



Pathways towards ANU Below Zero: A review of behavioural change, waste management, and carbon sequestration

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List of Acronyms

ANU	Australian National University
CCU	Carbon capture and utilisation
CO₂	Carbon dioxide
GI	Green Impact
IPCC	Intergovernmental Panel on Climate Change
LSE	London School of Economics and Political Science
NETs	Negative emissions technologies
UCSD	University of California San Diego
UoC	University of Cambridge

Executive summary

Recently, Australia has experienced a bushfire ecological crisis, damaging hailstorms, torrential rains, and is experiencing an ongoing pandemic. It is also facing the reality that the Paris Agreement and Intergovernmental Panel on Climate Change's targets to limit global warming to 2°C and 1.5°C, respectively, will not be met. In response, the Australian National University (ANU) has committed to reducing its greenhouse gas emissions to net negative as soon as possible through the ANU Below Zero Initiative. To facilitate progress towards this initiative, this report aims to investigate carbon emission reduction strategies employed at universities and organisations around the world.

A critical literature review was performed to evaluate (1) behavioural change and waste management, and (2) carbon sequestration strategies in universities such as the University of Cambridge, and organisations of Blue Planet. Notably, these strategies do not represent *all* negative emissions technologies just as the entities evaluated do not cover *every* entity reducing emissions. They were selected due to time constraints and data availability.

This evaluation highlighted 11 principles contributing to universities' success in behavioural change and waste management strategies to reduce carbon emissions which may be beneficial for consideration by ANU Below Zero. They comprised: top-down endorsement; staff, student and community engagement; communication and awareness campaigns; embedding awareness into practice; supporting institutional policies; alignment with other initiatives; appropriate governance and monitoring, and; the use of incentives or prohibitions. Similarly, 4 enabling environments were identified for effective carbon sequestration: long-term commitment, research funding, alignment with circular economy policies, and carbon accounting mechanisms.

Drawing from these insights, onwards it is recommended for ANU to implement behavioural change programs like Green Impact, and reform how ANU accommodations and districts minimise waste. These efforts should be supported by the above principles and environments, the integration of emissions reductions into research, teaching and communications, the development of an accountability mechanism and a carbon database, and an overall long-term commitment. While these recommendations are situated within uncertain contexts, they can contribute to national and global efforts to mitigate climate change.

1.0 Introduction

The Australian National University's (ANU 2020a) recent commitment to become greenhouse gas negative as soon as possible has provoked discussions about how this commitment will be delivered. Previously, ANU has attempted to reduce its emissions through a range of strategies including energy efficiency projects. ANU also has hosted International Alliance of Research Universities internships which combined carbon emissions reductions, student engagement, behavioural change, research, and international cooperation. Additionally, throughout 2007-2008, the ANU Facilities & Services Division maintained an organic recycling facility which diverted over 250 tonnes of waste from landfill and provided nutrient-rich compost for landscape works at Mount Stromlo (Hughes 2008). However, progressively, initiatives have not been sustained due to issues like high capital costs. This lack of momentum and prioritisation for sustainability and carbon emissions reductions has also been seen in the *Environmental Management Plan 2019-2021* (ANU 2019a) and *Acton Campus Energy Management Strategy* (ANU 2019b). The former sets ambitious targets for all ANU campuses, but lacks deadlines and has not been ratified. In mid-2019, the latter was ratified and signed-off, but there is still no plan for implementation. Barriers underlying these issues have been the lack of: 1) explicit mandates, 2) top-down endorsements, and 3) cultural focus on sustainable behavioural change strategies. Unfortunately, these issues are also compounded by the emerging reality that the Paris Agreement and Intergovernmental Panel on Climate Change's (IPCC) aspirational targets to limit global temperature warming to 2°C and 1.5°C, respectively, will not be met.

These past efforts and emerging issues position the ANU Below Zero initiative as a valuable opportunity for ANU to improve upon existing emissions reduction infrastructure and efforts, as well as to contribute to global goals of climate change mitigation. Spearheaded by the Climate Change Institute, the initiative commits itself to net negative carbon emissions as soon as possible, integrating this challenge with teaching and research, and building communities aware of climate change problems and solutions. This situates ANU as one of only two universities in the world aiming for net negative carbon emissions (LUT University 2019). There is a wide-ranging recognition that ANU can and should serve as a national leader in this regard, but the initiative is still developing and finalising its governance infrastructure (ANU 2020a).

To contribute to this development, the ANU Below Zero initiative should be considered in wider international contexts to derive lessons at the university-level. There has been significant literature on the role that universities can play in the transformation of sustainable societies (Ramos et al. 2015; Wade & Griffiths 2020), including the increase of ‘greening’ campuses (Brinkhurst et al. 2011). However, less critical attention has been dedicated to the behavioural and cultural shifts needed to embed carbon emissions reductions into university decision-making (Adlong 2013; Lozano et al. 2015). Thus, this report investigates emission reduction initiatives across university campuses and organisations worldwide which are informed and sustained by behavioural change strategies across various areas of interest. Section two proceeds by examining the value of behavioural change strategies and programs, like Green Impact, through major case studies of waste management at the London School of Economics and Political Science (LSE), University of Cambridge (UoC), and University of California San Diego (UCSD). Section three caveats this analysis with the recognition that carbon sequestration strategies are likely to be key approaches of ANU in the long-term. It provides examples from Colgate University and the construction industry. Section four distils the lessons learnt from these case studies and makes recommendations to progress ANU towards net negative emissions. Overall, this report is situated within both uncertain and opportunistic contexts of the COVID-19 pandemic and climate change, and aims to inform the future direction of ANU action on climate change through this uncertainty.

1. 1 Objectives

This report is completed as part of an Innovation and Professional Practice internship with the Climate Change Institute focused on the ANU Below Zero initiative. The primary objective is to research a range of pathways to facilitate progress towards ANU Below Zero commitments rapidly and efficiently. Complementing objectives include:

- Investigate emission reduction initiatives at universities and organisations worldwide focused on *negative* emissions activity, if available;
- Explore initiatives that could be relevant and applicable to the scale, role and interests of ANU;
- Consider initiatives across areas of interest of carbon sequestration, waste, and procurement;
- Address the less-researched Scope 3 emissions.

