HIGHER EDUCATION AND SUSTAINABLE DEVELOPMENT

A model for curriculum renewal

Cheryl Desha and Karlson 'Charlie' Hargroves

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HIGHER EDUCATION IN URGENT AND CHALLENGING TIMES

The higher education sector faces its most significant challenge since emerging in the 12th century: to equip society with knowledge and skills to address unprecedented environmental threats and population pressures. The imminent risk from inaction to reduce greenhouse gas emissions, curb energy demand and adapt to extreme weather patterns and temperature fluctuations means that capacity building is urgently required across all professional disciplines and vocational programs.

In this chapter we briefly overview why these times are 'urgent', considering growing pressures on the environment, growing economic impacts of environmental issues, and growing levels of enforcement (from regulation and policy changes, and professional body and accreditation agency requirements). We also discuss why these times are 'challenging', considering the scale and complexity of efforts required in a short period of time, alongside an increasing pace of technological innovation. The literature suggests that within the next decade there are likely to be abrupt market, regulatory and institutional shifts responding to global challenges, which will require graduates to be equipped with a range of new knowledge and skills.

While many authors have commented on the slow nature of curriculum for the last half-century, there is a lack of literature addressing how the process may be accelerated. Without such strategic guidance it is not surprising that universities and educational institutions around the world are struggling to update curriculum at a pace that matches societal progress. This is creating a time lag dilemma for the higher education sector where the usual or 'standard' timeframe to update curriculum for professional disciplines is too long to meet changing market and regulatory requirements for emerging knowledge and skills.

We conclude that given the current state of affairs, curriculum renewal activities must be accelerated, paying attention to the complexity embedded in producing graduate and postgraduate students within useful timeframes.

As the tertiary education sector transitions to significantly embed sustainability into its offerings over the next decade or so, a range of strategies will be used by higher education institutions. In this chapter we briefly discuss a number of risks and rewards associated with embedding sustainability into the curriculum, and highlight a number of organisations working to assist those who are transitioning their curricula now.

Introduction

With considerable growth and development of higher education over the last century, the effectiveness of preparing professionals to contribute to society would appear to be 'fait accompli'. The higher education sector has risen to the challenge of times of rapid change and upheaval, such as the industrial revolution and the world wars.[1] The first recognised universities grew out of 'cathedral schools' in 12th-century Europe. Devastated by Germanic and Viking invasions, cities demanded trained elites to serve the bureaucracies of the church and fill the emerging professions of the clergy, the law and medicine. The European universities of Oxford and Cambridge actually arose through emulating the successes of the earliest known universities in Paris and Bologna. The British then exported their model of higher education to North American colonies and quickly founded nine colonial colleges before the American Revolution, including Harvard in 1636 and Princeton in 1748.

The industrial revolution, which began in 18th-century Britain, forced universities away from their traditional medieval curricula (which included arts, theology, law and medicine) into a new era of natural, physical and social sciences. Industrial society required the invention of the modern research university and the technical college to teach applied sciences, such as chemistry, biology, engineering and medicine. Towards the end of the 19th century, student numbers had increased all over Europe and dramatically in the United States. During the first half of the 20th century, economic demands influenced the course of university curriculum. For example, in the sciences, as institutions focused on improving their research capacity, the focus shifted to fields that could directly improve industrial production, such as physics and chemistry. By the Second World War in the 1940s, a huge variety of academic disciplines could be found all over the world.

Now at the end of the first decade of the 21st century, higher education is entering urgent and challenging times where compelling evidence suggests that the imperative is now to rapidly and effectively incorporate education for sustainability (EfS) across all education programs. Despite successes in incorporating the digital wave of innovation into programs over the last two decades, signals clearly suggest that higher education has been slow to move to incorporate sustainability, and is generally poorly prepared to do so.[2]

> New forces are transforming higher education at a speed that could not have been foreseen 10 years ago . . . Higher education institutions play a strategic role in finding solutions to today's leading challenges in the fields of health, science, education, renewable energy, water management, food security and the environment . . . We need higher education institutions to train teachers in the conduct of pedagogical research and develop relevant curricula that integrates the values of sustainable development.
>
> Mr Walter Erdelen, Assistant Director-General for Natural Sciences, UNESCO[3]

David Orr, one of the world's leading environmental educators, has argued for decades that the planetary crisis we face is a crisis of education.[4] Sustainability, or sustainable development, poses educators the significant task of renewing programs to provide knowledge and skills in a range of relatively new areas across industry, government and society, in both developed and developing countries. Ian O'Connor, Vice Chancellor of Griffith University, spoke about this challenge at the Green Cross International 2006 Earth Dialogues forum (chaired by President Gorbachev), concluding,

> Higher education is beginning to recognise the need to reflect the reality that humanity is affecting the environment in ways which are historically unprecedented and which are potentially devastating for both natural ecosystems and ourselves. Like the wider community, higher education understands that urgent actions are needed to address these fundamental problems and reverse the trends . . . The urgent challenge for higher education now is to include ecological literacy as a core competency for all graduates, whether they are in law, engineering or business.[5]

A number of studies have since been undertaken in various parts of Europe, the United States and Australia in particular, to understand the state of higher education in providing education for sustainability opportunities for students. Typical of these is the 2007 UK Higher Education Funding Council for England study, which found that sustainable development education was disparate and widely dispersed across higher education institutions.[6] For the most part this comprised 'education *about* sustainable development' including awareness lessons or theoretical discussions, rather than education *for s*ustainable development, which increases the capacity of individuals, groups or organisations to act, through developing knowledge and skills.

