Carbon neutral education: Reducing footprint and expanding brainprint

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Definition

Carbon neutral education may be defined as either:

- The provision of education services in a manner that results in no net increase of greenhouse gas concentrations in the Earth's atmosphere; or
- Education of an organisation or an individual around how they can ensure that their activities result in no net increase of greenhouse gas concentrations in the Earth's atmosphere.

This chapter deals with both of these dimensions of the term carbon neutral education.

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1. Introduction

This chapter explores the topic of carbon neutral education (CNE) within the broader framework of the United Nations Sustainable Development Goal (SDG) 4: Quality Education.[1] More specifically, Target 7 envisages progress as follows:

> 4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development.

[1] https://www.un.org/sustainabledevelopment/education/

Situated within this context, CNE may comprise the following two foci. First, education providers are progressively adopting low-carbon practices and aiming to become 'carbon neutral' institutions. Second, education providers are adopting appropriate curricula and pedagogical approaches to educate students about carbon neutrality through formal, informal and non-formal learning and teaching programs, including Higher Degree Research (HDR). While educational institutions are increasing recognising their potential to combine these two dimensions and making carbon neutrality an explicit goal, these efforts can be challenging due to institutional inertia and complexity, especially within the higher education sector (Udas et al., 2017). This chapter will explore both aspects and offer practical examples from diverse case studies.

In terms of content arrangement, this chapter is divided into four sections. Section 2 begins by explaining the principles of carbon neutrality (Section 2.1) before moving on to the various emissions sources that make up the 'carbon footprint' of education services (Section 2.2). This process of carbon footprint analysis usually starts with direct emissions and then progresses to the various indirect emissions that can arise from education services, with emissions classified according to the following three 'scopes': Scope 1 emissions (direct use of fossil fuels for heating, transport etc.); Scope 2 emissions (indirect emissions related to electricity generation); Scope 3 emissions (indirect emissions such as those related to student and staff transport, materials used in construction or consumables used in education, water use, waste sent to landfill, etc.). Section 2.3 explores how education providers can assess, reduce and offset their emissions towards the goal of carbon neutrality, before Section 2.4 provides a case study of the Australian university sector.

Section 3 considers the curricular function of education for carbon neutrality, namely the roles that educational institutions can play through educating students and other stakeholders about greenhouse gas (GHG) emissions (Section 3.1). This role in enabling learning and research into the impacts of climate change and the technologies and practices to mitigate it has been referred to as the 'carbon brainprint' of educational institutions. Expanding the scope further, Section 3.2 highlights divestment from the fossil fuel industry as an emerging area in which universities and other educational institutions can play a community leadership role in achieving carbon neutrality. A short concluding synthesis of the main points in the context of the UN Sustainable Development Goals is provided in Section 4.

2. Carbon neutrality

2.1 Principles, methodologies and best practice

The term 'carbon neutral' implies that a given activity has no net impact on the overall concentration of greenhouse gases in the Earth's atmosphere. It is not a requirement that the activity causes no greenhouse gas emissions whatsoever, but rather than any emissions remaining after attempts have been made to reduce them are offset by commensurate removal of greenhouse gases from the atmosphere (Figure 1).

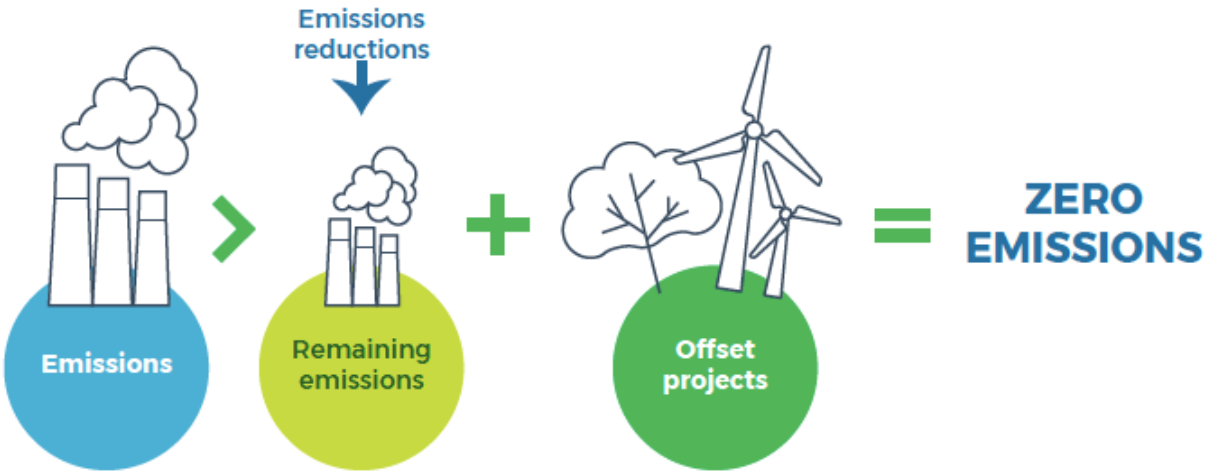

Figure 1: The process of carbon neutrality. Source: Commonwealth of Australia (2017) reproduced under a Creative Commons Attribution 4.0 International licence: https://creativecommons.org/licenses/by/4.0/

The education sector has a dual role to play around carbon neutrality by (1) ensuring that educational institutions are carbon-neutral and (2) by educating students, industry, government and community stakeholders on how to achieve carbon neutrality in their own spheres of influence.