This research will serve as an input for ANU Below Zero. This report establishes a scope of behavioural change strategies, waste management and negative emissions technologies (NETs) within carbon sequestration. Waste management strategies that address Scope 3 emissions are scalable and directly engage staff and students. Carbon sequestration involves emerging strategies like CCU and, as aforesaid, is a key long-term approach of ANU. Notably, renewable electricity and energy efficiency are excluded from this analysis as they have been evaluated previously.

1.2 Methodology

This report performs a critical literature review on emission reduction initiatives employed by universities and organisations guided by stakeholder consultation with the ANU Facilities & Services Division. This methodology synthesises knowledge and enables informed policy-relevant outputs. Case studies are mainly drawn from universities to ensure strategies are directly applicable to ANU and its physical, social and cultural infrastructure. Though, while the universities researched have been from Western and developed countries, this was not a determinant of case selection.

Multiple strategies across waste management and carbon sequestration are analysed as scenario modelling has shown that multiple NETs and innovations must be deployed to meet global targets (Minx et al. 2018). There are also ongoing debates on the feasibility of different emission reduction activities and NETs (Fuss et al. 2014; Rau et al. 2018), and their ethics (Morrow & Svoboda 2016). The selection of such strategies reflected data availability and their applicability, feasibility and relevance to ANU. Similarly, while I considered roughly 12 universities and organisations for this analysis, they were reduced for the same reasons.

2.0 Waste management & Behavioural Strategies

Universities are major producers of recyclable, plastic, furniture, office, and food waste. While climate change impact varies between the waste types, a significant by-product of waste is greenhouse gas emissions. To demonstrate, in 2019, it was estimated that waste from the ANU Acton campus sent to landfill produced 1,236 tonnes of CO₂ equivalent. More

generally, food production and waste produce up to 30% of global greenhouse gas emissions annually (Poore & Nemecek 2018). To combat these emissions and contribute to wider climate change mitigation, behavioural change strategies have been largely neglected as policymakers and researchers consider them value-laden, and difficult to quantify and model (Creutzig et al. 2016).

Fortunately, around the world, the Green Impact (GI) behavioural change and engagement program has been employed since 2006 at local scales and completed over 25,000 greening actions (Slaney 2016). The bottom-up environmental accreditation scheme brings individuals, staff, and students together to enact grass-roots initiatives and activism to change daily behaviours on the demand-side and minimise carbon footprints. Through behavioural interventions of friendly competition and awards, GI has enabled budget cuts, employability skills among students, relationships with local communities, and fostered university cultures focused on sustainability and climate change mitigation (ACTS 2020). Notably, while GI has been implemented in Australia since 2016, ANU is not one of the 14 Australian universities undertaking the program. Thus, this section stresses the significance of behavioural change programs in meeting targets of carbon emissions reductions.

To do so, it identifies 11 common principles which have contributed to the success of waste management programs and goals of LSE, UoC, and UCSD under the framework of behavioural change strategies (Table 1).

Pathways towards ANU Below Zero

Table 1. Some principles for successful carbon emission reduction strategies through behavioural change programs and waste management

<i>Principle & enabling environment</i>	<i>London School of Economics and Political Science</i>	<i>University of Cambridge</i>	<i>University of California San Diego</i>
<i>Top-down endorsement</i>	✓	✓	✓
<i>Staff engagement</i>	✓	✓	✓
<i>Student engagement</i>	✓	✓	✓
<i>Community/ Public engagement</i>	✓	✗	✗
<i>Communication & awareness campaigns</i>	✓	✓	✓
<i>Embedding awareness into practice</i>	✓	✓	✓
<i>Supporting university/ institutional policies</i>	✓	✓	✓
<i>Alignment with other initiatives</i>	✓	✓	✓
<i>Appropriate governance and monitoring mechanisms</i>	✓	✓	✗
<i>Use of rewards & incentivisation</i>	✓	✓	✗
<i>Use of prohibitions & regulations</i>	✓	✓	✓

2.1 Principle 1: Top-down endorsement

Successes in waste reduction, carbon neutrality strategies, and zero waste goals, have been enabled by top-down endorsement by university Directors and Chancellors in each case study. Notably, LSE and UoC engaged in behavioural change and incentivisation programs which received top-down endorsement. LSE (2020a) recently completed their 2019/2020 financial year GI campaign called [‘#SustainableLSE Consultation’](#) aimed at consolidating their governance model with a new Sustainability Group. The campaign launched monthly consultations with students, staff and stakeholders to develop a strategic plan for sustainability at LSE over the next 10 years, and to identify targets and reporting mechanisms to monitor progress in carbon emissions reductions (LSE 2020a). This program followed the previously successful [‘Plastic Free LSE’](#) (LSE 2020b) campaign which prompted ongoing practices of preventing the disposal of 108,589 disposable cups through a 10 pence levy (LSE 2020c). Both programs were endorsed and launched by LSE Director Minouche Shafik (LSE 2019b; LSE 2020c).

UoC (2019a) have engaged with GI and specifically the #NoBeef behavioural change program to remove ruminant meat and implement their [Sustainable Food Policy](#) since 2016. A 2019 review revealed that the overall carbon footprint of food at UoC decreased by 500 tonnes of CO₂ equivalent each year (UoC 2019b). In 2015, Vice-Chancellor Professor Sir-Leszek Borysiewicz endorsed UoC’s (2015) [Environmental sustainability vision, policy and strategy](#) which referenced the [Sustainable Food Policy](#). Notably, Borysiewicz was succeeded by Professor Stephen Toope (2019) who has voiced his policy support in [Vice-Chancellor blogs](#).

Behavioural strategies have not been explicitly mentioned in the efforts by UCSD to move towards zero waste, but implicit behavioural nudges could be assumed by UCSD’s [‘#MYLASTTRASH’ campaign](#) which encourages staff and students to reduce their waste (University of California n.d.). The overall zero waste effort has been endorsed by the UC Office of the President (UCSD 2019).

Top-down endorsement is key to legitimate programs, behavioural or otherwise. It ensures that carbon emission reduction activities are perceived as important by universities’ and organisations’ Divisions or Departments, and thus legitimates any financial, social, or human

capital investments dedicated to them. Hence, an endorsement is necessary to overcome barriers to implementing behavioural change, such as ‘profit mentalities’ (Scarborough & Cantarello 2018).

