this Action Plan offers a range of targeted strategies to the impacts that new buildings have from the beginning of the design stage. One of the main focuses of this Action Plan is to isolate and neutralize all emissions coming from new buildings.

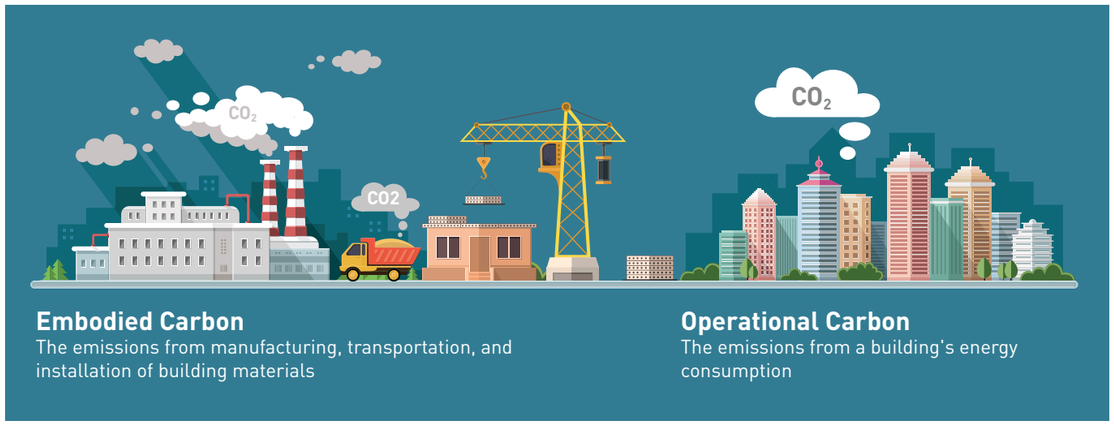
However, new buildings have two carbon challenges that increase the footprint of the campus and will make it more difficult to reach a target of net-zero carbon by 2045:

1) How to select materials and facilitate construction methods in ways that minimize the amount of carbon released during the construction process (embodied carbon)
2) How to design the buildings to minimize additional carbon emissions over the life of the building (operational carbon)

Embodied carbon: represents the life-cycle climate impacts released throughout the different phases of construction, before the occupant moves into the building. Today embodied carbon can represent up to half of the associated carbon emissions for a new building over its lifespan.[14] These emissions are categorized as Scope 3 emissions since the third party contractors are responsible for the materials and construction impacts. However, since HKUST has control over the site, the budget, selection of design teams, and approval of all elements within the process, the university is fundamentally accountable for the emissions. Figure 3.2 illustrates the types of emissions that result from the design and construction process.

Operational carbon: results from the day-to-day use of the building, mainly in the form of electricity consumption for cooling, ventilation, lighting and equipment use. These emissions are categorized as Scope 2 emissions.

Figure 3.2: Carbon Emissions from the Construction and Operations Phases

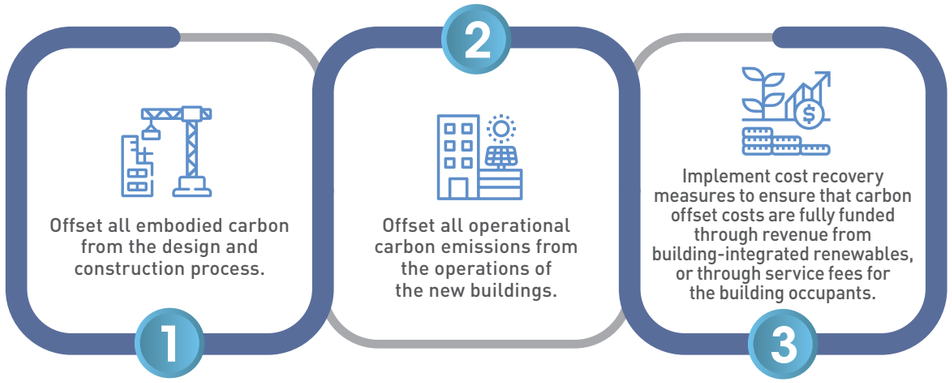


Specific strategies for minimizing both of these categories of emissions are included in the **HKUST Net-Zero Carbon Building Standards** (see Appendix 1). These strategies include a combination of high standards and requirements for design teams to act aggressively in reducing carbon in new buildings. With these considerations in mind, the overarching strategy for new buildings is: **all new buildings must be designed and operated as net-zero carbon buildings**.

Three-Pronged Approach

To ensure that all new buildings on the HKUST campus are carbon net-zero throughout their lifespan, this Action Plan includes three action items:

Figure 3.3: Approach for New-Buildings



Glossary:
Construction Floor Area: The total covered area of the building; Superstructure: Structural components above ground.; Stages A1: Product raw materials supply; Stages A2: Product transport; Stages A3: Product manufacturing; Stages A4: Construction stage transport; Stages A5: Construction and installation process during construction stage

These strategies will be continuously renewed to reflect updates in University growth.

Offset All Embodied Carbon from Design and Construction

Throughout the tendering process, from the initial development of the project briefs to the selection of lead design consultants (LDCs), the focus on net-zero carbon shall be infused into the processes. Utilizing the HKUST Net-Zero Building Standards (see Appendix 1), all stakeholders will be accountable for finding the least carbon intensive designs and material selections for the new building.

As noted in Chapter 2, high-quality carbon removal offsets are currently more expensive than other types of lower-quality credits. HKUST has developed an internal cost of carbon (see Appendix 6) that reflects our best estimates on the actual costs to society resulting from each metric ton of CO_2 released. With these costs, the capital project can determine the costs of embodied carbon that needs to be offset. For new capital projects, the process will be:

1. Senior leadership approves capital budget
2. Based on conceptual design, estimate size of building (in m^2)
3. Multiply size of building times 1,100 kg CO_2 (average embodied carbon metric)
4. Multiply result times CO_2 cost data table (Appendix 6)
5. Subtract the result from the capital budget. This is the amount that will need to be paid in carbon offset fees if no further work is done to reduce embodied carbon.

The key point in the process is that embodied carbon offset costs should be factored into the capital budget in the mid to long-term. This is appropriate and ensures that the embodied carbon is not cross-subsidized by other University activities or business units. It also creates an incentive for the design team to find ways to draw down the embodied carbon so that there is more available funding for other design priorities.

HKUST continues to work on the strategy to invest in the reduction of GHG emissions in all capital projects so that both embodied carbon and emissions from future operations are brought to zero, or as close as possible.

Embodied Carbon Performance Target:
The maximum amount of embodied carbon shall be 500 kg CO_2e/m^2 of construction floor area for the superstructure portion (stages A1 to A3) as well as the construction process (stages A4 to A5). This is aligned with the latest new constructions at HKUST.

Embodied carbon includes both (1) the carbon from the life cycle of product materials and equipment (e.g. concrete, steel), and (2) the emissions resulting from the construction process (e.g. use of large machinery). The emissions from the construction process must be included in the embodied carbon calculations. However, recognizing the limited nature of LCA databases and available information on building supplies, embodied carbon from the life cycle of materials will be calculated by including the following elements over time:

- **2023-2030**: **Core building and shell (superstructure, glazing, cladding, and wiring)**
- **2031-2035**: **Core building and shell, plus building services equipment, and selected finishes**
- **2035 onward**: **All building elements, including interior and exterior furnishing**

Offset All Operational Carbon from New Building Operations

The design of new buildings first starts with aggressive approaches to reduce the energy consumption.The existing standard for HKUST building is BEAM Plus Platinum, which is the highest sustainability level offered in the HK Green Building Council rating system. While the BEAM Plus standard is a good framework, the University has developed a more comprehensive Net-Zero Building Standard to ensure that new buildings are meeting the highest levels of energy, water, occupant well-being, and landscape performance.