Ensuring carbon neutrality requires a methodology for measuring the greenhouse gas emissions associated with particular activities, commonly referred to as carbon accounting or the calculation of a 'carbon footprint'. Carbon accounting and reporting involves the following five principles (WBCSD & WRI, 2015):

- **Relevance**: The greenhouse gas inventory of an organisation should include all relevant greenhouse gas emissions that can be attributed to that organisation.
- **Completeness**: All greenhouse gas emissions sources and activities within the defined boundary of an organisation or product should be accounted for and reported on, with any exclusions justified and disclosed.
- **Consistency**: Methodologies should be applied consistently to allow for meaningful comparisons of greenhouse gas emissions over time.
- **Transparency**: The credibility of greenhouse gas information should be able to be audited and all relevant assumptions and data sources should be disclosed.
- **Accuracy**: Quantification of greenhouse gas emissions should be unbiased and uncertainties reduced as far as practicable.

Carbon accounting and reporting is related to the broader concept of life cycle assessment (LCA), which is "a systematic evaluation of environmental impacts arising from the provision of a product or service" (Horne et al., 2009, p. 2). The principles and framework for LCA best practice are described in ISO 14040 (International Organization for Standardization, 2006)

which divides LCA into the four phases shown in Figure 2: (1) Goal and scope definition, (2) Inventory analysis, (3) Impact assessment, and (4) Interpretation. The phases are not strictly sequential, as earlier stages may need to be revisited as results emerge (e.g. the interpretation phase may identify a significant source of emissions that has been left out of the original scope).

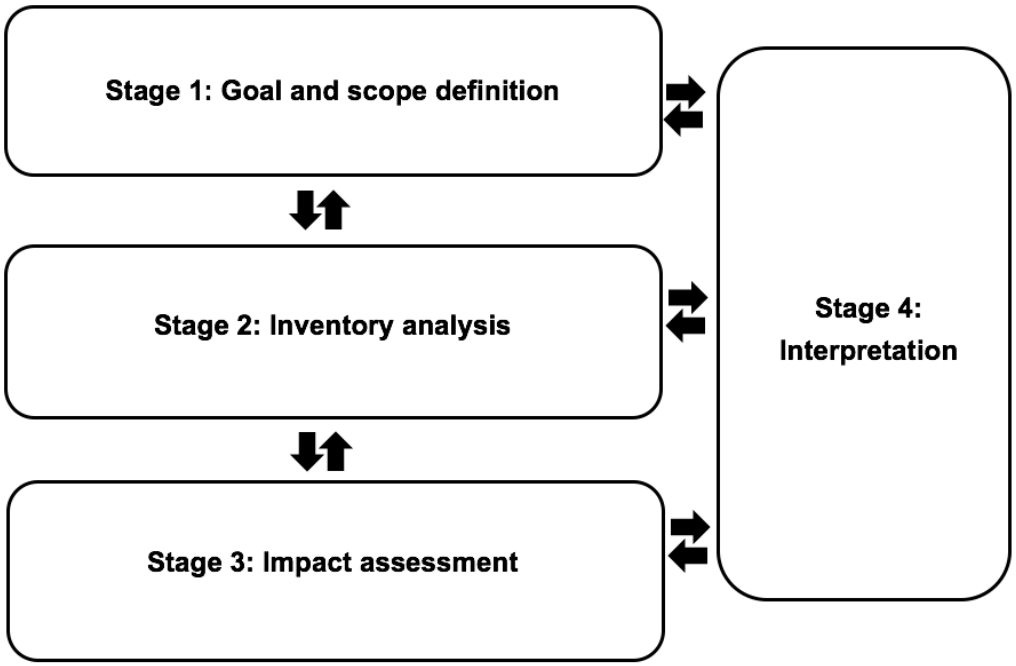

Figure 2: Phases of life cycle assessment

The first phase of a LCA, *goal and scope definition*, involves articulating why it is being undertaken, what units will be used to weigh up the key impacts of concern, and how far the boundaries of the LCA will extend. Where achieving carbon neutrality is the goal, the unit of impact is usually expressed as grams, kilograms or tonnes of carbon dioxide-equivalent (CO_2-e) that is emitted either directly by the activity or indirectly as a result of it. This may require conversion of other GHGs such as methane into CO_2-e based on their Global Warming Potential (GWP). The *inventory analysis* phase of LCA involves mapping out all the inputs and outputs that occur within the boundary that has been set. The *impact assessment* phase involves converting these various inputs and outputs into carbon dioxide equivalents in order to determine the relative impact of each life cycle stage on the overall emissions profile of the biofuel. Lastly, the *interpretation* phase involves a strategic assessment of the LCA results, which, if carbon neutrality is a goal should involve consideration of opportunities to avoid, reduce and offset emissions.