2.2 Principle 2: Staff engagement

Staff engagement at LSE and UoC has been participatory, empowering, and enabled successful carbon emissions and waste reductions. At UCSD (2020a), staff are encouraged to donate and buy from a second-hand shopping platform of ‘Surplus Sales’, and the Staff Sustainability Network developed guidelines for hosting a zero waste event in 2019. This is arguably not as empowering and seems to reflect top-down suggestions and implementation. Fortunately, in 2018, UCSD formed a Zero Waste Working group comprising students and staff to tackle issues impacting their zero waste goals, like lacking regional infrastructure, which then informed the newest UCSD (2019) *Zero waste plan*. However, unfortunately, there are concerns of whether this staff engagement will continue or improve, particularly since there have been cuts to funding, resources and staff dedicated to sustainability and carbon emissions reductions (Light & Stroth 2019).

At LSE and UoC, the toolkits and ‘change packs’ within their behavioural change programs have provided structured pathways to reducing carbon footprints –particularly for institutions unsure about where to begin– supported by relevant expertise and complemented with capacity building of staff and students. Many GI programs and campaigns are bottom-up in nature. In the *Plastic Free LSE* program, staff all across LSE were empowered to undertake their own waste reduction initiatives. For example, the Human Resources, Equity, Diversity and Inclusion, and Finance Division formed the GI Platinum-award-winning ‘*Plastic Fishing*’ team: they banned plastic bottles in the office, fished for plastic waste in nearby rivers, and built awareness in the building (LSE 2019a). At UoC (2019c), chefs in cafes and dining halls adopting the *Sustainable Food Policy* are trained in vegetarian and vegan cooking, and are empowered to source local products, sustainably-sourced fish, and communicate the commitment to sustainability to customers, other staff and suppliers. In these cases, staff empowerment has fostered the integration of carbon emission reduction activities into office practices, community engagement, dining habits, and university policies.

2.3 Principle 3: Student engagement

Participatory and empowering student engagement has contributed to success in carbon emission reduction initiatives, and overall university cohesion at LSE, UoC and UCSD. Such student engagement arguably complements the institutional top-down endorsement above: both are necessary for sustainable behavioural change. Students have been actively consulted and empowered to shape the future of sustainability and carbon emission reduction initiatives at LSE through [#SustainableLSE Consultation](#). Within GI, generally, students are afforded the opportunity to be auditors of projects at the university, thereby building their capacity and employability skills.

Similarly, at UoC students can get engaged and participate in GI and #Nobeef through Departmental teams, or individually. However, regarding the *Sustainable Food Policy*, students are predominantly impacted by University Catering Services changes like the removal of ruminant meat and thus are not required to make behavioural changes. Notably, the policy stipulates that students will be involved in ongoing monitoring, but when the policy was reviewed in *Our Sustainable Food Journey* (UoC 2019b) there was no explicit mention of the results of student monitoring. Positively, the policy review did state that moving forward they will continue to “seek and support the research of academics and students with regards to sustainable food, and implement their suggestions to improve our sustainable food offering” (UoC 2019b, p. 8).

As aforementioned, there is a cross-university Zero Waste Working Group empowering students and staff to address challenges and shape the zero waste efforts at UCSD. There are also student-organised initiatives in community gardens, and the Food Recovery Network to recover edible food from housing, dining and hospitality restaurants (UCSD 2020a). However, the *Zero waste Plan* (UCSD 2019) notes that student outreach requires improvement, particularly as UCSD struggles to meet its zero waste goals with an expanding student population and competition for space.

2.4 Principle 4: Community/ public engagement

Community engagement is contributing to carbon management and sustainability at LSE but has not been explicitly mentioned in behavioural, carbon management, climate change, nor sustainability strategies at UoC and UCSD. At LSE, communities, other than the campus

community, and stakeholders have been directly consulted within [#SustainableLSE Consultation](#) to shape LSE’s strategic plans for sustainability for 2030. Notably, LSE (2019b) considers ongoing dialogue with communities as a key requirement for reducing carbon emissions, and aims to consider how to better engage with external partners and participate in global networks.

2.5 Principle 5: Communication & awareness campaigns

Communication and awareness campaigns have been integral to the success and sustainability of behavioural change at LSE and UoC, and are also present at UCSD. The [Plastic Free LSE](#) Campaign was upheld by a communication campaign to spark conversations on the nuance of plastic, its role in today’s society and that it should be sourced and disposed of responsibly (LSE 2020b). Communication varied across different teams participating in the GI program, for example, the [Plastic Fishing](#) team utilised art installations in the building and a social media strategy (Figure 1). These communication strategies have extended beyond the 2018/2019 financial year GI program into ongoing education and communication of plastic pollution at LSE.



Figure 1. Communication campaign examples by the Human Resources, Equity, Diversity and Inclusion, and Finance Division’s ‘Plastic Fishing’ team

Source: LSE 2019a

Throughout the implementation of their *Sustainable Food Policy*, UoC and University Catering Services aimed to communicate the commitment to sustainable food to customers, staff and suppliers. However, there is recognition that communicating with customers about the environmental benefits of dietary change through posters and menu symbols should be improved (UoC 2019b).

UCSD's zero waste efforts have been supported by a [#MYLASTTRASH campaign](#) prompting staff and students to ask 'Could my next piece of trash be #MyLastTrash?' (University of California n.d). This is complemented with a strong social media presence demonstrated in [interviews](#) with zero waste influencers like Lauren Singer on the YouTube collaboration of Vox and the University of California called 'Climate Lab' (Vox 2017).

2.6 Principle 6: Embedding awareness into practice

'Embedding' here refers to the physical infrastructure or preconditions that support practically implementing behavioural change. The embedding of awareness into practice has contributed to successful carbon emissions reductions through behavioural change strategies in UoC and LSE, and outside of behavioural change strategies in UCSD.

UoC removed ruminant meat from menus in dining halls, provided compost bins and water refill stations across all University Catering Services outlets, and architecturally positioned plant-based food options first or at eye-level on menus to improve their sales (UoC 2019b; UoC 2019c). Similarly, UCSD (2020b) is installing a small anaerobic digester, and their Facilities Management group changed office bins in state-funded buildings to '[Bin Buddies](#)' which are unlined and have distinguishable compartments so employees see how much recyclable and non-recyclable waste they produce.