The Net-Zero building requirement comprises two elements (refer to Figure 3.3):

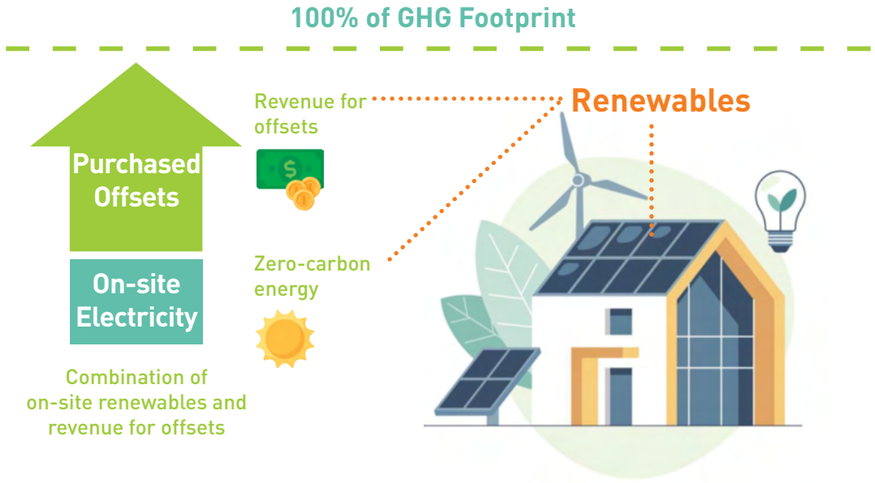
1. **Performance-based targets**, including embodied carbon in the construction process, and operational targets for energy and water post-occupancy.
2. **Comply-or-explain requirements** containing sustainability design strategies that shall be evaluated for each project. Non-compliance will require justification in the form of a technical feasibility study containing calculations and drawings, etc.

Figure 3.4: Key Elements of Net-Zero Building Requirements

The moment HKUST students and staff move into a new building, the emissions become operational. For the new building to be net-zero carbon over time, two things must happen; (1) the building should be generating as much carbon-free electricity as possible through the installation of renewable resources, and (2) any revenue generated by the renewable resources must be sufficient to cover the costs of purchasing approved carbon removal offsets. Ideally, these two measures will cover 100% of the carbon emissions, making the building a sustainable net-zero carbon building over time.

Operational Performance Target:
Greenhouse gas emissions from energy consumption must be offset by the revenue/avoided costs from building integrated zero carbon renewable energy production.

Figure 3.5: Net-Zero Carbon New Building



Implement Cost Recovery to Fund Carbon Offsets

There may be special cases where buildings may not be able to cover the entire greenhouse GHG burden with integrated renewables plus renewable-generated revenue. Large lab buildings or data centers are examples. In these cases, the buildings must be designed with cost recovery measures that charge the users for the services within the building, including carbon fees as part of the overhead cost recovery fee.

For example, in order to maximize the efficiencies of new data centers, the designs focus on a centralization model where the University purchases all of the equipment, pays for the electricity, and covers the costs of the maintenance. Researchers will no longer need to purchase their own servers or computing equipment, but rather will utilize the data centers through a fee-based model that recovers all overhead - including carbon fees.

Note on Carbon Fees from New Buildings and Purchase of Offsets

As noted in Chapter 2, the self-assessed carbon fees will be used to pay for high quality carbon offsets as aligned with the Oxford Principles for Net-Zero Aligned Carbon Offsetting. Unfortunately, the current state of global offsetting markets is relatively immature, making it absolutely imperative that any offsets purchased by HKUST must be of the highest quality and veracity.

> *Verifying offsets ensures that the emission reduction or carbon removal actually takes place, and that all forms of double-counting, including double-claiming of the emission reduction benefit, are avoided. [15]*

Embodied carbon: Purchased verified offsets should be sufficient to cover the embodied carbon released in all stages from A1 through A5 of the new building.

Operational carbon: Verified carbon offsets to sufficiently cover the operational carbon of the new building will be funded via two mechanisms:

1. Revenue from on-site renewables feed-in-tariff (FiT) will go to the purchase of verified offsets
2. Any funding shortfall after applying FiT revenue will be made up through chargeback mechanism to building users based on their carbon footprint

At the end of each academic year, the calculations will be determined by the Campus Management Office and verified by the Sustainability / Net-Zero Office. After confirmation by the Sustainable Operations Executive Committee, the purchase of the offsets will be completed by either the Finance Office, or the Sustainability / Net-Zero Office on behalf of the Finance Office. More information on the governance structure is included in Chapter 8.

Buildings as Carbon "Sinks"

One of the exciting developments in the building industry is the focus on utilizing buildings themselves as ways of absorbing carbon dioxide and trapping it for the duration of the life of the building. New research is focusing on specific building materials like concrete where the materials can be manufactured in ways that absorb carbon dioxide during the curing process. Structural timber is another promising avenue whereby steel and concrete is replaced by engineered timber frames and panels that replicate the same strength and functionality, while simultaneously reducing overall carbon. As this research progresses, we anticipate that newer buildings may have additional opportunities to reduce or even eliminate embodied carbon over time. HKUST has strength in many of these research fields, and this Action Plan anticipates active participation from our research initiatives that can contribute positively to future new low carbon buildings. More details on stimulating low-carbon research in Chapter 5.

CHAPTER 4

EXISTING BUILDINGS AND CAMPUS LANDSCAPE

Opportunities for Our Existing Campus

The previous chapter focused on the strategies for addressing the carbon in new buildings, but we need a different approach for existing buildings, many of which are over 30 years old and poorly designed (from a carbon-reduction perspective). The older buildings are both a challenge and an opportunity; as the buildings reach an age where they require extensive retrofits and renovations, the renewal work can include aggressive measures to reduce energy and carbon.

The landscape of the campus also represents opportunities for decarbonization measures. While much of the work will focus on existing buildings, we recognize that trees, soil, vegetation, and even the coastline offer areas for sequestering carbon or generating creative new sources of renewable energy.

The overarching strategy for the existing campus is to
Invest Aggressively in Energy Conservation, Renewables, and Decarbonization.

Four Approaches for Existing Buildings and Landscape

To maximize the potential for success, the strategy targets four Action Items:

Implement the Campus Renewal Plan (CRP) to address the most consequential existing buildings on campus in terms of overall improvements and carbon reduction.

Allocate funding for continuous improvements for buildings, infrastructure, and equipment not covered by the CRP.

Continue to invest in the "smart" infrastructure backbone of meters, sensors, monitors, and other data collection and visualization measures.

Explore new decarbonization opportunities on the campus, utilizing the slope, landscape, soils and coastline.

These strategies will be continuously renewed to reflect updates in University growth.

Campus Renewal Plan Implementation

The Campus Renewal Plan (CRP) is a comprehensive assessment of the current conditions of the campus built-environment with an action plan for systematically upgrading selected buildings in sequence through 2035.