Such findings are supported by our work in Australia on energy efficiency education over the last six years,[7] where we have found significant mismatches in what industry expects should be taught, what faculty think they are teaching, and what students think they are learning. We have found actual knowledge and skill development to be *ad hoc* and highly dependent on the expertise and interests of individual champions. Often this has no foundation in the overall program design, instead being 'bolt-on' attempts to embed sustainability within the curriculum.

Living in 'urgent' times

As 'Generation X' authors with engineering training, we are self-professed problem solvers and keen to get into the solution space of 'how to' engage in capacity building that makes a difference! However – following our own advice to others in 'whole system thinking' – we realise the importance of first appreciating the full extent and context of the problem. With this in mind, we use the following several pages to reflect on the question, 'what are the issues with 21st-century living that are so urgent to address?'

Growing pressures on the environment

As a result of the impact of the first 200 years of the industrial revolution, the second and third decades of the 21st century are shaping up to be characterised as the time in human history when the impact from our collective activities on our Earth grew to a scale that threatened the very conditions that support life as we know it. Furthermore, we like to think that our grandchildren will look back at this period as a time when there was a swift movement to significantly reduce environmental pressures while strengthening economies around the world.

Since 2002 the work of The Natural Edge Project and its partners has been focused on assisting efforts to achieve such a movement, by contributing to, and succinctly communicating, leading research, case studies, tools and strategies across government, business and civil society (see *The Natural Advantage of Nations*,[8] *Cents and Sustainability*,[9] *Whole Systems Design*,[10] *Energy Transformed*,[11] *Water Transformed*,[12] and *Factor 5*[13]). In this work our team has focused on a selection of key pressures on the environment, namely reducing greenhouse gas emissions, reducing impacts on biodiversity and natural systems, improving freshwater management, reducing waste production, and reducing air pollution. In each of these areas pressures on the environment have reached levels previously unobserved throughout history, and scientists are finding themselves analysing and attempting to quantify projections and predictions into unknown territory, often with an unknown number of variables to take into account. As it is outside the scope of this book, we provide a summary of material presented in *Cents and Sustainability* in Table 1.1 to demonstrate the severity of the impacts of environmental pressures, and refer readers to this work and the many works referenced within.

TABLE 1.1 Examples of environmental pressures set to increase with additional population growth and economic development

Greenhouse gas emissions: Considerations include increasing greenhouse gas concentrations, increasing temperatures, melting ice sheets, and melting permafrost.

- As Dr Rajendra Pachauri, IPCC Chairperson, states: 'The increased evidence of abrupt changes in the climate system, the fact that CO_2 equivalent levels are already at 455ppm, plus the current high rate of annual increases in global greenhouse gas emissions reinforces the IPCC's 4th Assessment finding that humanity has a short window of time to bring about a reduction in global emissions if we wish to limit temperature increase to around 2ºC at equilibrium'.[14]
- The 2006 UK Stern Review concluded that within our lifetime there is between a 77% and 99% likelihood (depending on the climate model used) of the global average temperature rising by more than 2ºC, with a likely greenhouse gas (GHG) concentration in the atmosphere of 550 parts per million (ppm) or more by around 2100.[15] Modelling by Stern further suggests that to stabilise atmospheric GHG concentrations at or below 550ppm, global emissions must peak between 2020 and 2030 and subsequently decline by 1.5–4% per year.[16]
- Scientists estimate that annual emissions of methane from the thawing of permafrost and wetlands may increase by more than 50% – which would be equivalent to 10–25% of current human-induced greenhouse gas emissions in the atmosphere.[17]
- Current models suggest that if global average warming were sustained for millennia in excess of 1.9–4.6°C relative to pre-industrial values, the Greenland ice sheet may completely disappear, contributing 7m of sea level rise,[18] significantly affecting the 'global conveyor' ocean current which assists in regulating global temperatures.[19]

Biodiversity and natural system resilience: Considerations include current species loss, species committed to extinction, deforestation, desertification, human population dynamics.