LSE (2020c) developed a [Furniture ReUse program](#) to encourage the reuse of furniture and office waste. This program is mirrored in [initiatives at Microsoft's Redmond Campus](#) (Wagner 2016) and the University of Tasmania's (nd.) [re-use program](#) which has catalogued and claimed reusable furniture, and prevented 48 tonnes of CO₂ equivalent from 2016-2018.

2.7 Principle 7: Supporting university/ institutional policies

Complementing the above principle, this principle refers to the institutional infrastructure enabling behavioural change. As alluded to, institutional policies have provided guidelines for action and monitoring related to waste reduction at UCSD, as well as behavioural change strategies at LSE and UoC. Demonstrably, LSE's [Plastic Free LSE](#), [#SustainableLSE Consultation](#), and future GI campaigns are supported by the *LSE Sustainability policy* (LSE 2018), *LSE Sustainability travel plan* (LSE 2016), and now the *Waste action plan 2020/21* (Beleva 2020). Additionally, across all University of California (2020) campuses, waste reduction strategies are now informed by the *UC Sustainable procurement guidelines*.

2.8 Principle 8: Alignment with other related initiatives

The success of GI and behavioural change generally at LSE and UoC are arguably attributable to their alignment with other waste reduction initiatives. The GI program serves as an ideal opportunity to bring together multiple environmental initiatives, streamlining their collective impact (ACTS 2020). In the 2018/2019 financial year, 49% of LSE waste was recycled or composted totalling 789 tonnes, and 9.6 tonnes of unwanted items from departing hall students –equivalent to 97 tonnes of CO₂–were donated to the British Heart Foundation through the annual [ReLove program](#) (LSE 2020c).

UoC's (2019b) *Sustainable Food Policy* also comprises a range of carbon emission reduction strategies of utilising Vegware compostable packaging and removing single-use plastics which altogether has prevented over 2.5million single-use plastics from going to landfill, thus reducing carbon emissions. Similarly, though UCSD (2020a) lacks a behavioural change program, they have displayed many emission reduction strategies by reducing single-use plastic waste with plastic bag and straw bans, and composting food in community gardens.

While invaluable, the year-long GI programs themselves are not enough to implement, monitor, and sustain long-term behavioural change regarding carbon emissions reductions. Rather, they must be complemented and overlaid with various initiatives to cultivate a cultural focus on sustainability and climate change mitigation. Thus, these alignments can be considered as synergies between waste management initiatives producing varied outcomes of waste reduction as well as emissions reductions, awareness-raising, campus community development and cohesion, and sustainability.

2.9 Principle 9: Appropriate governance and monitoring mechanism

Governance and monitoring systems have been vital to ensuring successful, impactful behavioural change in LSE and UoC. All GI programs in both universities entail student monitors and auditors which verify teams' results and identify instances of creativity and innovation. These audits are critical to measuring the effectiveness of GI projects and fostering competition (Slaney 2016). Moreover, LSE's most recent [#SustainableLSE Consultation](#), and its aim to restructure LSE governance (Figure 2) and identify reporting and monitoring mechanisms for reducing emissions with stakeholders demonstrates the school's commitment to improved governance, accountability, and monitoring. Such improved monitoring will arguably focus on targets such as decreasing the overall amount of waste from 1,668 tonnes to 1,3000 tonnes in their [Waste action plan 2020/21](#) (Beleva 2020).

Alongside the GI programs, governance and monitoring for UoC's (2019a) [Sustainable food policy](#) are still under development. Evidence of reviewing, monitoring, and accountability are shown in [Our sustainable food journey](#) (UoC 2019b). Onwards, the policy stipulates that ongoing monitoring will be held by the Environment & Energy Section with support from the University Catering Services, academics, students and external partners, and important next steps are dedicated to monitoring the impact of the policy *annually* (UoC 2019a; UoC 2019b). The monitoring, for example, will focus on targets to reduce carbon emissions from food yearly with indicators of carbon emissions per kilo of food procured, per £ revenue, and per transaction (UoC 2019a). At both universities, commitments to improved accountability and monitoring have enabled the significant emissions reductions mentioned previously.

UCSD has only diverted 38% of waste to recycling and compost, compared to the objective of 90%, which indicates a lack of aggression of their monitoring (Light & Stroth 2019). They lack accountability mechanisms to uphold their zero waste or any other sustainability goals (Light & Stroth 2019). However, the newest version of the [Zero waste plan](#) (UCSD 2019) states that weekly and monthly progress towards the plan's recommendations will be monitored by the newly-formed Zero Waste Working Group. Perhaps this highlights the potential for improved accountability and monitoring moving forward.