The CRP adopts an "everything touched" approach meaning that when we have an opportunity to upgrade a space, we must take advantage of the opportunity to implement all feasible decarbonization measures at that time. This recognizes that major upgrades do not happen frequently so we must be opportunistic when the chances arise. It also recognizes that with a limited timeframe for reaching our net-zero target, we will not have a second chance to return to these buildings before 2045.

The CRP focuses primarily on the oldest labs, student residential halls, and staff quarters and includes a reasonable implementation schedule to complete the work by 2035.

Most importantly, a new set of sustainable building standards for renovations cover building performance disclosures to gather information for future standard development, while providing comply-or-explain requirements that shall be evaluated for each project. The HKUST Net-Zero Building Standards (see Appendix 1) cater for major building renovations 5,000 m^2 or more, while HKUST Building Renewal Standards (see Appendix 2) serves minor renovations ranging from 500 m^2 to less than 5,000 m^2.

Allocate Funding for Continuous Building Improvements Beyond CRP

In addition to the carbon reductions anticipated by the CRP, this road map recognizes that the campus will still have many buildings that are not touched. To address these buildings, and to maximize the carbon reductions, investments will need to be made into upgrades such as electrical equipment, air conditioning units, lighting, and other appliances that add to the carbon burden.

The University has access to funds from the government that can help with some of these items. The Alterations, Additions, Repairs and Improvements (AA&I) Programme from the University Grants Council (UGC) provides grants and should be maximized for carbon reductions. Additionally, an annual allocation of funds for general improvements can be earmarked for specific energy reduction measures that will both reduce the University's costs and carbon emissions. The University should pursue other grant opportunities as well, including opportunities for funding from The Hong Kong Jockey Club and other donors who share a vision of decarbonizing Hong Kong.

Figure 4.1: Technology Readiness Level Scale Diagram

Source: TWI Global

Figure 4.2: Sustainable Smart Campus as a Living Lab "Smart Building Integrated Photovoltaic Systems Toward Zero Energy HKUST Campuses" Project

HKUST is well-suited to being aggressive with installations to test new technologies and approaches, with world-class researchers and a progressive campus community that is accustomed to Living Lab among research initiatives on campus. In addition to carbon-related Sustainable Smart Campus as a Living Lab projects (see Chapter 5), the Campus Management Office and other units have regularly experimented with new technologies that have the potential for energy and carbon savings. The approach has been to utilize the Technology Readiness Level (TRL) model for assessing the relative readiness stage of new technologies and where we might test on campus. Unlike commercial properties, a research institution like HKUST can test different on-site interventions at earlier stages (such as TRL level 3 to 5) on campus to evaluate the results under real conditions. This ability means that HKUST has the potential to see new carbon-related technologies early in the development stage and provide a platform to test them as proof-of-concepts on our campus.

Create a Robust "Smart" Infrastructure Backbone for Innovation and Carbon Management

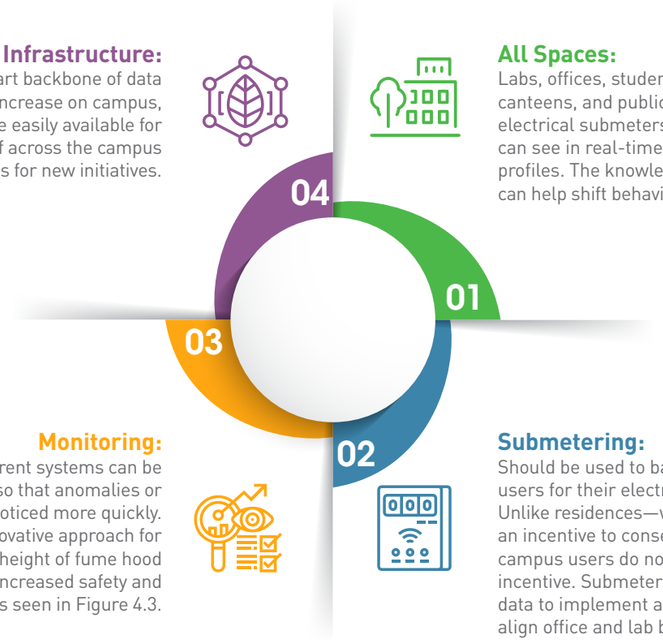
A decarbonized campus must be a smart campus, and a smart campus is one where the building performance data is utilized to optimize systems and provide behavioral incentives to members of the campus community.

HKUST has been installing electrical submeters on major systems since 2019, and now data is collected (sometimes in real-time, and at least at monthly intervals) for water, waste recycling, paper consumption, renewable energy production, indoor air quality, and population flows through the buildings. The data is transformative, providing essential information for facilities professionals to improve building performance. It is also used by faculty and students for group projects and innovative research initiatives. With the increase of data, the decarbonization efforts will continue to get more precise and effective.

While the University has a good start, there is much more that should be done.

Smart Infrastructure:
As the smart backbone of data generating devices increase on campus, the information must be easily available for students and staff across the campus who have ideas for new initiatives.

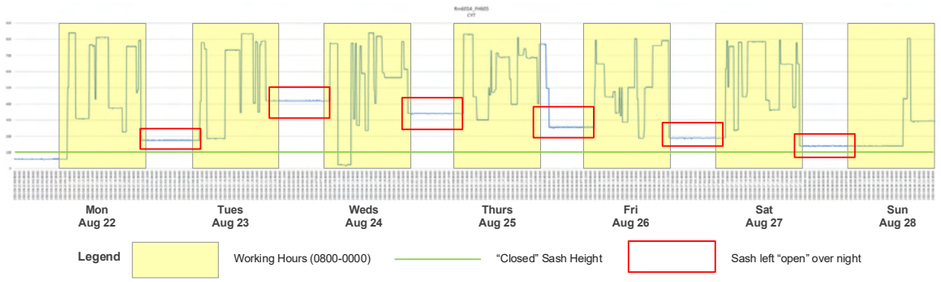
All Spaces:
Labs, offices, student residential hall rooms, canteens, and public areas should have electrical submeters so that the occupants can see in real-time their energy consumption profiles. The knowledge of the consumption can help shift behaviors and create good habits.



Monitoring:
Performance of different systems can be more easily monitored so that anomalies or failures are noticed more quickly. For example, an innovative approach for collecting data from the height of fume hood sashes has resulted in increased safety and reduced energy costs as seen in Figure 4.3.

Submetering:
Should be used to back-charge campus users for their electricity consumption. Unlike residences—where monthly bills provide an incentive to conserve energy at home—campus users do not currently have such an incentive. Submeters will provide the correct data to implement a charging system to align office and lab behaviors with a mindset of conservation.

Figure 4.3: Data of Laboratory Fume Hood Sash Occupancy Showing Frequency of Sash Left Open Overnight



Collectively, the combination of smarter facilities management and providing conservation incentives through metering and billing will provide new avenues for decarbonization on campus.

Explore Campus Landscape Opportunities for Decarbonization

While HKUST's carbon footprint mainly comes from the consumption of grid-powered electricity, decarbonization does not need to be limited to electricity reduction. The campus provides numerous opportunities to capture and sequester carbon as well. One promising opportunity is in using the campus trees, soil, and coastline as prospects for reducing carbon from the atmosphere directly.

Soil has unique ability to trap carbon dioxide for long periods of time. As trees and plants grow, carbon dioxide absorbed by the leaves can be transferred to the roots where the carbon is sequestered. This process can be accelerated by taking landscape materials like branches and tree trunks and converting them to a substance called biochar. The resulting biochar is a carbon dense material that can be ground and mixed with soil as an amendment, thereby trapping it underground for decades. Research suggests that using biochar as an amendment improves soil quality and health in a natural way as well. This is a promising area of research to find the best ways of absorbing carbon dioxide from the atmosphere and trapping it into the soil on the HKUST campus.

