Defining sustainability metric targets in an institutional setting

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Abstract

Purpose – The purpose of this paper is to expand on the development of university and college sustainability metrics by implementing an adaptable metric target strategy.

Design/methodology/approach – A combined qualitative and quantitative methodology is derived that both defines what a sustainable metric target might be and describes the path a university might take to get there. Local to global spatial scales and short to long-term time scales are accounted for. Four popular metrics are developed: carbon emissions, water use, recycling rate, and energy use. Sustainability metric data available from Yale University are utilized to show the applicability of this metric target strategy.

Findings – Targets for sustainability metrics may be set at short, medium, and long-term time scales. While quantitative targets may be set for sustainability metrics, these are often long-term ideals that offer no information on the path to achieve them. If a path to achieving these targets is outlined, it is often arbitrary quantitatively, if not also qualitatively. This paper finds that sustainability metric targets can be founded upon clearly delineated, rigorously quantified targets. At the same time, the process framework for developing sustainability metric targets is adaptable to the unique situation of a particular university. This adaptable metric target strategy reflects the ideals of sustainability to be at one time both local and global in scope. The metric target strategy is globally applicably, but the sustainability metric targets produced will be unique to each institution.

Research limitations/implications – The process framework for developing sustainable metric targets is only outlined for four popular metrics. Achieving these four targets alone will certainly not define a university as sustainable. Further development of other sustainability metrics utilizing the framework presented would be helpful.

Practical implications – The application to real metric data shows the feasibility of this approach for use at other universities and colleges. They can define their own sustainability targets using the approach outlined.

Originality/value – This paper highlights how sustainability metrics being collected by universities may be used to define a target path towards sustainability. The process framework presented has the potential to provide unique solutions for each institution while remaining a universal methodological approach.

Keywords Sustainable development, Universities, Targets, Measurement, Higher education, United States of America

Paper type Research paper

Introduction

A vast international effort is presently underway across campuses (University of Edinburgh, 2008; Australian National University, 2008; Concordia University, 2007; Michigan State University, 2007) and other institutions (e.g. the Global Reporting Initiative) to collect quantitative data on sustainability. These raw data provide the

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necessary information for concurrently developing sustainability metrics that provide some indication of what is, or is not, "sustainable." For instance, repeated measurements of energy use, and associated carbon emissions, comprise the metrics that policy makers can reference to track progress towards values that are sustainable. However, rigorously and scientifically defining this potential sustainable end-state has had far less investigation than developing metrics (Valentin and Spangenberg, 2000; Lozano, 2006). While much discussion has occurred on the etymology of sustainability (Brown *et al.*, 1987; Wright, 2002), more effort needs to occur in defining what is sustainable in relation to the metrics collected.

Many metric targets are constructed relationally. That is, a university will look at its peers and associates, identify what has been done, and then construct its own metrics. International, national, and regional goals also provide context when developing a sustainability goal (Rauch and Newman, 2009). Further refinement occurs as economics, technological feasibility, and stakeholder values are accounted for. Certainly, setting targets this way heads towards sustainability, and the approach provides consensus amongst these viewpoints. However, this approach does not directly address the underlying, fundamental question of "what is sustainable?"

While visionary statements, such as carbon neutrality, perhaps suggest a long-term answer to the question "what is sustainable?", the path towards a sustainable vision is dynamic and hard to define. What may be a reasonable target at one point in time may not be so 15 years in the future. Corporate average fuel economy standards in the USA are a good example. Dynamism also exists in the time horizon of "sustainable" that is set (Worster, 1993). Does one want to sustain for 10, 50, or 200 years or more? The time horizon can dictate the ultimate metric targets that an institution may choose.

Acknowledging such dynamism, sustainability can be thought of as a process, as opposed to an end-state (Parker, 2002). The authors present a process framework for application of scientifically grounded sustainability targets, in development of Graedel (2002). The process framework is then applied utilizing real data from a US university of 12,000 students. The methods of the process framework are the true value of this work. Every institution has its own unique set of circumstances, and the process framework is designed for application to developing each institution's own metric targets.