SUSTAINABILITY DECISION-MAKING IN 2018/19

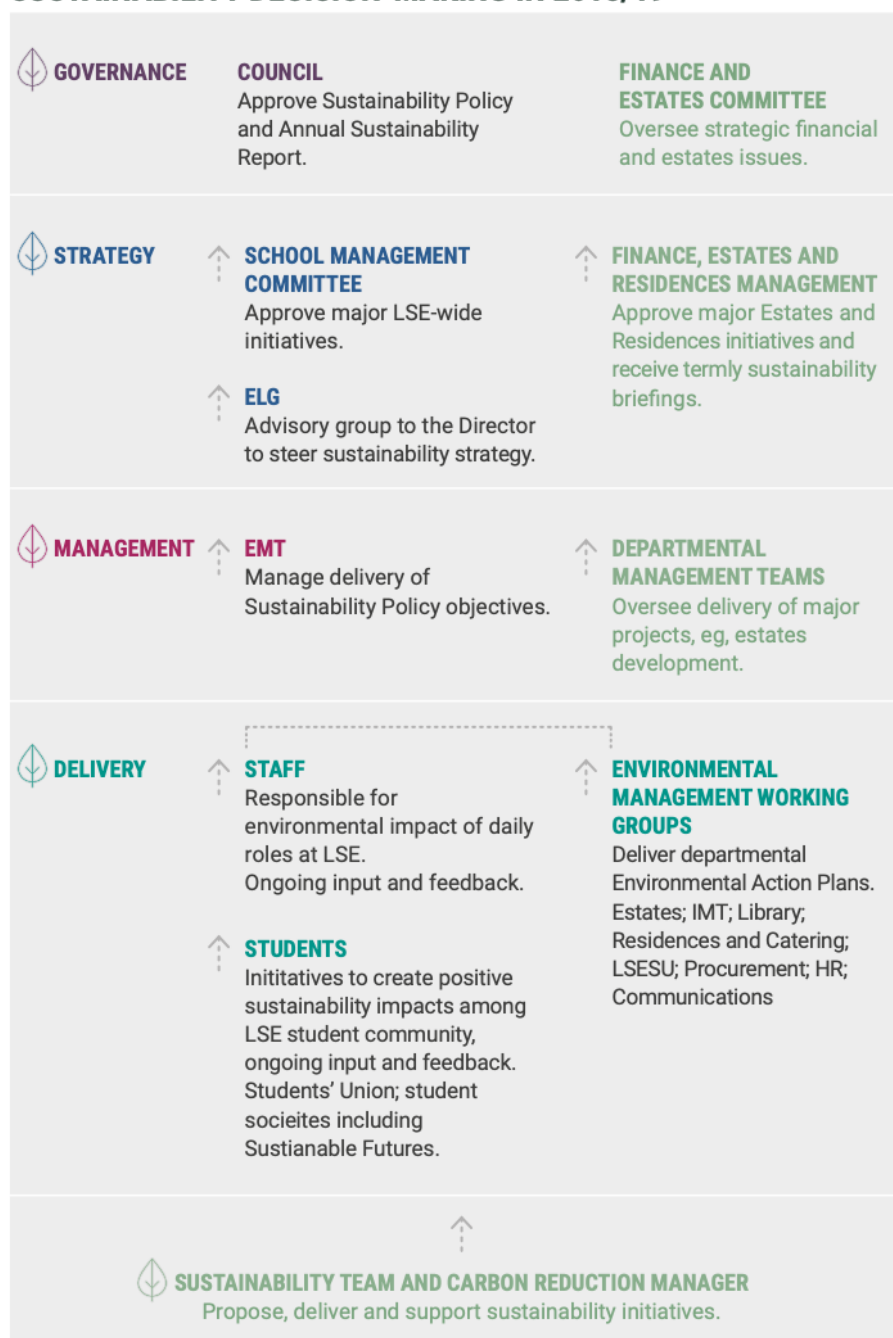


Figure 2. LSE’s renewed sustainability **governance and decision-making model**

Source: LSE 2020d

2.10 Principle 10: Use of rewards & incentivisation

The use of rewards and incentives drove the successful behavioural change programs at LSE and UoC. External of a specific behavioural change program, UCSD (2019) have suggested the implementation of incentive programs like a discount for customers bringing reusable bags in their *Zero waste Plan*.

The GI programs in both LSE and UoC comprised an online toolkit of actions to support carbon emission reduction initiatives, followed by a year-end award ceremony wherein teams can receive Bronze, Silver, Gold, Excellence and Platinum awards. For example, as aforementioned, the ‘[Plastic Fishing](#)’ team at LSE was awarded a Platinum award as the highest-scoring project by GI auditor criteria. This behavioural intervention of competition and rewards enables positive enforcement, teamwork, and, importantly, institutes a sense of time pressure. This pressure could address the gradual decline in interest and commitment to environmental issues as visualised in Downs’ (1972) ‘issue attention cycle’ (Figure 3).

Notably, incentivisation also occurs at LSE and UoC in initiatives related to their GI programs. For example, LSE and UoC provide discounts when customers use reusable cups of 25 and 20 pence, respectively.

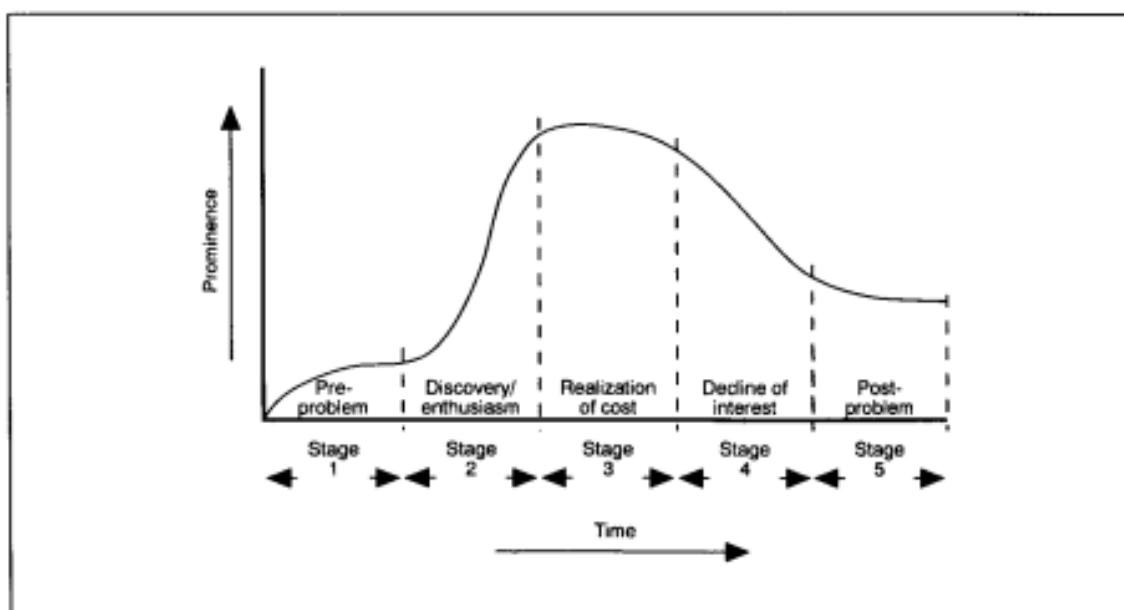


Figure 3. The issue attention cycle

Source: Downs (1972)

2.11 Principle 11: Use of prohibitions & regulations

Behavioural interventions of prohibitions and regulations have been utilised effectively, or are planned, in LSE, UoC and UCSD. LSE has regulated the purchase of disposable coffee cups through a 10 pence levy, which interestingly is paired with the above discounts for purchasing and using reusable cups.

At UoC, ruminant meat has been removed from most University Catering Services menus, ruminant meat is no longer provided daily in the Main Dining Hall, and single-use plastics for tap water have been removed. Significantly, all catering companies included on UoC's (2019c) preferred supplier list are must meet the minimum requirements of the *Sustainable food policy*: they must align with product specifications of seasonality, local sourcing, vegetarian and vegan, and sustainability. Additionally, all Catering Managers Committee Contracts now include the sustainability criteria.