Aside from ISO 14040 covering LCA principles and the related ISO 14044 covering LCA guidelines, there are a range of other standards that specifically cover the assessment of

greenhouse gas emissions. Most notably, ISO standard 14065 specifies principles and requirements that should be taken into account when validating or verifying greenhouse gas emissions (International Organization for Standardization, 2013) and is supported by a number of other ISO standards covering verification of GHG assertions (ISO 14064), competence requirements for GHG assessment teams (ISO 14066) and carbon footprint requirements for products (ISO 14067). The Greenhouse Gas Protocol, jointly published by the World Business Council for Sustainable Development and World Resources Institute, also provides guidance on best practice accounting and reporting for greenhouse gas emissions associated with specific organisations, goods or services (WBCSD & WRI, 2015).

2.2 Setting boundaries

Setting boundaries for carbon footprint assessment can be contentious, as it is not always clear which activities are directly connected to the organisation being assessed and indirect emissions can be difficult to fully account for. For example, an educational institution may have multiple campuses and sub-entities, as well as being linked to a wide variety of associated activities, including student and staff travel, offsite disposal of waste and investments in a range of non-educational activities (e.g. pension funds).

When setting organisational and operational boundaries for carbon footprint assessment, a balance may need to be struck between the principles of completeness and relevance. Where an organisation does not have full ownership or control over an entity that it part-owns, the Greenhouse Gas Protocol (WBCSD & WRI, 2015) allows them to choose either a financial control approach, whereby they only include entities that they have financial control over within their organisational boundary, or an equity approach, whereby they include a portion of the part-owned entity's emissions within their organisation's carbon footprint based on their level of equity in the entity (e.g. 5%, 30%, 70%). This is of particular significance to universities with large endowment funds who may own small proportions of many different entities through such funds (see Section 3.2 on divestment).

Aside from issues of ownership and control, carbon accounting needs to consider how direct the link is between an organisation's activities and the emissions that may result. As such, emissions sources are typically divided into three 'scopes' that define both direct (Scope 1) and indirect (Scope 2 and 3) emissions. Figure 3 shows some common sources of emissions from universities and schools, divided by the activities they relate to and whether they fall under Scope 1, 2 or 3.

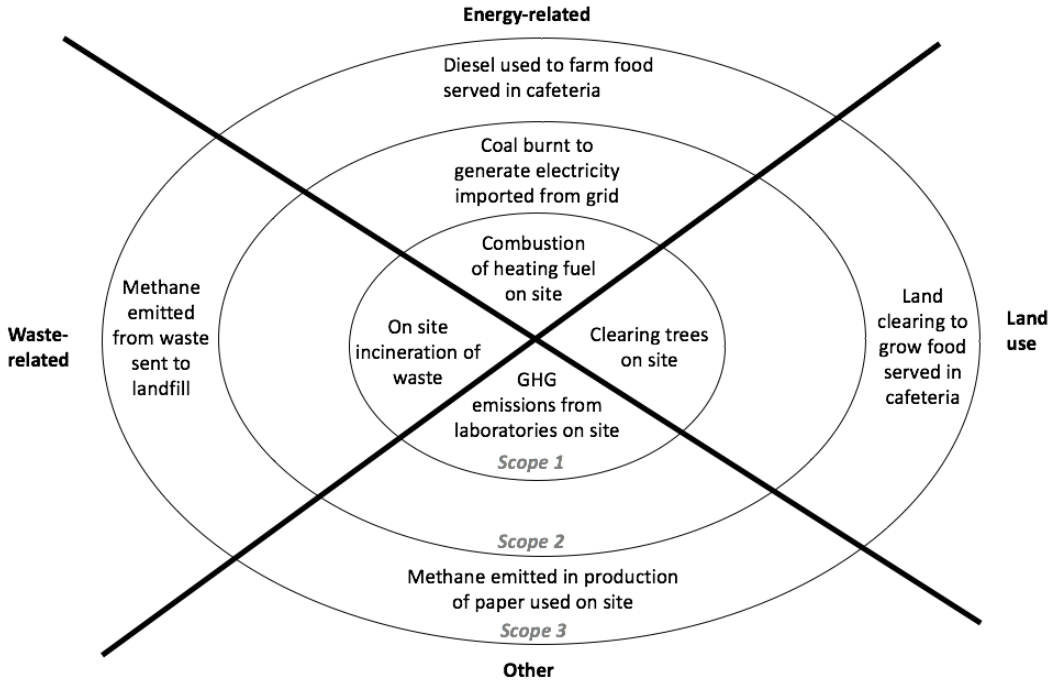

Figure 3: Common sources and scope of emissions related to a university

Scope 1 emissions are emitted at an organisation's premises or by activities directly carried out by an organisation. This may include emissions from the on-site combustion of natural gas or other fuels, emissions from on-site chemical processes such as waste processing, emissions from the organisation's vehicle fleet and fugitive emissions such as methane or hydrofluorocarbon (HFC) leakages from gas pipes or refrigeration units.

Scope 2 emissions are a special category of indirect emissions that result from an organisation's use of electricity, such as the emissions from burning coal to generate electricity at a power plant that is purchased by a school through a transmission and distribution network. Although these emissions are considered indirect, the nature of electricity supply systems allows the resulting emissions to be clearly attributed to the organisation consuming the electricity.

Scope 3 emissions are indirect emissions that result from activities carried out by an organisation, but can be more difficult to attribute to the organisation due to higher uncertainty, a lack of control by the organisation and the role of other organisations in producing the emissions. Education-sector examples include methane emitted from waste after it is sent to landfill, emissions from the production of foodstuffs served at a cafeteria and emissions from staff and students transporting themselves to and from educational facilities.