The way we manage the landscape of the campus will also influence our decarbonization strategies. Recognizing that chemical fertilizers have a large carbon footprint due to the use of fossil fuels in their production, and shifting to more environmentally friendly landscape maintenance techniques will create a more natural environment while also reducing global emissions from supply chains. The University will continue to focus on natural fertilization strategies, such as the use of compost and other beneficial soil amendments.

HKUST also has a viable coastline where waves and tides present an opportunity for small scale energy production. The mountainside location of HKUST may also present an opportunity to capture the energy of rainfall as it cascades down the mountainside into Clear Water Bay.

While these efforts may not be sufficient to decarbonize the campus completely, they represent an important opportunity to demonstrate HKUST's commitment to thinking creatively about how we use the natural resources in ways that help solve problems for the future.

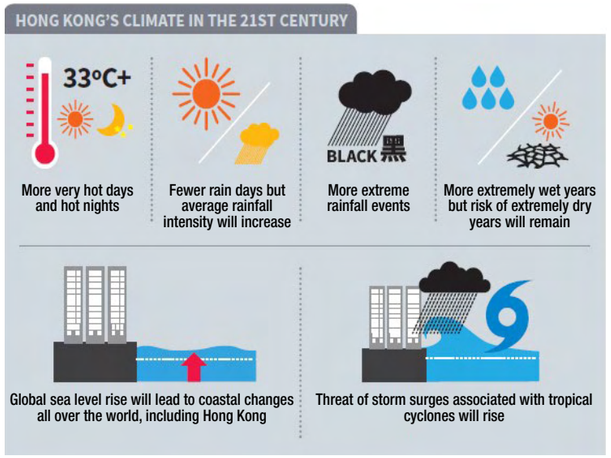
CHAPTER 5

CAMPUS ADAPTATION AND RESILIENCE

Climate Risks for the Campus

While measures in the previous chapters are targeting the reduction of greenhouse gas (GHG) emissions from HKUST operations, we must also recognize that decades of emissions into the atmosphere have already altered weather and climate patterns. Climate change is not a far-off concept; we are already experiencing the impacts today, and we anticipate the impacts growing in intensity over the next decades.

Figure 5.1: Hong Kong's Climate in the 21st Century



Source: Hong Kong Water Supplies Department

The campus has several features that make it critical that we address the risks of expected changes to the climate; first, the campus is on steep slopes that funnel large volumes of rainwater into ravines and engineered concrete trenches. Data from the Hong Kong Observatory indicates that annual rainfall has increased by an average of 2.2 mm per year [16] with expectations of this increase continuing. Secondly, the campus is on a coastline so storm surges and other coastline events may have bigger impacts than if further inland. It means the campus is also more vulnerable to a rise in mean sea levels, which have risen by a rate of 32 mm per decade since the 1950s. [17] Thirdly, the campus is surrounded by natural forests which may be vulnerable to fires during extended droughts. Further, increased heat within the forested areas may impact insects, mosquitoes, and other biodiversity systems that could manifest into health concerns for the campus community.

To prepare our campus for these impacts, the overarching strategy will be to ***implement measures that allow us to adapt to some changes and become more resilient to others****.*

Six Approaches for Building Resiliency and Adaptability to Mitigate Climate Risks

To prepare for expected impacts from the changing climate, the strategy includes six Action Items:

01 Focus on redundancy of slopes through maintenance and design to ensure their stability.

02 Develop measures to protect the coastline from storm surges and rising seawater levels.

03 Prepare for extreme heat by developing standards for workers and monitoring systems for airborne illnesses, and other stresses on campus biodiversity.

04 Adopt measures to reduce the urban heat island effect within the campus to mitigate further heating within the campus microclimate.

05 Adopt "sponge city" measures to ensure that when heavy rainfall events occur, the campus can deflect the large volumes of rainwater away from buildings and critical infrastructure.

06 Create new policies on remote learning, working from home, and flexibility in job functions to adapt to alternative work and learning patterns during extreme weather events.

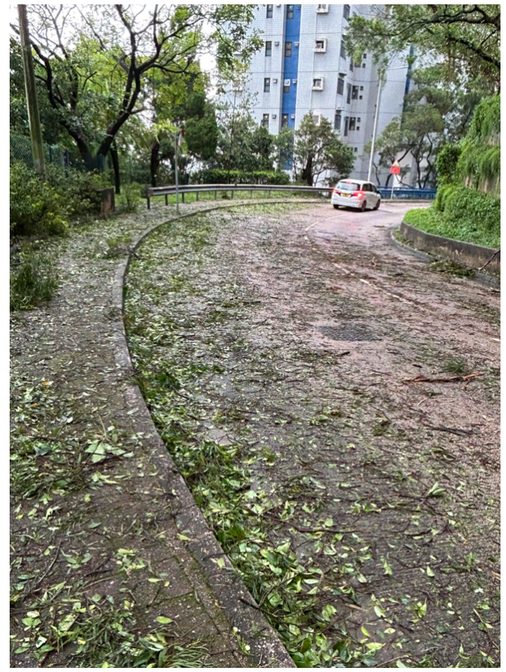
These strategies will be continuously renewed to reflect updates in University growth.

Campus Slopes

The Clear Water Bay campus begins at the water's edge and rises to over 150 meters above sea level at the campus North Gate. Such a rise creates slopes that are both breathtaking to behold and challenging to maintain. Many of these slopes were engineered and strengthened over the past 30 years to make them safer during extreme weather events (these are often referred to as "man-made slopes"). [18] The campus also includes natural hillsides that have not been modified. Both man-made and natural slopes present risks to the campus as the climate changes. For man-made slopes, the risk is most prevalent if the areas are not inspected and maintained as required. This risk is mitigated by maintaining a regular schedule for maintenance and following established processes.

For natural slopes, the risks are a little higher because the surface areas have not been modified to harden the soil structures and integrate engineering solutions to reduce the risks of landslides. The types of vegetation growing on the slopes can help reduce some of the risks (some vegetation is better at holding soil than others), but vegetation alone cannot prevent landslides if the conditions deteriorate. Mitigation strategies must include measures to ensure the slopes are secure and hold minimal risk to the campus users and infrastructure.

Figure 5.2: Typhoon Damage to the Campus Roads



Protect the Coastline

Typhoon Mangkhut in September 2018 was a wakeup call on the dangers of a coastal campus. The super typhoon drove waves into the seawall and destroyed the wall and the access road leading to the sports front areas. The damage was fixed and no one was hurt, but the typhoon was a reminder that experts predict that storms such as these will become more frequent.

To prepare for these expected storms the University will need to conduct regular monitoring and inspection of the breakwater infrastructure, as well as the buildings and sports facilities at the water's edge.

If the sea level continues to rise at the same recent historical rate of 32 mm per decade, the campus should not feel a strong impact by 2045. However, it will be imperative that HKUST use the next two decades to further harden in the infrastructure by preparing for higher sea levels in the years ahead. The University may consider measures such as increasing the height of the sea walls, adding depth to the seafront access roads, and reviewing the drainage piping to ensure that seawater breaching the sea walls can continue to drain back into the bay.