As part of their *Zero waste plan*, UCSD (2019) aims to phase out the sale, procurement and distribution of expanded polystyrene, like plates, cups, and clamshells.

To summarise, this section has highlighted the value of reducing emissions via waste management through behavioural programs of GI which readily encompass or are supported by all 11 of these principles. Potentially, at ANU these principles could be enacted through future partnerships with sustainable suppliers, such as the Food Co-op Shop & Cafe who provide local, unpackaged food. Overall, in identifying instances where universities have or have not optimally addressed these principles, this report has illuminated pressure points, pitfalls, and opportunities to guide behavioural change and emissions reductions through waste management at ANU.

3.0 Carbon sequestration

Meaningful action to reduce carbon emissions and meet the targets set by the Paris Agreement and IPCC requires multiple emission reduction strategies. Thus, to complement the above waste management and behavioural strategies, this section discusses the significance of carbon sequestration, or negative emissions, strategies. Given the youthful nature of these strategies, this discussion frames carbon sequestration as a set of innovations and policy developments with technological, financial and political potential.

Carbon sequestration refers to a broad set of technologies that capture waste CO₂ and deposit or store them to prevent their release into the atmosphere. Carbon Capture & Utilisation (CCU) is a sub-category of carbon sequestration and encompasses “all established and innovative industrial processes aiming at capturing CO₂ and transforming it into a variety of

value-added products” such as chemical building blocks or synthetic materials (CO₂ Value Europe 2020a, para. 1). In other literature, CCU may be called CO₂ transformation, conversion, recycling or upcycling. Various sequestration strategies have been demonstrated in [sequestration in Colgate University forests](#) (2018), [carbon offsets through tree planting at Duke University](#) (Adair et al. 2019), in trees in universities in New Zealand (De Villiers et al. 2014), and [Blue Planet’s](#) (2015) carbon transformation into synthetic limestone coating and production of concrete aggregates.

Ultimately, in the long-term, CCU will serve as a key approach to reduce carbon emissions at ANU, supplementing a suite of other carbon emission reduction instruments. There is already research in progress into [magnesium-based concrete](#) which traps CO₂ within the crystalline structure (ANU 2020b). However, in further efforts to progress towards effective carbon sequestration at ANU, there are several considerations for ANU decision-makers to attend to. Along with highlighting the potential of carbon sequestration through tree planting, offsets, and concrete development, this section asserts 4 enabling environments that may foster effective and sustainable carbon sequestration.

3.1 Enabling environment 1: Long-term commitment

Carbon emissions reductions via sequestration is not a rapid solution: it is a long-term process comprising ongoing scientific discoveries and innovations, governance building, capacity building, raising public awareness, gaining social licence, and, more practically, the development of carbon accounting mechanisms. Moreover, the results may not be evident until a few years into its implementation and accounting. Therefore, it is incredibly important that universities and organisations commit long-term investments of financial, social, and cultural capital to carbon sequestration efforts.

Such long-term commitment has been integral to the successes of sequestering 193,755 tonnes of CO₂ equivalent in the 1,059 acres of forest at Colgate University. Colgate University (n.d.) became the first higher education institution in New York to achieve carbon neutrality after a *10-year-long* effort to reduce greenhouse gas emissions and weave sustainability into education curriculums. Throughout there have been developments of a Sustainability Council of students, faculty and staff, and an inventory of greenhouse gas emissions from 2019 (Colgate University n.d). Also, Colgate University’s (2018) *Forest*

carbon inventory & projections served as the first periodic re-measurement of carbon sequestration since the *Sustainability climate action plan* (Colgate University 2011) stipulated the need to establish a baseline for forest carbon accounting and projections. This baseline was eventually established in 2013.

More specifically regarding CCU, the organisation of *CO₂ Value Europe* (2020b) also emphasises the vitality of long-term commitments through their vision to develop a future wherein CCU is an integral part of a low carbon economy and society by raising awareness, gaining acceptance, and working with European national policymakers.

Carbon sequestration and CCU still require further research and public awareness and have only recently received Federal government endorsement as priority low emissions technologies in the *Technology investment roadmap discussion paper* (DISER 2020; CO2RC 2020). ANU must be committed to enduring and opportunistically seizing ongoing developments in carbon sequestration.

3.2 Enabling environment 2: Research funding

The long-term commitment by universities must also be complemented with ongoing research funding to foster carbon sequestration innovations. Dr Anna Herring, a researcher at ANU Research School of Physics, is undertaking research into CCU regarding concrete formed with magnesium instead of calcium. The processing of conventional concrete involves releasing CO₂. *Magnesium-based concrete*, however, has the capacity to ‘re-trap’ CO₂ within the crystalline structure of magnesium-based minerals and only needs to be heated to 800°C compared to the conventional 1500°C (ANU 2020b). This trapping of CO₂ and reduced temperature could cut over 70% of the emissions from concrete (ANU 2020b).

Also, Dr Zongyou Yin of ANU has been researching the development of carbon neutral or carbon-storing compounds. However, funding is necessary to support his postdoctoral researchers in these fields. Funding is integral to ensure this, and other research continues to develop and position the ANU as a national leader in carbon emissions reductions.

3.3 Enabling environment 3: Alignment with circular economy policies

Circular economy refers to an economic system that supports the elimination of waste and the reuse of resources. Related policies and practices have informed the success of [Blue Planet](#). The organisation uses CO₂ to replace limestone rock –the main component of conventional concrete– through a process shown in Figure 4. The resulting carbonated solutions form a synthetic limestone coating around a nucleus which serves as a carbon-sequestering coating that is 44% by mass CO₂ (Blue Planet 2015). This then produces CO₂ sequestered aggregates through carbon mineralisation, which is notably one of the most effective ways to achieve carbon neutral or negative concrete, and they also upcycle aggregate (Blue Planet 2015). Overall, this process is incredibly impactful and globally sustainable as it does not require new physical or product delivery infrastructure as they already exist in countries producing concrete, asphalt, and road bases (Blue Planet 2015). Such upcycling and utilisation of existing infrastructure serves to highlight Blue Planet’s circular economy practices but also highlights the significant opportunities for reducing carbon emissions through the choices made in construction. ANU should aim to align with circular economy policies within future carbon emission reduction initiatives to inform mandates, governance structures, and product delivery. Potentially, ANU should also aim to support organisations, particularly in construction, that already do so.