The degree to which different emissions sources are included in an organisation's carbon footprint depends on the purpose of the accounting exercise. Under the Greenhouse Gas Protocol, the inclusion of Scope 1 and 2 emissions is strongly encouraged while Scope 3

emissions are described as 'optional' (WBCSD & WRI, 2015). However, national or subnational agencies may specify stricter standards, as may certification bodies in cases where the purpose of carbon accounting is to be certified as 'carbon neutral'. For example, Australia's National Carbon Offset Standard is published by the Australian Government and is used to award its Carbon Neutral Certification Trade Mark (Commonwealth of Australia, 2017). It sets higher benchmarks for organisations than the Greenhouse Gas Protocol, requiring:

- the inclusion of all Scope 1 and 2 emissions;
- the inclusion of certain Scope 3 emissions (related to fuel use, waste, business travel and accommodation, base building services, office paper and water use);
- a relevance test to be undertaken for certain other Scope 3 emissions (staff commuting, food and catering, postage and freight, stationery, office printing, cleaning services, IT and telecommunication services), which considers their size relative to the organisation's overall footprint, the views of key stakeholders and whether such activities have been recently outsourced; and
- a materiality test to be undertaken to ensure that all emission sources that represent more than 1 per cent of an organisation's overall footprint are included.

2.3 Emissions reductions and offsets

Carbon footprint analysis can help educational and other organisations to identify opportunities to reduce emissions through energy efficiency measures, replacement of fossil fuels with renewable energy, improved waste management, alternative procurement arrangements or dispensing with high-emissions practices altogether. Comparing different components of their footprint (e.g. electricity use, heating, transport, waste) allows organisations to identify which actions are likely to have the biggest impact on emissions, while complementary financial analysis may help to identify the most cost-effective actions or 'win-win' opportunities which reduce both emissions and operational costs (e.g. installing energy-efficient lighting). The choice of learning mode can also play a role, with the rise of distance-based learning offering a means of reducing the Scope 3 transport-related emissions that are a major contributor to the carbon footprint of educational institutions (Swithenby et al., 2015).

While direct measures related to energy efficiency, replacement of fossil fuels and alternative waste management may be able to reduce emissions within an educational institution, achieving full carbon neutrality is likely to require some offsetting of remaining emissions that are unable to be reduced further. Carbon offsets can compensate for an organisation's ongoing emissions by directly removing GHGs from the atmosphere (e.g. biosequestration from tree planting) or by preventing emissions that would otherwise have occurred in the absence of the offsetting arrangement (e.g. paying for another organisation to switch over to renewable energy or adopt energy efficiency measures). The focus of this chapter is on 'voluntary' offsets, whereby educational institutions purchase offsets to meet voluntary goals around carbon neutrality. In contrast, 'compliance' offsets relate to obligations that countries have signed up to under international agreements (e.g. the 2016 Paris Agreement) or obligations that have been imposed on organisations by their governments (e.g. under carbon cap-and-trade schemes or carbon taxes), whereby offsets may be purchased to avoid having to purchase emissions permits or pay penalties.

Some technologies and approaches to carbon offsetting can be controversial (Lovell & Liverman, 2010), with concerns raised around issues such as *permanence* for biosequestration (i.e. how certain is it that a tree planting will not subsequently be cleared?), *additionality* for renewable energy projects (i.e. could the switch to renewable energy have happened anyway without the offset payment?) and *baselines* (i.e. what level of emissions can be assumed to have occurred under a business-as-usual scenario). These concerns highlight the need for credible schemes to certify offset credits. At the global level, a leading example of such a scheme is the United Nations Climate Neutral Now program, which enables organisations to purchase Certified Emission Reduction units (CERs) created in accordance with the rules of the The Clean Development Mechanism (CDM), which operates under the UN Framework Convention on Climate Change (UNFCCC). Schemes can also operate at the national level, such as Australia's National Carbon Offset Standard.

2.4 Striving to achieve a carbon neutral higher education: Australian stories

The Australian education sector is managing its greenhouse gas emissions to position itself for growth and competitiveness in a lower-emissions future. Australian education exports are worth $28 billion a year[2], and 37 Australian universities are included among the world's best in the 2018 edition of the QS World University Rankings. The higher education sector has been proactively working to advance carbon neutrality in its institutions, in many instances as part of their strategic plans. Some universities have attained carbon neutral certifications awarded by the Australian Government against the National Carbon Offset Standard (i.e. Charles Sturt University and the University of Tasmania)[3], others like the University of New South Wales (UNSW Sydney) are proactively working towards carbon neutrality through strategic, participatory planning of commitments and targets, and action plans. The following paragraphs provide three case studies that demonstrate the diversity of approaches and contexts within the Australian university sector.