Basic methodological framework

While Graedel (2002) states 50 years as an approximate sustainability time frame, here a process framework is offered for setting sustainability targets that is adaptable in time and among institutions. Different institutions may exist at different points along a continuum with regard to a particular metric. For instance, one institution may already be carbon neutral (i.e. no net carbon emitted to the atmosphere from institutional operation due to zero net fossil carbon use), while another is only beginning a greenhouse gas inventory, let alone setting targets for emission reduction. The general framework is illustrated in Table I.

Initial development of any goal or target will by necessity take into account the existing circumstances of the institution. Though the traditional institutional timeframe is 5-15 years, sustainability challenges this mindset by asking institutions to think in longer timeframes. The initial goal is likely to be on a shorter time horizon, developed through multiple stakeholder inputs and consensus building to derive a mutually achievable target. Although targets already set on the local, state, regional, national, and/or global scale often provide needed guidelines, emphasis should be placed upon the most local geographic and political context available.

Because sustainability necessitates long-term thinking by definition, medium-term generational and visionary targets should also be set, and a path laid out on how to navigate from short to medium to long-term. While it is fairly certain these targets will require revision sometime in the future, they provide a reference point from which to work, as opposed to leaving future generations to set a new metric target without any guidance. In the medium time frame, the authors suggest utilizing "green" scenarios as generated by scientific models. What constitutes a "green" scenario may be subject to interpretation, so care should be taken to vet the choice of "green" scenario. If unavailable, a rough in-house calculation can be developed that may be as simple as projecting historic trends into the future. In the long-term the intention is for the visionary sustainable target to be achieved.

Application of the process framework

Potentially hundreds of sustainability metrics can be tracked (Cole, 2003), ranging in topic from material and energy management to community and governance, and many would be amenable to the general process framework proposed. However, the actual task of applying the process framework to even just one metric can be quite intensive. Certain metrics are more qualitative and not as conducive to the application of the proposed process framework. In as much as Graedel (2002) provides frameworks for calculating sustainability metric targets for the two broad categories of use (energy, water, material resources, land) and emissions (water, land, and air), this paper focuses upon only four popular sustainability metrics:

(1) air emissions (carbon dioxide);

(2) energy use;

(3) water use; and

(4) material resource output (waste and recycling).

These four metrics were chosen based upon data availability and the popularity of these metrics across institutions. In addition to building upon the methods of Graedel (2002), a layer of complexity is added by applying the methods to actual data.

Greenhouse gas (carbon dioxide) emissions

Applying the metric target framework to greenhouse gas emissions, short-term institutional targets for a university are established based upon multiple stakeholder participation, assessment of the present situation, and projection into the foreseeable

Time frame	Process by which metric target is established
Institutional (up to ~15-20 years)	Multiple stakeholder consensus given present-day circumstances
Generational (mid-term, up to ~50 years)	Scientifically-based "green" scenarios, if available In-house projections of historical trend into future
Visionary (up to ~100 years)	Theoretically ideal target

Table I. Process framework to set sustainability metric targets future as to what would be an achievable emission reduction target (Rauch and Newman, 2009). Context also plays a large role, as targets are often pegged to local, state, and/or international (e.g. Kyoto) targets. The example US institution set its greenhouse gas emission reduction target in 2005 to 10 percent below 1990 levels by 2020, or in other words 45 percent below 2005 levels by 2020.

While the visionary sustainability target for greenhouse gas emissions may arguably be carbon neutrality, the question remains how to proceed from the level of emission in 2020 to this ultimate goal. For greenhouse gas emission reduction, the authors use climate models of projected carbon emissions. Climate stabilization at 450 ppmv was chosen as the "green" scenario that would minimize future catastrophic risks of climate change (Speth, 2004). Climate stabilization scenarios at 450, 550, 650, and 750 ppmv are averaged from three climate models analyzed by the DOE US Climate Change Science Program (Clarke *et al.*, 2007). Implicit in the use of these models are the assumptions of global burden-sharing among the world's nations that the models use in order to derive the US's contribution to global carbon emission reduction. Only US anthropogenic emission estimates of CO_2 from fossil fuels and other industrial sources, excluding CH_4, NO_2, and F-gases, were included in order to simplify the analysis.