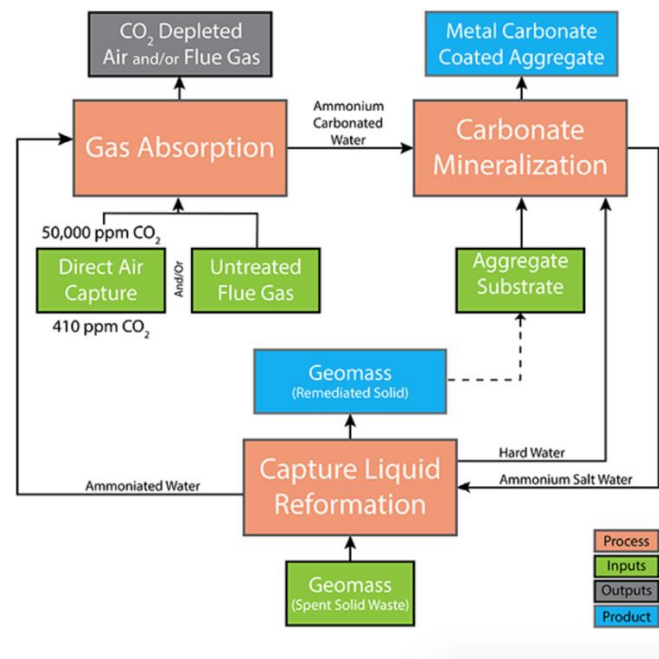


Figure 4. Blue Planet’s process flow

Source: Blue Planet (2015)

3.4 Enabling environment 4: Building a carbon accounting mechanism, inventory and database

One of the greatest hindrances to effective carbon emissions reductions is the lack of baselines which support measuring, monitoring, accountability, and reporting. Without a baseline, accounting mechanism, or inventory, carbon emission reduction initiatives are largely wasted and may not be sufficient. As alluded to above, baselines and carbon accounting have been integral to Colgate University (2018) measuring and presenting their success in the *Forest carbon inventory & projections*. Duke University asserts that one of the [best practices for additionality](#) –the measurement of whether something has an effect– in tree planting and offsets is to first develop a 5-year inventory of all campus trees and establish strict tree replacement policies (Adair et al. 2019). Colgate University follows this through their inventory of on-campus trees and calculations of rates of sequestration and emissions when trees are removed (Adair et al. 2019).

Such inventories and databases are necessary to document the trees planted, carbon sequestered, CO₂ emissions generally, waste management, and energy use. They form a basis for universities or organisations to disclose carbon-related information and support informed decision-making.

To surmise, this section has emphasised the potential of carbon sequestration to significantly mitigate carbon emissions, and the conditions enabling these strategies. Onwards, this broad list of enabling environments offers an adaptable guide for ANU to undertake carbon sequestration amongst uncertainty and ongoing scientific, political and social developments.

4.0 Conclusions & Recommendations

The ANU Below Zero initiative has committed itself to achieving net negative carbon emissions and subsequently positioned ANU as a national leader in carbon emissions reductions. To assist in meeting this goal, this report performed a critical literature review to investigate emission reduction initiatives employed at universities and organisations around the globe and identify pathways for progress towards ANU Below Zero. Behavioural change

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and waste management, as well as carbon sequestration in the long-term, are initiatives that can significantly contribute to such progress.

Upon evaluating the behavioural change and waste management strategies in universities such as LSE, UoC and UCSD, this report identified 11 common principles enabling the success of such strategies. They included: top-down endorsement; staff, student and community engagement; communication and awareness campaigns; embedding awareness into practice; supporting institutional policies; alignment with other initiatives; appropriate governance and monitoring, and; the use of incentives or regulations. The principles were implemented to varying extents of success in each university and should serve as a road map of guiding principles, potential pitfalls and opportunities for ANU Below Zero.

Emerging carbon sequestration strategies were also evaluated across universities and organisations such as Colgate University and Blue Planet. Rather than principles, however, 4 enabling environments and conditions were identified as necessary for ANU decision-makers to consider. They ranged from long-term commitment, research funding, alignment with circular economy policies, to carbon accounting mechanisms.

It is pertinent that ANU addresses these principles and enabling environments in their carbon emission reduction activities. Additionally, several recommendations to progress towards ANU Below Zero have been derived from and informed by them. The recommendations are associated with these principles and environments in Table 2 and expanded in Table 3.

Table 2. Recommendations informed by principles and enabling environments

<i>Recommendation</i>	<i>Informing principle and/or enabling environment</i>
1. Endorse and implement behavioural change programs like GI	<ul style="list-style-type: none"> • <i>Principles:</i> Top-down endorsement; staff, student and community engagement; communication campaigns; embedding awareness; supporting institutional policies; alignment with other initiatives; appropriate monitoring mechanisms; use of rewards and incentivisation.
2. Reform how ANU accommodations, districts, shops and restaurants minimise waste	<ul style="list-style-type: none"> • <i>Principles:</i> Staff, student and public engagement; embedding awareness into practice; use of prohibitions and regulations. • <i>Enabling environment:</i> Alignment with circular economy policies.
3. Integrate carbon emissions reductions into research, teaching, and communication campaigns	<ul style="list-style-type: none"> • <i>Principles:</i> Staff and student engagement; communication campaigns; embedding awareness into practice. • <i>Enabling environment:</i> Long-term commitment; research funding.
4. Develop an accountability mechanism with public and stakeholder engagement	<ul style="list-style-type: none"> • <i>Principles:</i> Staff, student, and community engagement; appropriate governance and monitoring mechanisms.
5. Develop a carbon accounting inventory and database	<ul style="list-style-type: none"> • <i>Principles:</i> Communication campaigns; appropriate governance and monitoring mechanisms. • <i>Enabling environment:</i> A carbon accounting mechanism, inventory and database.
6. Maintain long-term commitments	<ul style="list-style-type: none"> • <i>Principles:</i> Staff, student, and community engagement. • <i>Enabling environment:</i> Long-term commitment.