Charles Sturt University (CSU)[4] is a multi-campus regional, public university with over 16,000 on-campus students, 24,000 online students, 2,000 staff and campuses spanning a combined land area of 2,612 hectares. CSU was certified as the first Carbon Neutral University in Australia in July 2016. Major contributors to reducing its carbon footprint related to electricity, gas, construction activities, livestock, travel and waste. Offset projects have also played a significant role in achieving carbon neutrality, including around indigenous fire management in northern Australia, forest protection in Indonesia and renewable energy in India[5]. Offset projects have been selected to improve both social and environmental outcomes and to combine local and global scale impact. Co-benefits being delivered through local-based projects include

[2] https://www.afr.com/leadership/education-exports-are-worth-28-billion-a-year-nearly-20pc-more-than-we-thought-20171005-gyvc8v

[3] http://www.environment.gov.au/climate-change/government/carbon-neutral/certified-businesses

[4] https://www.csu.edu.au/

[5] https://www.csu.edu.au/csugreen/about-us/commitments/carbon-neutral-university/offset-projects

restoration of habitats for native fauna, new employment opportunities for regional Australians and diversification of income streams for Australian farmers. The benefits of being carbon neutral are also economic, with CSU reporting savings close to $500,000 per annum because of the energy efficiency and alternative energy generation projects implemented (Department of Environment and Energy, 2017).

University of New South Wales (UNSW Sydney)[6] is a public University with 59,000-plus students from 137 countries, and over 7,000 staff mostly located in its main campus of 38-hectares in Kensington, seven kilometres from the centre of Sydney. As an innovative leader in sustainability-related research and teaching, it is currently working towards a low-carbon, clean-energy university's operations. The University's Estate Management is drafting a strategy to deliver by the end of 2018 a new environmental sustainability plan that will place clear commitments, targets and identify priority actions to achieve net zero carbon buildings by 2030, and a total (Scope 1,2,3) carbon reduction target in line with the Science-Based Targets (Paris-aligned) between 2025 and 2050. Ongoing initiatives tackling scope 1, 2 and 3 emissions (Figure 4) will be expanded to achieve the targets. Noteworthy is that Scope 3 emissions represent roughly two-thirds of the University's footprint. In implementing the strategy, the University plans to invest $13 million in energy efficiency and solar projects to facilitate transition to renewable energy and reduce net greenhouse gas emissions, which in tandem will improve preparedness for climate risks.

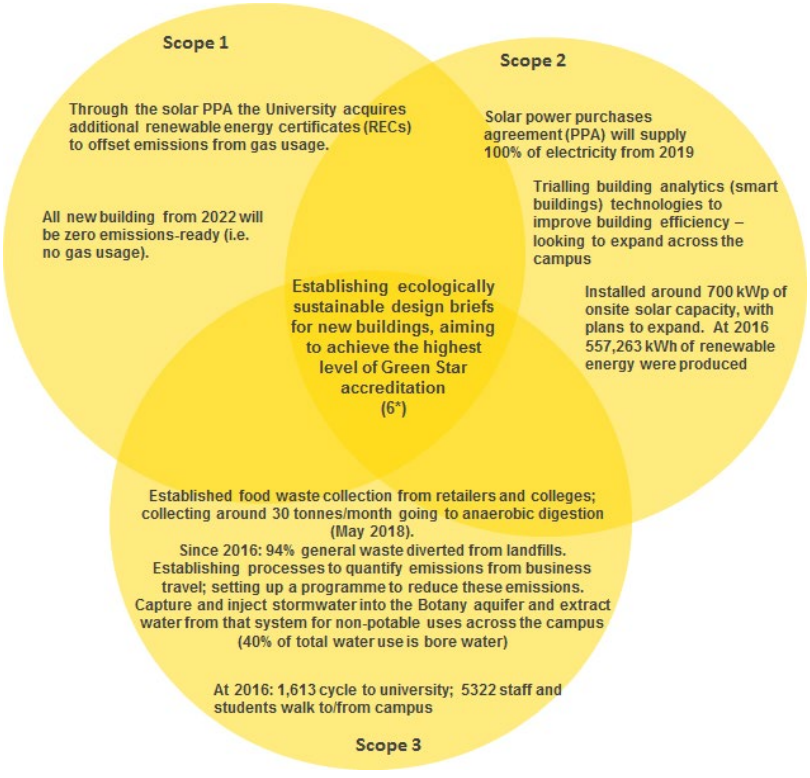

Figure 4: Actions undertaken to achieve carbon neutrality by UNSW Sydney

[6] https://www.unsw.edu.au/

Christian Heritage College (CHC)[7] is a private Higher Education Provider (HEP) offering bespoke education to university students in Carindale in the outskirts of Brisbane, Australia's third-largest city. Founded in 1986, CHC has more than 750 students enrolled in a total of 30 undergraduate and postgraduate degrees across the five disciplines Business (6); Education (7); Liberal Arts (5); Ministries (5); and Social Sciences (7). In 2018, Blue Sun Group (BSG)[8] and CHC agreed on a comprehensive solar system partnership. An assessment of the CHC campus scoped out electrical usage and cost reduction possibilities, installation options available on existing buildings, and location of panels due to the sun's azimuth and any limiting factors of nearby trees as well as cost-benefit impacts upon linkage into the electrical board. This assessment led to a power purchase agreement (PPA), which stipulated that no upfront installation costs were to be incurred by CHC and that cost savings were to be shared at an agreed rate by CHC & BSG as assessed by benchmarking historical usage levels, thus making it a positive commercial cost saving from the first year. The solar system was installed in February 2018 (Figures 5a & b) and generates 126,805kWh a year,[9] which represents a reduction in greenhouse gas emission of 103,980 kg CO2/year[10] (Scope 2 emissions). This represents a 40% reduction on previous emissions. In addition to the solar system installation itself, there have been unexpected synergistic benefits. The high visibility of the solar panels has given latent support to other institutional sustainability engagements, including a campus community garden, which received a tacit boost by the institution's push towards carbon neutrality (Luetz & Beaumont, 2019). In summary, the private-private partnership resulted in 100 kW of solar power capacity being added and delineates a replicable example of innovative industry practice with wide mainstreaming potential for schools and other HEPs. Finally, the prominence of the panels in the context of a small private HEP has already raised internal and external awareness of the institution's social and environmental responsibility, thus raising hopes to expand sustainability into other areas where the campus does not yet operate, such as composting food waste and recycling water and other common products.