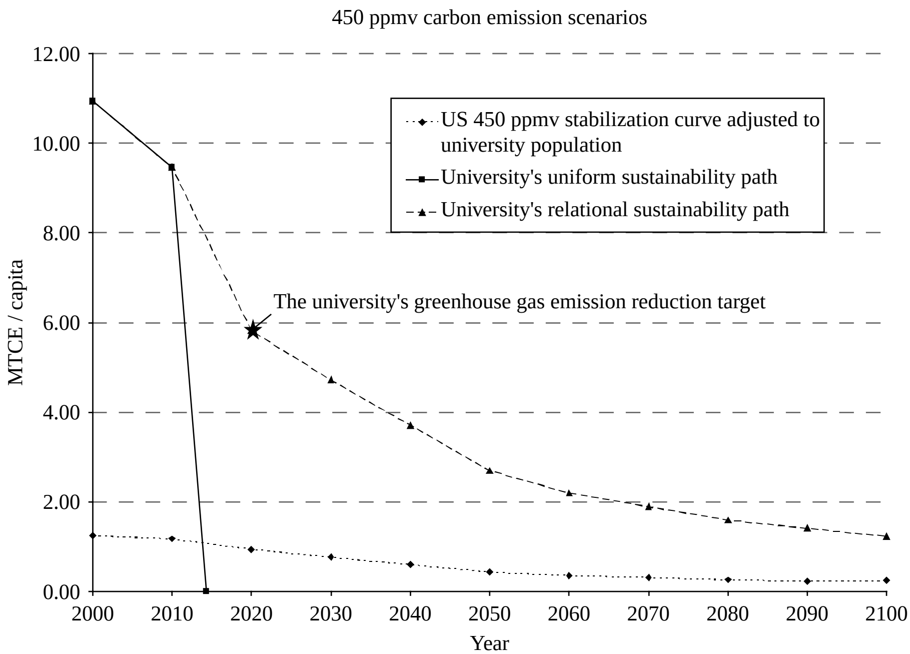
Total projected emissions from the USA (E_n) were scaled to the university population based in part upon relative population size, where P_c is the campus' projected population, and P_n is the national projected population. As a university only operates as a commercial and, for students, a residential sector entity, projected emissions to stabilize climate at 450 ppmv (E_c) were also scaled by applying the fraction of emissions attributable to the commercial and residential (student population only) sectors:

$$E_c = E_n \times (P_c/P_n) \times (0.17 + 0.19 \times (P_s/P_c)), \quad (1)$$

where 0.17 is the US average commercial sector fraction (held constant) of projected carbon emissions and where 0.19 is the projected US average residential fraction (held constant) of projected carbon emissions. P_s is the projected student population living in campus housing.

The relative contributions of each US sector (i.e. transportation, industrial, commercial, and residential) to carbon emissions were available for recent years (US EPA, 2006), as were projections for 2010, 2015, and 2020 (US DS, 2002). Although formula (1) ignores industrial and transportation existing to allow for the operation of the university, it nonetheless provides a more accurate estimate than scaling from total US emissions alone.

Uniform and relational sustainability paths can be calculated using formula (1). Uniform sustainability assumes that one unit of carbon emitted by the institution is of equal importance today as 50 years from now. Assuming this uniform sustainability, an institution can choose to emit more carbon today and emit less in the future, but can still only emit a total amount of carbon equal to the area under the 450 ppmv stabilization curve (Figure 1). Overall, this uniform sustainability target is not feasible for the example institution; even at 750 ppmv the example university would have to become carbon neutral by 2023. Alternatively, a relational sustainability target path can be constructed (Figure 1), wherein it is assumed that every entity in the USA will reduce emissions in the same proportion. While more true to the realities of inequity in society, it is less true to the egalitarianism professed by the definition of sustainability. The actual future target path for the example institution likely lies between the relational and



Notes: Data were only available every ten years for projected US carbon emissions, E_n. MTCE stands for metric tonnes of carbon equivalent

Figure 1.
Projected carbon emission target paths for the example institution to stabilize global climate at 450 ppmv

uniform sustainability curves, where the university emits more total carbon than what would stabilize climate at 450 ppmv, but is compensated by other communities which reduce their already lower emissions.

Energy use

Examining the local energy use context of the case study institution, the short-term target is 10 percent renewable energy use by 2010, as set by the local state's renewable portfolio standards and applicable to all energy consumers. Institutions in other states or nations should consult their local and regional renewable energy targets for guidance.