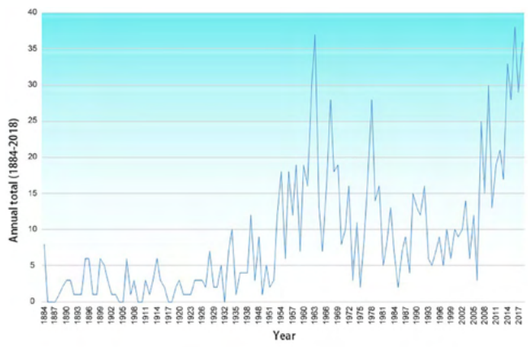
Figure 5.3: Damage to the Campus Seawall and Access Roads

Extreme Heat

Weather data shows that extreme heat days are increasing in Hong Kong, and the recent years are the hottest on record in terms of very hot days, hot nights, and overall increases in average temperature. [19] The consensus is that climate change will exacerbate these trends and create even more difficult conditions in the future. [20] On a local level, we are feeling the impacts of the warming in increased electricity consumption—in part because we are using more air conditioning, and in part because the sea water cooling system becomes less effective as the coastal waters become warmer.

Besides energy impacts (which also indirectly increase our GHG emissions too) the extreme heat events can create dangerous conditions for our campus community. For staff who predominantly work outdoors (e.g. landscapers, cleaners, security officers) we will need to revise work protocols to ensure their safety. Similarly, we will need to add additional safety provisions into construction contracts which may increase overall costs or delay deadlines for completion. For example, some jurisdictions are recommending that workers take longer mid-day breaks or even work into the evening hours to avoid heat extremes of the day. [21] On the HKUST campus we will need to revise continuously the safety manuals to ensure that work can continue under safe conditions.

Figure 5.4: Very Hot Days Recorded in Hong Kong Since 1884



Source: Hong Kong Observatory

Urban Heat Island Effect

Areas where urban development significantly changes the natural landscape by removing vegetation and replacing it with concrete, steel, and asphalt see a corresponding increase in the average temperatures. Where vegetation absorbs sunlight, manmade structures tend to radiate it back to the surrounding area. Additionally, the urbanized areas tend to include heat generating equipment—mainly from air conditioning, but also cars, machinery, and electricity transformers—that contribute to higher temperatures. The increase in temperatures is referred to as the Urban Heat Island effect (UHI) [22] and exacerbates the impacts of climate change.

Fortunately, the HKUST campus is relatively remote and suffers less from UHI effects than our urban counterparts. Even so, a densely packed campus can still create small microclimates of heat that impact our ability to keep buildings and people cool. Concrete in campus buildings and asphalt on campus roads absorb and radiate heat back into the buildings, while air conditioning units blow hot air into the surroundings. These conditions simply make it more challenging to reduce energy consumption, so they will need to be addressed in our mitigation and adaptation strategies.

Heavy Rainfall

Heavy rain events—like during typhoons or Black Rain situations—create substantial cascades of water rushing from the slopes towards buildings and the coastline. September 7, 2023 holds the distinction of recording the heaviest rainfall in Hong Kong since the beginning of records in 1884, with 158.1 mm of rain falling within a one-hour span. [23] These kinds of rain events are expected to get stronger over time, placing more stress on the landscape. They also create large pools of water around drains and overflow cisterns if the drainage is blocked.

Because of our subtropical climate, Hong Kong generally has decent infrastructure for handling large volumes of rainfall, and the HKUST campus is no exception. However, the pinch points stormwater management strategies are:

1) Keeping the water away from basements

2) Keeping waterproofing membranes on rooftops surfaces secure

3) Maintaining seals around windows and doors to prevent water from entering buildings when being driven by wind

4) Keeping drains clear from blockages

For the first pinch point, HKUST has no current buildings with a fully-enclosed basement structure. While some parts of buildings are underground, the hillside generally keeps at least one side of the basement above ground, and therefore more protected from floodwaters being trapped. The other three pinch points require constant vigilance and maintenance protocols to ensure buildings and campus infrastructure are protected and rainfall risks are mitigated.

Flexible Work and Study

The 2023-24 academic year began with a series of extreme weather events that closed the campus on two consecutive Fridays. These disruptions are difficult for staff, but even more challenging for teaching and learning considering course schedules are fixed and not easily adjusted. The experience was a reminder that flexibility in both teaching and staff work will be a necessity in the future.

To mitigate the risks of disruption to University operations, it will be essential to revisit flexible work and study strategies so that work and classes can continue when unexpected extreme weather events occur. The University developed Staff Mobile Commuting Guidelines to provide recommendations on "devices, network connectivity, and cloud services that enable users to perform their duties while not based in one fixed location." When extreme weather conditions are in effect, online classes and recordings will be available. [24] Staff who have genuine difficulties in returning to office will also have access to alternative work arrangements. [25] These guidelines can allow staff and faculty to continue work during weather events.

As the climate conditions changes, further mitigation strategies or refinements may be introduced to ensure that the University is more adaptable and resilient to changing conditions.

CHAPTER 6

NET-ZERO RESEARCH AND SKILL-BUILDING

Teaching and Learning Strategy

HKUST is recognized for scholarship and hands-on research relating to decarbonization, climate adaptation, and green finance. Additionally, HKUST has developed a unique research platform using the campus as a "living lab" for developing proof-of-concept interventions that address on-campus sustainability challenges. With staff, student, and research pathways, the University has a rich assortment of opportunities for members of the campus community to get involved to help reach the net-zero carbon goal.

However, there is more HKUST can do to ensure that we are moving in the right direction for decarbonization. We also recognize that any benefits that arise from University-led research can have spill-over impacts for the rest of the greater Hong Kong region.

From a teaching and learning (T&L) perspective, this Net-Zero Action Plan will align with the sustainability education vision for HKUST:

To ensure that all HKUST students gain a solid understanding of sustainability concepts and graduate with the capacity and commitment to solve problems locally and globally.

No matter their field or concentration, students will leave HKUST and enter a carbon-constrained world where their problem-solving skills will determine their long-term success in navigating the changing economic and climate-impacted landscape. The skills and competencies HKUST imparts on students will have a lasting impact over the course of their careers, so it is imperative to make sure students are equipped with experience in solving complex problems that result in sustainable outcomes.

Over the past decade, HKUST has been a leader in developing coursework and programming that allow students to get hands-on training and build skills through experiences. The results are clear: students retain more information, gain more skills, and enjoy the process more when learning through doing.

Further, HKUST has an obligation to help members from the local community to build the types of skills needed to solve the kinds of decarbonization issues that impact our campus and Hong Kong more broadly. As a large employer of staff, and a large client for consultants, contractors, and suppliers, HKUST has a unique chance to raise the competency level of professional staff members who work on our campus through the awarding of contracts.

Therefore, the overarching decarbonization research strategy is to ***create viable pathways to net-zero research and skill-building.***

Four Approaches for Research and Net-Zero Skill-Building

This Action Plan recommends the following four Action Items to maximize the ability for HKUST to contribute to the global conversation and development of solutions on decarbonization.

Create funding pathways for research and implementation of campus-based energy production and carbon removal.

Create course content and hands-on extra-curricular programs to engage students throughout their programs to build sustainability thinking skills and problem-solving competencies.

Establish a global research alliance of like-minded universities to utilize our campuses as living labs for sharing and collaborating on decarbonization solutions.

Develop educational resources for the professional staff of the broader Hong Kong community.