[7] http://www.chc.edu.au

[8] https://bluesungroup.com.au/wholesale/

[9] Projected figures are based on Clean Energy Council Database (CEC 2017, p. 4) and other data on file with authors.

[10] National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGERA 2016, p. 340).

(a)

(b)

Figures 5a & b: Recent large-scale installations of solar panels at CHC

3 Beyond carbon footprint: The broader role of education in achieving carbon neutrality

The previous section highlighted how educational institutions can achieve carbon neutrality in their own operations through emissions reductions and offsetting. However, the education sector also has a fundamental role to play in ensuring that learners at such institutions acquire the knowledge and skills needed to promote sustainable development, including an understanding of how carbon neutrality can be adopted by a diverse range of organisations and individuals. In addition, as major employers and focal points of knowledge and innovation hubs, educational institutions can play an important community leadership role by setting examples and norms.

3.1 'Carbon brainprint': Enabling learning around carbon neutral practices

Educational institutions have an important role to play in educating environmental auditors, engineers, community organisers, corporate leaders, policy-makers and the general public about actions that can be taken to mitigate climate change. Analysis of education around environment and sustainability in the higher education sector has shown a shift globally over the past decade, away from a dominant focus on environmental protection in curriculum development and towards a more diverse approach that incorporates climate change, corporate social responsibility, energy, resources, culture and ethics (Wu & Shen, 2016).

The educational role of universities, schools and other educational institutions is not usually factored into standardised life-cycle assessments and carbon accounting processes. For example, a university cannot generate offsets from the widespread adoption of a new solar panel developed by one of its engineering graduates or energy-efficiency measures championed by one of its business graduates. However, it is this role of educational institutions in facilitating the learning of knowledge and skills that potentially offers the greatest potential for achieving carbon neutrality on a national or global basis. This concept has been described as the 'carbon brainprint' of universities and other educational institutions (Chatterton et al., 2015).

UNSW Sydney, introduced as an example in Section 2.4, demonstrates the links between carbon brainprint and conventional carbon footprint assessment. Section 2.4 was focused on activities that are typically incorporated into the carbon footprint of organisations, such as emissions from energy use and waste, and offsets that have been directly paid for by the university. However, aside from its actions in this area, UNSW Sydney is also a recognised world leader in research related to climate change and renewable energy, for example through its solar photovoltaics research program that has set various records for solar cell efficiency (Yan et al., 2018). It offers a range of formal programmes providing education towards carbon neutrality, including coursework across Arts, Sciences, Law, Medicine, Engineering and the Built Environment and Masters and PhD programs in Sustainable Built Environment, Environmental Management and Environmental Policy. Specific subjects offering skills in carbon neutrality include Reporting for Climate Change and Sustainability, Managing Greenhouse Gas Emissions, Energy Efficiency in Residential Buildings and Sustainable Energy for Developing Countries. To ensure integration across these diverse activities, UNSW Sydney has established an Environmental Sustainability Reference Group to guide the development of the strategy that will include commitments and targets across 10 key themes: research and advocacy, learning and teaching, emissions and energy, buildings and campus, water, waste and recycling, travel and transport, goods and services, awareness and engagement, and investment.

The University of Edinburgh provides another example of how educational, operational and whole-of-university initiatives can be integrated to help society move towards carbon neutrality on multiple fronts (Table 1). These measures are closely integrated, with, for example, a whole-of-university Department for Social Responsibility & Sustainability that links to a new online course for students and a series of incentives aimed at changing staff behaviour. This close integration between learning and teaching, research and operations is a key asset that universities possess in leading the shift towards a carbon neutral future.

Table 1: Educational, operational and whole-of-university initiatives relating to carbon neutrality at the University of Edinburgh

Educational initiatives	Operational initiatives	Whole-of-institution
• The ESSA project: The 'European Students Sustainability Auditing' Project (3 year Erasmus+ project to learn about social responsibility and sustainability in European universities) • Sustainability and social responsibility online course for all undergraduates • Climate change scholarships • Living Lab projects, such as the "Building Futures" projects for MSc Advanced Sustainable Design students • Architecture: teaching students how to make concrete more sustainable	• Switch energy saving campaign (aimed at staff) • Voluntary staff Energy Coordinators • The Sustainable Campus Fund: funding carbon-saving projects proposed by staff • Sustainability Awards: offers staff and students an opportunity to make a difference and contribute towards the University becoming more socially responsible and sustainable • Warp It: an online portal for staff to reuse items internally • Promoting sustainable travel, including business travel • PC reuse initiative - promoting the circular economy by reusing pcs internally and externally	• Climate strategy: commitment to become carbon neutral by 2040 • Established a Department for Social Responsibility & Sustainability (remit includes finding new ways to reduce carbon) • Responsible investment: the University has committed to avoid investments in fossil fuels • Low carbon and renewable energy generation