While the ideal visionary sustainable target for energy use is 100 percent renewable energy, the mid-term target path on how to reach 100 percent renewable energy differs depending upon whether local contextual goals or modeling scenarios are used. The university's local state government has set a target to use 50 percent renewable energy by 2020 and 100 percent renewable energy by 2050 in its own buildings, providing a contextual sustainability target that institutions within the state could choose to emulate. The thought given to how and why to achieve the renewable energy use targets for the state government in the timeframe specified is unclear, however. Alternatively, the same climate modeling framework developed for carbon emissions can be applied for renewable energy use. Again selecting an average of the 450 ppmv stabilization scenarios (Clarke *et al.*, 2007), the example institutions renewable energy use can be pegged to the projected national fraction of energy production from renewable sources.

The two alternate target paths are presented in Figure 2. All greenhouse gas emission models include some sort of carbon sequestration occurring in the energy source mix, indicating that, for institutions, the actual renewable energy target will likely need to be a higher fraction than is suggested by the modeling.

Water use

Little is more essential to life than water, which acts as a regulator of temperature, sculptor of landscapes, and carrier of nutrients. Water is generally a local resource, so local context is especially important in setting sustainable water use targets. Goals may already be identified in the local context, providing short-term sustainability targets. Certain climates, and even microclimates, provide more water available for use than others, so a national target is unlikely to be amenable to all institutions. As such, a contextual but rigorous quantification of what is a sustainable level of water use should be defined, providing a long-term visionary target of sustainable water use.

The authors suggest applying the definition of sustainable water use as defined by Graedel (2002). This calculation uses the amount of renewable water available in the local watershed(s) in which the university is located and, with certain modifications, allocates a proportion of that water to the university based upon the university's land footprint (see Graedel, 2002 for calculation details). Graedel's method of calculation is:

- determine the total land within the watershed (γ) and the total land area classified as "urban" (ρ);
- determine the land occupied by the university being assessed (Λ);

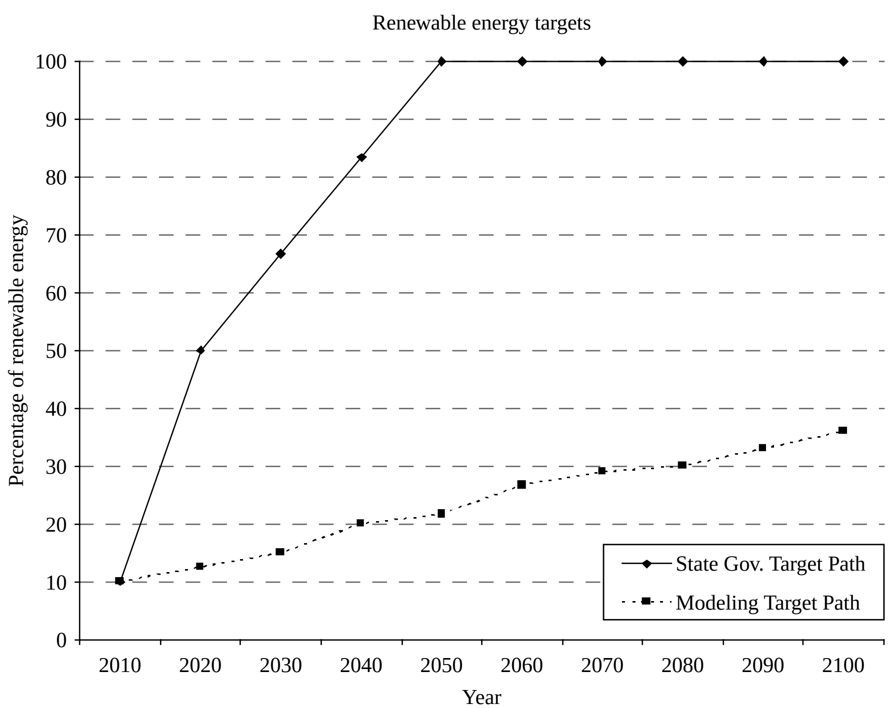


Figure 2.
For the US university example, possible target paths for renewable energy use based upon: locally contextualized policy targets (state government) and greenhouse gas emission model 450 ppmv scenario assumptions of energy production mix