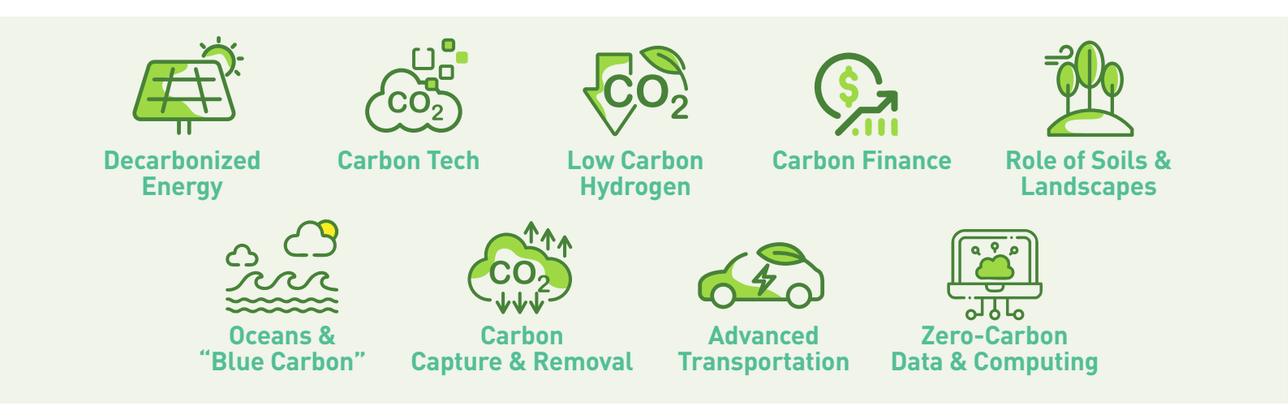
These strategies will be continuously renewed to reflect updates in University growth.

Funding Pathways for "Living Lab" Research

Building on the successful model of HKUST's Sustainable Smart Campus as a Living Lab (SSC), this Roadmap recommends an accelerated approach to engaging the research expertise of the University to focus on campus related decarbonization challenges. The SSC currently focuses on two thematic areas: net-zero carbon research, and community well-being. The standard process begins with engaging members of the campus community through targeted workshops and project development activities and then works with the faculty, staff, students, and alumni to propose projects that can be funded and implemented on campus. Through this process, a large number of proposals are received, vetted, and the strongest proposals are accepted and funded for a two-year appointment whereby project teams implement their ideas on campus to test their viability and effectiveness.

The Living Labs program has a strong track record of success and is an excellent starting point for additional measures where there are opportunities to identify specific areas of the campus that are problematic or challenging from a decarbonization perspective. With this additional pathway, the SSC can encourage—and fund—members of the campus community to focus on reducing carbon in existing buildings as well as the broader campus landscape.

Figure 6.1: Proposed Living Lab Net-Zero Themes



By bringing net-zero solutions to life on the campus, we strengthen our ability to:

Educate and Engage Faculty, Staff, Students, and the Community on Net-Zero Challenges

Through tours, workshops, and other activities that showcase the need for Net-Zero solutions, demonstrate the benefits, and encourage their adoption.

Foster Tangible Collaborations and Partnerships for Net-Zero Solutions

The Living Lab can provide an opportunity for collaboration and partnerships between the University, industry, and government organizations to effectively draw expertise and best practices from all sectors.

Develop and Refine More Effective Net-Zero Policies

The Living Lab enables the University to incorporate data collected and lessons learned to design and adopt policies that support the adoption of these solutions on a larger scale.

Net-Zero-Aligned Research Networks for Living Labs

Building on the proven model of HKUST's Sustainable Smart Campus as a Living Lab approach, HKUST will pursue pathways to activate campuses around the world as living laboratories for innovation . The aim of such networks is to bring together both academic research and transdisciplinary operational expertise to enable the testing of novel lab-level concepts in real-world settings. The collaboration will allow researchers to test their interventions across campuses, providing a robust evaluation of real-world evidence that crosses geographic, climatic, and cultural barriers. These proof-of-concept interventions are also a tangible demonstration of network members' meaningful technology transfer while simultaneously making bold steps towards achieving ambitious net-zero goals.

A network of universities can provide a powerful platform for addressing complex, global net-zero problems by fostering collaboration, shared knowledge, and interdisciplinary solutions. Furthermore, a consortium can bring together expertise and resources to tackle these problems at a larger scale and develop holistic solutions developed by experts from various fields such as engineering, science, policy, economics, and social sciences.

Guided by a formed Net-Zero Research Committee (NZRC), this will strengthen our community connections while ensuring that our expertise is integrated with other world-class research.

Key features of the Net-Zero Research Committee:

"Bottom-Up" Net-Zero Challenges on Campus

The Committee will direct HKUST's research institutes, centers, and other administrative offices to identify on-campus net-zero challenges that will serve as the focus of sponsored research collaboration with other universities. This "bottom-up" approach helps to ensure that the visible on-site demonstration projects can showcase the forward-looking work of HKUST researchers as contributors to solving global sustainability challenges while simultaneously contributing directly and impactfully to our Net-Zero goals.

Eye Towards Hong Kong/Greater Bay Area Net-Zero Adoption

The challenges and associated sponsored research will be selected for the on-campus impact as well as the potential spill-over benefits and adoption throughout Hong Kong and the Greater Bay Area (GBA).

Accelerates Technology Transfer

Activities will focus on identifying and supporting net-zero related research facing the "valley of death" between lab findings and validated findings in a relevant environment. Collaborators can overcome these barriers by co-generating proposals with operations teams and gaining broader access to potential testing sites.

Achieve Campus Sustainability Objectives through Innovative Research

Aggressive sustainable operations goals will require universities to go beyond mainstream solutions and embrace radical interdisciplinary approaches. The Committee will drive progress towards meeting these goals while strengthening the long-term collaborative capacities among academic and operational leadership at partner universities.

Net-Zero Literacy Training and Skill-Building

The strategic vision for HKUST is to become a regional leader in sustainability education with a global outreach. In practical terms, this means delivering education and training to ensure all members of our community are sufficiently equipped to support actively the net-zero strategies.

Recognizing that climate change is a systems problem, the focus will be to create educational resources and opportunities for both HKUST students to learn and gain understanding of net-zero challenges and opportunities. The approach for students is two-fold; we will create learning tools and resources to help them build sustainability-related skills and create the conditions on campus for students to employ those skills within structured hands-on experiential learning practices.

For skill-building, research suggests that training students to develop certain sustainability-oriented competencies are effective in preparing students for the future by creating a problem-solving mindsets that are more capable of addressing the kinds of complex challenges they are likely to see in their future careers. [26] Further, competencies are discipline agnostic—the adoption of problem solving skills can benefit all students regardless of their majors or fields of study. This is critical because we recognize that students are likely to change careers many times after they graduate, so imbuing them with a strong set of thinking and problem-solving skills will transfer from one career to the next.

This Action Plan recommends prioritizing the following competencies in school-wide curricula:

Systems Thinking

A prescient warning is "today's problems were yesterday's solutions," [27] noting that today's problems were largely created with good intentions, but without the perspective of how broader systems work. In fact, climate change is a systems phenomenon, both in the respect that the inputs and impacts are system-wide, but also that the global disruptions are a direct result of "solutions" (the development of the modern energy infrastructure). Systems thinking will help students understand how to solve problems without simply shifting the problem elsewhere.