3.2 Expanding the scope further: Carbon neutrality and the global divestment movement

Aside from operational emissions and their role in facilitating learning, educational institutions can also exert influences over the adoption of carbon neutral practice through their ownership of stocks and bonds. Universities are uniquely placed to exert this influence due to a combination of the large endowment funds possessed by some institutions and their status as

knowledge-creators and leaders in innovation. However, such investments are typically left out of carbon footprint analyses due to the universities involved not holding a controlling interest (as per the financial control approach to boundary-setting outlined in Section 2.2). In response to increasing concerns about these issues, a global 'divestment' movement has emerged to push for greater recognition of this important component within the portfolio of available strategies pursued by global universities seeking to become fully 'carbon neutral' (Arabella 2018; Stephens, 2018; Stephens et al., 2018).

Expressed in simple language, "[d]ivestment is simply the opposite of an investment - it means getting rid of stocks, bonds, or investment funds that are unethical or morally ambiguous." (Hart et al., 2018, p. 5). Stephens (2018) argues that increasing recognition of universities as 'citizens' and 'change agents' is a key reason for the growing popularity of divestment in educational settings.

Given that universities are perceived by the public to "educate and train the future leaders" also implies that on the basis of ethical citizenry they cannot concurrently be "complicit in putting that future at risk by partnering and investing in coal, oil and gas companies." (Hart et al., 2018, p. 6). The basics of university divestment have been outlined by Hart et al. (2018) as follows:

> Most universities have a set of funds called an endowment. This is […] where most bequests and donations likely end up. They invest this endowment in a range of different [companies] to make a profit. Often the profit from investing goes towards paying for scholarships […] Therefore, divestment effectively means that universities freeze any new investments in fossil fuels immediately and divest from any direct investments they have in fossil fuel companies, and then within five years remove themselves from any commingled funds that still include fossil fuel companies. (pp. 9-11)

On this basis, universities all around the world are increasingly divesting. According to Arabella (2018), the United Kingdom has emerged as the leader among university divestments, with 12 new commitments in 2018 and 68 in total. United States universities are currently under-represented in the movement compared to their global influence, with 89 percent of educational institutions that have pledged to divest since 2016 being outside the US (Arabella, 2018). However, the divestment movement has strong support amongst university and college staff in the United States and Canada, with over 4,550 having signed letters endorsing fossil fuel divestment (Stephens et al., 2018). In the Australian context, major publicly funded universities have also made a range of divestment commitments (Hart et al., 2018), with La Trobe recognised as Australia's first university to commit to completely divesting from fossil fuels (Slezak, 2016), accompanied by varying commitments from Queensland University of Technology (Robertson, 2016), Monash University (Green Left, 2016), Australian National University (ANU, 2016), The University of Sydney (Mortimer, 2017), The University of Melbourne (UMel, 2017) and Swinburne University of Technology (SUT, 2015).

A tally of divestment commitments prepared by global campaign group Fossil Free[11] indicates that as of October 2018, global divestment commitments total $7.17 trillion, of which 15% is linked to educational institutions.[12] Arabella (2018) notes the rapid growth in this aspect of carbon neutral education, with commitments to divest estimated to have grown by 11,900 percent between 2014 and 2018.

4 Concluding remarks

The education sector globally is increasingly recognising its responsibility to contribute to the mitigation of climate change through the adoption of carbon neutral goals and actions. Furthermore, it is uniquely placed to bridge the gap between direct action and the dissemination of knowledge and skills that have the potential to lead to further action across multiple other sectors. It is important the education sector adopts a broader view, extending beyond emissions that are typically taken into account in life cycle assessment and carbon footprint analysis, to explicitly consider the 'carbon brainprint' of universities, schools and other educational institutions, as well as the influence these are able to exert through financial investments and community leadership. As such, an integrative approach is essential in achieving the vision of carbon neutral education that is increasingly finding its way into the strategic vision of leading academic institutions, and to reach the targets set under the SDGs.

Acknowledgments

The authors wish to thank the following individuals for their constructive comments, input and support: Kirsty Andersen, Richard Holmes, Adele Turnbull, Jordan Geizer, Jackson Turner, Sion Pickering, William Syddall.

Cross-References

References

Australian National University (ANU, 2016) Update on ANU socially responsible investment policy. https://cecs.anu.edu.au/news/update-anu-socially-responsible-investment-policy. Accessed 27 Sep 2018

[11] https://gofossilfree.org/about/

[12] https://gofossilfree.org/divestment/commitments/

Arabella (2018) The global fossil fuel divestment and clean energy investment movement. 2018 report. Author. https://www.arabellaadvisors.com/wp-content/uploads/2018/09/Global-Divestment-Report-2018.pdf. Accessed 2 Oct 2018

Chatterton J, Parsons D, Nicholls J, Longhurst P, Bernon M, Palmer A ..., Davies G (2015) Carbon brainprint -- An estimate of the intellectual contribution of research institutions to reducing greenhouse gas emissions. Process Safety & Environmental Protection: Transactions of the Institution of Chemical Engineers Part B 96: 74-81