- subtract the university land area that is impervious surface (σ); and
- compute the university's sustainable land use allocation (A):

$$A = \frac{\Lambda - \sigma}{\gamma - \rho} \times N + 50 \times S,$$

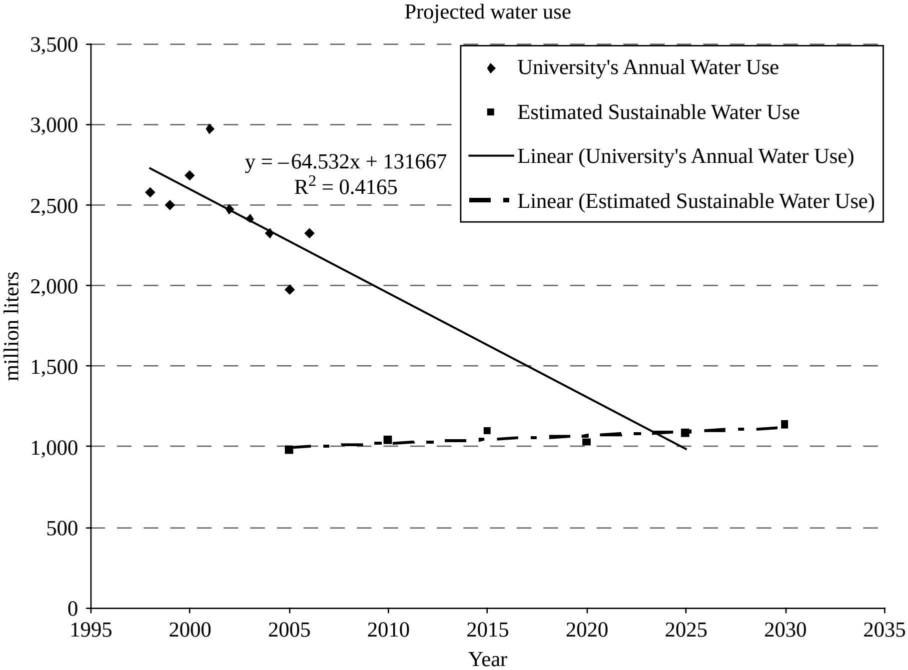
where S is the number of resident students, and N is defined as:

$$N = R - 50 \times P,$$

where R is the recharge rate (precipitation minus evaporation) of the watershed (e.g. l/day) and P is the population contained in the watershed.

To make the calculation tractable, the authors derived from a GIS analysis that 38 percent of the example institution's total land area is covered in impervious surface area (the "land area covered by residential use" in Graedel (2002)), and that the analogue in the watershed is the 31 percent urban land cover calculated for the local watershed (Zajac, 2001). The state's rate of urbanization (approximately 0.5 percent a year (Nowalk and Walton, 2005)), the university's population growth, and the university's land footprint are all underlying variables in Graedel's (2002) formula that model projected sustainable water use. The institution's long-term visionary target for sustainable water use is plotted in Figure 3. The quantity of what would be sustainable water use increases slightly over time as university's land footprint increases in the future.

In the particular case of the example institution, no short-term targets exist for water use, nor do any contextual city, regional, or state targets. As such, having



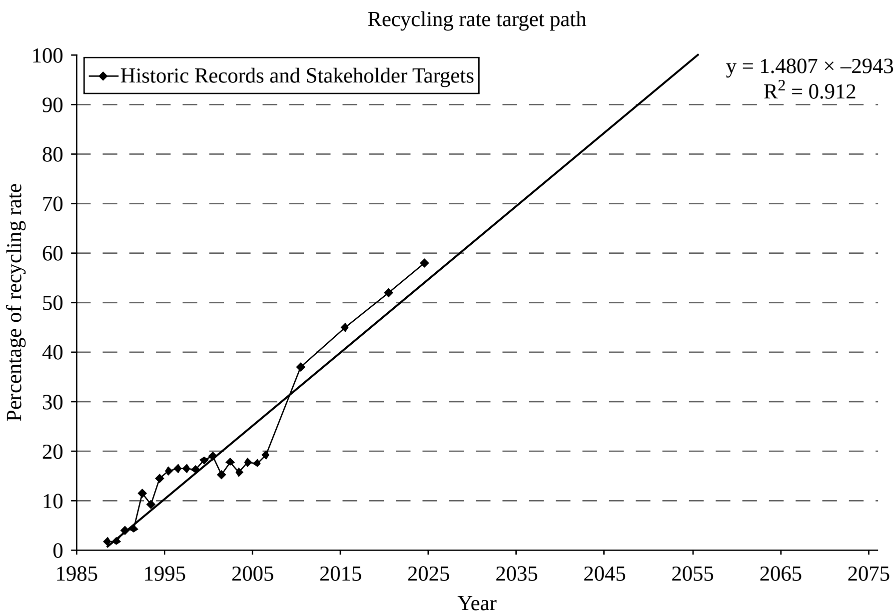
Note: Projected future reduction in water use will intersect the modeled sustainable water use in about 2020