Future Thinking

One of the most difficult tasks for humans is to plan carefully and clearly about the future because of a phenomenon called the "end-of-history illusion." [28] Since the future is uncertain, and our brains address uncertainty as a source of stress, our brains will often solve the problem by convincing us that the future will look much as it does today. This, of course, is false, and inhibits good decision-making. Future thinking skills can help students overcome this bias and be better prepared for future planning.

Values Thinking

The ability to fully comprehend net-zero pathways requires students to step outside their comfort zones and consider impacts from the perspective of others. Considering the fact that the overwhelming degree of climate change impacts will be felt by future generations, it is critical for students to embrace values, ethics, and empathy.

Life Cycle Thinking

This term generally refers to employing the skills needed to evaluate the overall impacts of decisions and actions across the supply chains (life cycle analysis), and over time (life cycle cost accounting). Life cycle thinking will train students to recognize how to utilize funding and resources most efficiently.

Creating the conditions on campus for experiential learning

The Action Plan recommends accelerating existing efforts to implement hands-on learning, competitions, workshops, service learning, and other experiential learning activities that provide opportunities for students to participate. In combination with expanded skill-building learning efforts, the ability of students to test new ideas and approaches is an ideal way to lock in the skill sets and make them easier to recall later. Programs like the Tung Foundation-funded Sustainability Design Thinking Workshop combine the skill-building with hands-on learning. They also provide a safe space for students to fail and learn from the mistakes in a nurturing setting.

Resources for Professional Staff

The footprint of the HKUST campus is in constant change; new buildings come on-line while existing buildings are updated and modified for new uses. Each time we enlist contractors to come on the HKUST campus, we have an opportunity to train their professional staff to understand our needs and decarbonization priorities. There are two important reasons the Action Plan recommend this action: first, the mission of HKUST is to advance learning and knowledge, and this mission does not end at the campus edge. As an educational leader in Hong Kong, HKUST has a responsibility to advance knowledge through our activities and interactions with the broader community. The second reason is more personal; if we are successful in training contractor staff on the basic elements of decarbonization and lifecycle thinking, then we benefit from the work output of a professional group of designers and engineers who plan, build, and renovate our campus using the skills and tools we promote for effective long-term sustainable and net-zero planning.

To accomplish this outcome, the Action Plan recommends the coordination of resource development and distribution through collaborative academic and administrative department activities. The existing Life Cycle Lab—a collaboration between the Division of Environment and Sustainability and the Sustainability/Net-Zero Office—has created a network of local academics and practitioners who recognize the importance of utilizing lifecycle thinking tools to solve problems in property development, construction, and across supply chains. The Action Plan recommends four specific areas of activity:

01

Create and maintain a knowledge base of the latest information and research on lifecycle initiatives, tools, databases, and applications.

02

Develop a broad range of teaching tools, including online self-learning modules, lesson plans, case studies, experiential learning tools, and educational / instructional videos for use by HKUST Faculty and Teaching Assistants.

03

Develop a career development workshop series for early stage and mid-career professionals in the construction, architecture, engineering, and supply chain fields. The series would grow to include certification programs and possibly accreditation in collaboration with relevant professional institutions.

04

Over time, concentrate research capabilities for work in developing innovative approaches, interesting fields of inquiry, publication, and sponsored research.

CHAPTER 7

FUNDING AND INVESTMENTS

Allocating Our Financial Resources

Getting to net-zero carbon emissions will not only require a change in our current practices and operations, but also in the way we allocate our financial resources.

Specifically, this Action Plan proposes:

01 **Aligning our financial investment strategy and our operations investment strategy towards a long-term consideration will be a vital cornerstone of achieving our Net-Zero aspirations.**

02 **Establishing funding avenues to create funding pools to make direct investment into campus operations.**

Aligning Long-Term Investment Pool Investments with a Net-Zero Future

Our role as a responsible steward of our capital involves greater emphasis on utilizing Environmental, Social, and Governance (ESG) criteria for our Long-Term Investment Pool. This fulfills two distinct facets of our stewardship:

1 **Considers Material Determinants to Long-term Returns:**

Responsible stewardship of our own portfolio requires us to take into account all material determinants of risk and opportunity for the investments we make. These include ESG factors which are in many cases material to the longer-term success, adaptability, and resilience of businesses in which we invest.

2 **Strengthens Alignment with Values:**

We seek alignment with our values as an educational institution. Our goal is to be a sustainability leader where our investments reflect our commitment to solving grand generational challenges in climate change, water scarcity, building a circular economy, transforming food production systems, and building a fair, just, and equitable society. This alignment also strengthens our sense of purpose as a higher education institute.

HKUST's ESG Investment Policy

In the works since 2018, and approved by University Council in 2022, the Environmental, Social And Governance (ESG) Policy For The Long-Term Investment Pool policy ("ESG Investment Policy") marks a significant step forward in ensuring that University funds are invested in a responsible way that reflects our core values and decarbonization goals. The policy should ensure that fund managers are always looking for ways to increase viable decarbonization investments while adequately protecting University resources.

Objectives: The ESG Investment Policy sets out the guiding principles for investment managers who invest on behalf of HKUST (see Appendix 4). The policy has three broad goals specifically for decarbonization:

1. To ensure the risks and opportunities arising from a low carbon transition are reflected in the way investments are chosen for the portfolio.
2. To seek out investments whose activities can profitably accelerate or otherwise support the low carbon transit.
3. To support and encourage all businesses to adopt business plans and strategies consistent with the goals of the Paris agreement.

Goals: This policy will guide the University through the next several decades when climate disruptions will significantly increase risks to investment opportunities. The strategy focuses on the following goals:

1. Eliminating all investments in fossil fuels over time, with specific target of halving all investments in fossil fuels by 2030.
2. At least 5% of investments shall go into climate solutions—defined as opportunities that are intended to further the decarbonization infrastructure—by 2025.
3. More open and transparent accounting of the investments to ensure that HKUST has a better sense of the overall carbon accounting from the investment pool.

This Net-Zero Action Plan recommends reviewing and revising the ESG Investment Policy every three years (as is standard University procedure) to ensure that the policy can be strengthened as conditions change and new opportunities arise.

Aligning Operational Investments with a Net-Zero Future

The foremost consideration when pursuing net-zero improvements in campus operations is setting up funding avenues for funding pools to make direct investment into the campus. The allocation of the funding pool is covered in the previous chapters and highlight the strategies for how the funds will be utilized in new buildings, campus renewal of existing buildings, and targeted research.

Raising Net-Zero Operational Investment Funding Pools

This Action Plan recommends that the net-zero operational investment pool is funded via two sources:

1. **Sensible cost-recovery mechanisms:**
   The overarching strategy is to implement a hybrid Internal Carbon Pricing (ICP) mechanism that assigns a monetary value to the carbon emissions resulting from our new and existing buildings.

Our hybrid Internal Carbon Price can be applied in two ways:

01

A Carbon Fee

Charged to campus users under the "polluter pays" principle; the aim is to foster a culture of innovation, accountability, and environmental stewardship, ultimately contributing to HKUST's overall sustainability performance in both operational and embodied carbon.

02

Shadow Pricing Mechanism

This is applied in decision-making processes for future projects, ensuring capital and purchasing decisions account for the cost of emissions and create the most value for the University over time.

The pooled funds generated from internal carbon pricing ensures that the University has a long-term, predictable, and consistent source of net-zero operational improvement funding through the target date of 2045.

Beyond 2045, the costs recovered will be used to purchase the needed high quality, verified, carbon offsets.