CEC - Clean Energy Council (2017). Guide to installing solar PV for business and industry. https://www.solaraccreditation.com.au/dam/cec-solar-accreditation-shared/guides/guide-to-installing-solar-pv-for-business-and-industry-october-2017.pdf. Accessed 12 Oct 2018

Commonwealth of Australia (2017) National carbon offset standard for organisations. Commonwealth of Australia, Canberra

Department of Environment and Energy (2017) Carbon neutral stories. Charles Sturt University case study. Author. http://www.environment.gov.au/climate-change/government/carbon-neutral. Accessed 11 Oct 2018

Green Left (2016, Apr 8) Monash University to divest from coal. Melbourne 1090. https://www.greenleft.org.au/content/Monash-University-divest-coal. Accessed 27 Sep 2018

Hart G, Louey P, Fairall A, Turner J (2018) Divest your uni from coal, oil and gas and build a clean, safe and fair future for everyone: A starters guide. https://docs.google.com/document/d/1269Ob8OUEeBsv8g_yL3ixJ4GYFCsoWatJnLXvg8NgI4/edit#heading=h.w6mym7xsxins. Accessed 26 Sep 2018

Horne R, Grant T, Verghese K (2009) Life cycle assessment: Principles, practice and prospects. CSIRO Publishing, Collingwood, Australia

International Organization for Standardization (2006) Environmental management - Life cycle assessment: Principles and framework, ISO 14040:2006. International Organization for Standardization, Geneva

International Organization for Standardization (2013) Greenhouse gases -- Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition, ISO 14065:2013. International Organization for Standardization, Geneva

Lovell H, Liverman D (2010) Understanding carbon offset technologies. New Political Economy (15): 255-273

Luetz JM, Beaumont S (2019) Community gardening: Integrating social responsibility and sustainability in a higher education setting – A case study from Australia. In: Leal Filho W (ed) Social responsibility and sustainability – *How businesses and organizations can operate in a sustainable and socially responsible way. World sustainability series.* Springer, Berlin. https://doi.org/10.1007/978-3-030-03562-4_26

Mortimer D (2017, May 29) Investment policy 2017. University of Sydney. http://sydney.edu.au/policies/showdoc.aspx?recnum=PDOC2012/258&RendNum=0. Accessed 27 Sep 2018

NGERA - National Greenhouse and Energy Reporting Act 2007 (2016). National Greenhouse and Energy Reporting (Measurement) Determination 2008. Compilation 8. Amendments up to 1 July 2016.

Quality Indicators in Learning and Teaching (QILT, nd) Compare student experience and graduate employment: Find a study area or institution. Online resource. Author. https://www.qilt.edu.au. Accessed 28 Apr 2018

Robertson J (2016, Sep 5) Queensland University of Technology to dump fossil fuel investments. The Guardian. https://www.theguardian.com/environment/2016/sep/05/queensland-university-of-technology-to-dump-fossil-fuel-investments. Accessed 27 Sep 2018

Slezak M (2016, May 25) La Trobe becomes Australia's first university to commit to fossil-fuel divestment. The Guardian. https://www.theguardian.com/environment/2016/may/25/la-trobe-becomes-australias-first-university-to-commit-to-fossil-fuel-divestment. Accessed 27 Sep 2018

Stephens JC (2018, Sep 7) Fossil fuel divestment debates on campus spotlight the societal role of colleges and universities. The Conversation. https://theconversation.com/fossil-fuel-divestment-debates-on-campus-spotlight-the-societal-role-of-colleges-and-universities-102689. Accessed 27 Sep 2018

Stephens JC, Frumhoff PC, Yona L (2018) The role of college and university faculty in the fossil fuel divestment movement. Elem Sci Anth 6(1):41. doi: http://doi.org/10.1525/elementa.297

Swinburne University of Technology (SUT, 2015) Responsible investment charter. Approved by Council 1 Dec 15. Author. http://www.swinburne.edu.au/media/swinburneeduau/about-swinburne/docs/pdfs/Swinburne-University-Responsible-Investment-Charter.pdf. Accessed 27 Sep 2018

Swithenby E, Lane A, Caird S, Roy R, Potter S (2015). Design of higher education teaching models and carbon impacts. Int J Sustain Higher Educ 16: 96-111

Udas E, Wölk M, Wilmking M (2017) The “carbon-neutral university” – a study from Germany. Int J Sustain Higher Educ 19: 130-145

UMel - University of Melbourne (UMel, 2017) Sustainability plan 2017-2020. Author. https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.um-ourcampus.files/2914/8480/0942/UoM_Sustainability_Plan_2017-2020_40pp.pdf. Accessed 27 Sep 2018

WBCSD & WRI (2015) The greenhouse gas protocol: A corporate accounting and reporting standard. World Business Council for Sustainable Development and World Resources Institute, Geneva

Wu Y-CJ, Shen J-P (2016) Higher education for sustainable development: A systematic review. Int J Sustain Higher Educ 17: 633-651

Yan C, Huang J, Sun K, Johnston S, Zhang Y, Sun H, Pu A …, Hao X (2018) Cu2ZnSnS4 solar cells with over 10% power conversion efficiency enabled by heterojunction heat treatment. Nature Energy 3: 764-772