Figure 3.
Target path to reach sustainable water use

created a reference scenario of sustainable water use, historic water use changes at the university is projected into the future. Though past trends may not predict future success, fitting a simple linear regression to data available from 1998 to 2006 indicates a downward trend in water use over this time period. The projection of the trend into the future indicates the mid-term target path to reaching sustainability between 2020 and 2025 (Figure 3), when the example institution's actual water use is projected to cross the amount of water that is estimated to be sustainable. This extrapolation suggests a reduction in water consumption by about 65 million liters per year, or about a 40 percent reduction by 2020 from 2005 levels.

Material output (waste and recycling)

In terms of regional initiatives to contextualize setting a sustainability target, for the university example the local state government had set a goal to reach a 40 percent diversion rate by 2000 (1993 law, PA 93-423), but the recycling rate had only reached about 30 percent by 2005 (CT DEP, 2006). A target path has now been set to achieve a 58 percent recycling rate by 2024, with projected recycling rates at 37 percent in 2010, 45 percent in 2015, and 52 percent in 2020 (CT DEP, 2006). This target path has been selected because it aims to eliminate the in-state waste disposal capacity short-fall by 2024. Using these contextual targets as short-term sustainability goals, as well as the historic change in the recycling rate at the example institution since 1988, a linear regression model was fit and projected into the future (Figure 4). This projection method was used as no recycling rate scenario models were found. The mid-term recycling rate target path depicted in Figure 4 reaches the visionary long-term sustainability target of zero waste (100 percent of discards entering the recycling stream) by around 2060. This result translates into an increasing recycling rate of about 1.5 percent annually.



Note: The linear regression model, with an R^2 of 0.91, fits the >30 year trend in data points very well

Figure 4.
Projected recycling rate targets based upon historic trends and local state and US EPA targets

Conclusion: lessons and perspectives for process framework application

While the metric target results proffered use one US university's approximate set of data, the intent of relaying these results is to illustrate the applicability of the methods described. Once an institution has an adequate data collection system in place for sustainability metrics, it should be able to follow the same methods outlined above to arrive at its own sustainability metric targets. The process framework for developing these metric targets is designed to provide a scientific and logical process methodology, but at the same time to adapt to the unique circumstances that exist at each individual institution. Because sustainability is both global and local, developing metric targets should also follow a process that is global in its scope, but specific in its result. For example, an institution that already recycles over 50 percent of its discards is much further along the path to zero waste than another that presently only recycles 20 percent of its discards, and would adopt a different target path.

The general framework outlined, and the specific application of the framework to certain sustainability metrics, also reconciles shorter-term institutional and generational sustainability goals with longer-term visionary targets. For many institutions, it is not practical today to envision a carbon neutral or zero waste campus, despite the grandest hopes. Institutions set shorter-term targets that go out as far as technology, economics, and their present situations allow. Moving from multiple stakeholder-based targets in the near-term, to projections and scenario modeling in the medium term, provides a target path to follow toward the long-term ideal. And while scenario modeling and historic projection have their own inaccuracies, the target paths they present are vested in logical and scientific reasoning.

Sustainability forces one to think across generations. Setting sustainability targets that may not be achieved in a lifetime is necessary to remain true to the very ethos of sustainability. Short and medium-term targets, to achieve long-term sustainability goals, provide a process path to creating a sustainable institution. Future generations might or might not achieve the targets set, and they will very likely redefine what "sustainability" means in the context of a particular metric, but the least we can do in the present is orient a reasonable path from which they can navigate the future.