Table 3. Detailed recommendations to progress towards ANU Below Zero

<i>Recommendation</i>	<i>Priority actions</i>	<i>Potential benefits</i>
1. <i>Endorse and implement behavioural change programs like GI</i>	<ul style="list-style-type: none"> • Get in contact with GI and the Australasian Campuses Towards Sustainability. • Gain and advertise endorsement from the Chancellor and Vice-Chancellor. • Choose a theme for the program for that year, for example, food waste reduction. • Implement a communication campaign advertising the program theme potentially utilising existing ‘On Campus’ or college-wide email chains like the Crawford School of Public Policy’s ‘CAP’. • Support student and staff teams with expertise to complete the online toolkit, projects, auditing and awards ceremony. 	<ul style="list-style-type: none"> • The program provides a framework for climate change mitigation for organisations unsure of where to begin. • The skeletal framework ensures sustainable measures despite staff and student turnover. • Knowledge transfer from 10 years of GI across more than 350 organisations, professional advice, training, and peer learning. • Student auditing has empowered students and developed their employability skills. • Past projects have contributed to budget cuts and savings, for example, chemistry laboratories at the University College London examined their inventory management and developed a cataloguing tool which saved roughly £90,000 (Slaney 2016). • Reduced carbon emissions depending on the projects. • Building linkages across the campus and community.
2. <i>Reform how ANU accommodations, districts, shops and</i>	<ul style="list-style-type: none"> • Build new partnerships with sustainable suppliers, shops and restaurants such as the Food Co-op Shop & Cafe 	<ul style="list-style-type: none"> • Levies discourage the usage of disposable cups and materials and serve as a behavioural intervention.

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<p><i>restaurants minimise waste</i></p>	<ul style="list-style-type: none"> • Implement ANU-wide discounts for reusable cups, and/or levies for disposable cups. • Ban the usage of plastic bags and straws. • Further advertise the ‘Tips to host a waste-free event at ANU’ (ANU 2018) and the consumption of vegetarian, seasonal, local, sustainably sourced food. • Monitor these reforms with the accountability mechanisms mentioned below. • In the long-term, provide recycling and compost bins, and anaerobic digesters. This enables banning the usage of disposable takeaway containers or cups, and replacing them with biodegradable or compostable materials, such as those from Biopak or Vegware. 	<ul style="list-style-type: none"> • If monitored and made accountable, bans could reduce plastic waste at ANU • Vegetarian, seasonal, local, and sustainably sourced food reduces the carbon emissions tied to food delivery, preservation, and packaging as demonstrated with UoC reducing their carbon footprint by 500 tonnes of CO₂ equivalent each year (UoC 2019b).
<p>3. <i>Integrate carbon emissions reductions into research, teaching, and communication campaigns</i></p>	<ul style="list-style-type: none"> • Create a space for ANU Below Zero and carbon emission reduction strategies at ANU Open Days and Orientation Week. • Communicate emission reduction strategies to incoming students, staff, and external partners within e-mail or physical ‘Welcome packs’. 	<ul style="list-style-type: none"> • Through Open Days, Orientation Weeks or welcome packs, ANU publicises carbon emission reduction as a priority and key commitment. • Students, future leaders and changemakers, will be engaged and knowledgeable of the significance of carbon emission reduction.

	<ul style="list-style-type: none"> • Support research into carbon emission reduction innovations financially, as well as socially through news stories and including achievements in ‘Welcome packs’. • Invite students in communication, science, and other relevant backgrounds to write news stories on emissions reductions research at ANU. 	<ul style="list-style-type: none"> • Increased financial support for research enables further innovations which can elevate ANU as a national leader and centre for innovation in the field.
<p>4. <i>Develop an accountability mechanism with public and stakeholder engagement</i></p>	<ul style="list-style-type: none"> • Formulate an ANU staff, student, and public stakeholder working group to identify targets for carbon emissions reductions, monitoring and reporting mechanisms, potentially enabled by Zoom technology. • Alternatively, send out online surveys throughout the ANU campus and wider community to gain insights. • Train and invite students in science, environmental management, and climate change degrees to intern as auditors and monitors of GI programs, reforms in dining halls and restaurants, and emission reduction initiatives. 	<ul style="list-style-type: none"> • Affords an opportunity for ongoing stakeholder engagement. • Involving varied stakeholders ensures that ANU has social licence and capital when implementing carbon emission reduction strategies. • Targets, indicators, and reporting periods will cater to varied economic, social and cultural values of different stakeholders. • Students and staff will be empowered and develop skills to hold ANU accountable for carbon emissions reductions. • Inviting student interns widens the resource base available to perform regular monitoring.

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<p>5. <i>Develop a carbon accounting inventory and database</i></p>	<ul style="list-style-type: none"> • Collect carbon information tracking emissions from specific sources like air travel, sequestration, offsets, and relevant policies. • Perform measurements on an annual basis. • Collate the data in an inventory and database. • Coordinate information sharing. • Publicly communicate this data and database in an annual <i>Carbon Management Report</i>. 	<ul style="list-style-type: none"> • Demonstrates accountability and social responsibility to stakeholders. • Accounting provides a basis for carbon management. • Information sharing contributes to informed carbon management at other universities and organisations and elevates ANU as a centre of innovation.
<p>6. <i>Maintain long-term commitments</i></p>	<ul style="list-style-type: none"> • Long-term considerations should be factored into proposals for any carbon emission reduction strategy. • ANU must be prepared to commit economically, socially and culturally, particularly to carbon sequestration, over the long-term. • Adopt an adaptive management approach. • Document these long-term commitments and communicate them through ongoing staff, student, public and stakeholder engagement across platforms of e-mail, LinkedIn and posters across campus. 	<ul style="list-style-type: none"> • Long-term commitment and considerations ensure holistic thinking, and adaptability of strategies in contexts of uncertainty, and emerging low emission technology innovations. • Publicly communicating commitments serves as a form of accountability.

Source: Slaney (2016); ANU (2018); (UoC 2019b).

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Overall, these recommendations are directed towards ANU Below Zero and wider ANU decision-makers and acknowledge the “imperative that organisations promote action towards decarbonisation, meeting their economic, legal and moral obligations, protecting their financial viability and leading a transition” amongst shifting government priorities (Wade & Griffiths 2020, p. 15).

As a disclaimer, they may vary in their short-term or long-term feasibility, requirements of financial capital, and may not be representative of *all* the potential pathways to progress towards ANU Below Zero as NETs and innovations are constantly developing. Nonetheless, these principles, enabling environments, and recommendations provide a framework for ANU when implementing behavioural change, waste management, and carbon sequestration strategies.

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