2. **Revenue generated from on-campus renewable energy:**
   Hong Kong's feed-in tariff (FiT) scheme is an initiative designed by the government to promote the adoption of renewable energy. Launched in 2018, the scheme offers financial incentives to organizations to generate electricity from renewable sources and sell to the grid operator. Although the scheme is set to end by 2033, the pooled revenue until then is predictable and consistent.

FiT revenue is channeled into two pooled funds:

01

Sustainable Smart Campus as a Living Lab Fund

Funded by FiT revenue from renewable energy sites connected to the grid in 2024 or before; supports innovative projects that directly address greenhouse gas emissions or generate co-benefits for the campus.

02

Net-Zero Campus Projects & Research Fund

Funded by FiT revenue from renewable energy sites connected to the grid after 2025; supports breakthrough technology pilots on campus for net-zero-aligned solutions and research implementation on campus that directly impacts the University's net-zero goals.

These strategies will be continuously renewed to reflect updates in University growth.

CHAPTER 8

OVERSIGHT AND PROGRESS CHECKS

Strategic Planning and Interim Goals

While the ultimate goal is to achieve a level of net-zero emissions by 2045, it is important to have interim goals and targets to ensure we are on track. The earliest greenhouse gas (GHG) baseline was the year 2014, which became the starting point for the first University-wide sustainability plan (the HKUST 2020 Sustainability Challenge). In 2014, HKUST emitted 61,200 metric tons of GHG. By 2023, HKUST had reduced emissions by 38%. Further reductions are expected because of the continued diligence of the professional campus operations staff, combined with new innovations in the marketplace. However, these gains will be challenged by the continued growth of the campus growth in terms of new buildings and increased population.

To remain in alignment with Hong Kong's decarbonization plan, **HKUST will cut emissions by 50% from our 2014 baseline to roughly 30,000 metric tons by 2035**. These cuts will be accompanied by comparable reductions in water consumption, waste to the landfill, and overall campus sustainability advances as articulated in each seven-year sustainability plan update (currently the HKUST 2028 Sustainability Challenge).

Since 2014, the "Sustainability Challenge" plans (2020, and now 2028) served as close accompaniments to the University's triennial Strategic Plan process. The process of developing the Strategic Plan is well-established, and the end results serve as touchstones for the campus community when designing new programs or evaluating new initiatives. The Strategic Plan serves as a reminder of what is important and how we should prioritize our efforts. It is also an effective snapshot of current conditions and how we might pursue new opportunities in ways that are consistent with our values and unique brand. Over the years, the "Sustainability Challenge" roadmaps have been successful, largely because they reflected the goals and aspirations of the University's Strategic Plan. This Net-Zero Carbon Action Plan is designed to do the same.

Figure 8.1: HKUST Strategic Plan 2021-2028

The current version of the Strategic Plan highlights five strategic objectives. The Net-Zero Carbon Action Plan contributes to each.

A University of Talents

HKUST has been successful in drawing top minds from around the world, and many of those come with a genuine interest in focusing on the grand challenges of the 21st century. The Action Plan demonstrates to potential high calibre students and Faculty that our University is serious about leadership on the most pressing issues of our time (see Chapter 2).

An International Leader in Education and Research

With the focus on utilizing our campus as a Living Lab, the Action Plan complements this strategic objective by fostering a thriving environment for talented staff and faculty to pursue their ambitions (see Chapter 6).

An Exemplar of Best-in-Class Standards, Practices and Operations

The Action Plan is ambitious and sets a striking tone in its embrace of new technologies and incorporating innovation into the campus. The potential for members of the HKUST community to get actively involved in developing solutions is incorporated in many elements of the Action Plan, including the new HKUST Net-Zero Building Standards (see Chapter 3 and Appendix 1).

Incorporating Innovation and Entrepreneurship in our Spirit

The Action Plan embraces the vision of best-in-class campus buildings and grounds and creates the highest standards for new construction and renovations. The improvements to the campus buildings will create more functional and comfortable buildings for users while significantly improving resource efficiency and reducing energy and greenhouse gases (see Chapter 3, Chapter 4, and Chapter 5).

A Champion of Diversity

In pursuing "an open, cohesive, and collaborative environment across all levels," the University provides a nurturing ecosystem for members of the campus community across disciplines and interests to collaborate on climate solutions, while learning new skills that will prepare them for the workforce of the future (see Chapter 6).

Stability and Continuity over Time

While the Strategic Plan serves as a valuable resource for aligning the priorities of the University, the Action Plan also needs to be connected to other governance structures to ensure stability and continuity over time.The University Council—and particularly the Campus Development Committee—will assume the task of ensuring that the campus continues to evolve in ways that combine our academic and research needs with our net-zero ambitions (see Chapter 3 and Chapter 4). Further, because some of the effects of climate change are already beginning to impact our campus, it will be important to evaluate continuously the conditions where we might be vulnerable to sea level rise, extreme heat, and other weather emergencies (see Chapter 5).

These weather emergencies reflect a greater category of risks to the well-being of our campus. The University publishes an Environmental, Social, and Governance (ESG) report every year to be transparent about our data and show that we are taking seriously risks to our long-term resilience. The Finance Committee of the University Council undertook a similar approach when adopting an ESG strategy for investments, recognizing that our financial well-being is also contingent upon investing in companies who take these risks seriously and are transparent about their resiliency strategies (see Chapter 8). The University Council and subcommittees will continue to play an important role in ensuring high-level oversight on progress towards the net-zero targets.

Responsibility and Oversight

This Action Plan is bold in scale and ambitious in envisioning a transformation of the University into a truly sustainable enterprise that can live and thrive within its own footprint. With this in mind, the responsibility for the oversight and stewardship of the Net-Zero Action Plan requires meaningful contributions from across the campus community.

- **The Sustainable Operations Executive Committee** (OpCo, existing, Vice-President for Adminstration and Business Chair) will be responsible for overseeing the progress and performance of campus operations, new buildings, campus renewal, and adaptation and resilience measures. The Committee will also be responsible for ensuring that funding and resources are available and allocated measures needed to meet the interim and long-term goals of the Action Plan. The Committee will continue to provide the overall stewardship of the interim sustainability plans and ensure that all elements of operational sustainability are supported.

- **The Net-Zero Education Committee** (NZEC, proposed, Provost Chair) will be responsible for ensuring that support is garnered for the development of educational resources and hands-on learning opportunities for students and members of the broader community. The NZEC will also oversee the establishment and facilitation of net-zero global research networks to activate campuses around the world as living laboratories for innovation and experiential learning.

- **The Sustainable Smart Campus as a Living Lab** (SSC, existing, Dean of Engineering and Director of Sustainability / Net-Zero Office Co-Chairs) will be responsible for supporting faculty and alumni researchers who implement proof-of-concept decarbonization interventions on the HKUST campus. The Living Lab program will continue to serve as a bridge between the campus research community and campus professional staff members so that the collaborations among those with conceptual vision and those with practical experience continue to thrive.

- **The Sustainability / Net-Zero Office** (SUST, existing) will serve as the steward of the Action Plan and will provide the staffing and resources for all related Committees. The Office will also be responsible for collecting data to measure performance and will report progress in HKUST's annual sustainability reporting.

- **HKUST's Senior Leadership** (senior adminstration) will review updates from each of the Committee Chairs on an annual basis (or more frequently) and will inform University Council on progress and performance towards the Net-Zero target.

These committees will be continuously renewed to reflect updates in University organization.

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