References

Australian National University (2008), "Environmental management at The Australian National University: 2007-2008 annual report", ANUgreen – Sustainability Office, Canberra, available at: www.anu.edu.au/anugreen/files/845_ANUgreen-Annual-Report_07-08.pdf

Brown, B.J., Hanson, M.E., Liverman, D.M. and Merideth, R.W. (1987), "Global sustainability: toward definition", *Environmental Management*, Vol. 11 No. 6, pp. 713-9.

Clarke, L.E., Edmonds, J.A., Jacoby, H.D., Pitcher, H.M., Reilly, J.M. and Richels, R.G. (2007), "Scenarios of greenhouse gas emissions and atmospheric concentrations", US Climate Change Program and the Subcommittee on Global Change Research, Washington, DC, available at: www.climatescience.gov/Library/sap/sap2-1/finalreport/default.htm

Cole, L. (2003), "Campus sustainability assessment framework CSAF", Masters thesis, Royal Roads (B.C.) University, Victoria, British Columbia.

Concordia University (2007), "Blueprints for change, Concordia sustainability assessment 2007", Sustainable Concordia, Montreal, available at: http://sustainable.concordia.ca/ourinitiatives/assessment/index.php

CT DEP (2006), "State of Connecticut, state solid waste management plan", Connecticut Department of Environmental Protection, Hartford, CT, available at: www.ct.gov/dep/lib/dep/waste_management_and_disposal/solid_waste_management_plan/swmp_final_chapters_and_execsummary.pdf

Graedel, T.E. (2002), "Quantitative sustainability in a college or university setting", *International Journal of Sustainability in Higher Education*, Vol. 3 No. 4, pp. 346-58.

Lozano, R. (2006), "A tool for a graphical assessment of sustainability in universities (GASU)", *Journal of Cleaner Production*, Vol. 14, pp. 963-72.

Michigan State University (2007), "Campus sustainability report", Office of Campus Sustainability, University Committee for a Sustainable Campus, East Lansing, MI, available at: www.ecofoot.msu.edu/c.s.report.htm

Nowak, D.J. and Walton, J.T. (2005), "Projected urban growth (2000-2050) and its estimated impact on the US forest resource", *Journal of Forestry*, Vol. 103 No. 8, pp. 383-9.

Parker, H.W. (2002), "Sustainability as a process", in Sikdar, S.K. (Ed.), *Sustainable Engineering Conference Proceedings, American Institute of Chemical Engineers Annual Meeting, November 3-8*, pp. 2-12.

Rauch, J.N. and Newman, J. (2009), "Setting a greenhouse gas emission reduction target at Yale", *International Journal of Sustainability in Higher Education*, Vol. 10 No. 2.

Speth, J.G. (2004), *Red Sky at Morning*, Yale University Press, New Haven, CT.

University of Edinburgh (2008), "Policies & reports", Energy and Sustainability Office, Edinburgh, available at: www.eso.ed.ac.uk/PoliciesAndReports/index.shtm

US DS (2002), "US climate action report 2002", US Department of State, Washington, DC, available at: www.gcrio.org/CAR2002/

US EPA (2006), "Inventory of US greenhouse gas emissions and sinks: 1990-2004", US Environmental Protection Agency, Washington, DC, available at: www.epa.gov/climatechange/emissions/downloads06/06_Complete_Report.pdf

Valentin, A. and Spangenberg, J.H. (2000), "A guide to community sustainability indicators", *Environmental Impact Assessment Review*, Vol. 20, pp. 381-92.

Worster, D. (1993), "The shaky ground of sustainability", in Sachs, W. (Ed.), *Global Ecology*, Zed, London, pp. 132-45.

Wright, T.S.A. (2002), "Definitions and frameworks for environmental sustainability in higher education", *International Journal of Sustainability in Higher Education*, Vol. 3 No. 3, pp. 203-20.

Zajac, R. (2001), "On-line atlas of the Quinnipiac River watershed", University of New Haven, West Haven, CT, available at: http://qrwgis.newhaven.edu/index2.htm

Further reading

Board on Sustainable Development (1999), *Our Common Journey*, National Academy Press, Washington, DC.

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