- Coral reefs, such as the Great Barrier Reef, are predicted to rapidly bleach if sea surface temperatures increase beyond 1ºC above the usual seasonal maximum, and to potentially die beyond increases of 2ºC. Coral vulnerability is increased due to increasing acidity from ocean absorption of greenhouse gases, and nutrients from land runoff.[20] The current rate of species loss is predicted to accelerate due to climate change such that by 2050 'between 15 and 37% of the species on the earth might be committed to extinction'.[21]
- It is estimated that some 75% of fisheries worldwide are currently fished at or beyond sustainable levels.[22] A 2003 study concluded that 90% of the large fish in the ocean have disappeared since the middle of the last century.[23]
- In Europe, over 80% of crops are pollinated by insects. However, a decline in bee diversity and abundance threatens the viability of many crops this decade. The collapse in bee populations is linked to habitat loss and disease.[24]
- Globally, natural forests are disappearing at a rate of 13 million hectares a year (ha/year, roughly the size of Greece). Regrowth and commercial plantations replaces approximately 5.6 million hectares, leaving a net loss of 7 million ha/year. It is estimated that the natural forests in Indonesia and Myanmar will be gone within 10 years, and those in the Russian Far East within 20 years.[25]
- The Amazon rainforest is approaching an ecological tipping point, where the last remaining forest is unnaturally dry and vulnerable to fire from lightening strikes.[26] It is predicted that this threat will peak when deforestation exceeds 20–30% of the Amazon; it is currently at 17%.[27] In many countries such as Haiti,

TABLE 1.1 Continued

Madagascar and Malawi, deforestation is resulting in soil loss and a disruption to the hydrological cycle that will result in a collapse of crops in our lifetime.[28]
- In semiarid Africa, human and livestock demands for trees and vegetation are converting large swathes of land to desert; and rapid population growth is exacerbating this trend.[29] Continued degradation has already caused biodiversity and food, water and fibre shortages.[30]

Freshwater extraction: Considerations include global water demand, groundwater depletion, lake water consumption, and effects of climate change.

- Global freshwater use has tripled over the last century, with much of this demand met from aquifers where water is extracted faster than it can be replaced.[31] In Yemen, groundwater resources are depleting so quickly that some towns have access to water only once every 24 days, with the capital Sana'a receiving water once per week. It is estimated that Sana'a will have completely exhausted groundwater sources by 2025.[32]
- Aquifers are being depleted throughout the world causing a significant loss in food production capacity. In Pakistan, it is estimated that the city of Quetta will run out of water by 2016,[33] around the same time the groundwater supplies of the surrounding grain growing region are expected to be exhausted.[34]
- Population pressures have reduced Lake Chapala, the primary water source for Guadalajara, Mexico, to 20% of its volume.[35] In China's Qinhai province, over 2,000 lakes have disappeared over a 20-year period, while in the Hebei province, falling water tables have claimed 969 of the 1,052 lakes which used to exist in the region.[36]
- By 2050, climate change is predicted to exacerbate existing water shortages with areas subject to increasing water stress projected to be twice the size of those with decreasing water stress.[37]

Waste production: Considerations include diminishing landfill space, and diminishing access to finite resources such as oil and precious metals.

- In the United States, at least five states estimate there remains less than 10 years' worth of landfill capacity, after which point waste will need to be trucked into other states and regions.[38] New York City has been trucking waste to landfill sites up to 300 miles (close to 500km) away since 2001.[39]
- In urban areas in China, waste generation is predicted to increase three-fold between 2000 and 2030.[40]
- Assuming annual extraction growth of 2%, US Geological Survey data show economically recoverable reserves of primary lead will run out by 2025, tin by 2027, copper by 2033, iron ore by 2062 and bauxite by 2076.[41] This will lead to a focus on mining urban waste streams and reprocessing vast existing waste sites.

Air pollution: Considerations include (in addition to greenhouse gas emissions) premature deaths and acid rain.

- The WHO estimates there are over 400,000 premature deaths each year due to outdoor air pollution and a further 1.6 million due to indoor air pollution.[42]
- Based on current trends, the OECD projects that the number of deaths in 2010 due to airborne particulate matter will double from approximately 1.5 million to just over 3 million by 2050.[43]
- Climate change may exacerbate existing air pollution issues through increased ozone and VOC formation, increased frequency of forest fires, and the potential formation of inversion zones trapping pollutants at ground levels.[44]
- In China, acid rain affects just under one-third of the country and around half of the cities and counties being monitored.[45] In some cities, all precipitation is in the form of acid rain.[46] NOx and SOx emissions are generated primarily in China's coal-fired power plants and from burning oil, and recent projections suggest that annual coal consumption will reach 3.8 billion tonnes by 2015, an increase of 800 million tonnes compared to 2009.[47] Further, the increase in greenhouse gas emissions from China's coal use is predicted to exceed that of all industrialized countries combined by 2031, surpassing by five times the reduction in such emissions that the Kyoto Protocol seeks.[48]

Source: Summarised from Smith, M., Hargroves, K., and Desha, C. (2010)[49] with references noted within table.

Growing financial impacts on economies

> The 'business as usual' model, where profits come before sustainability, is absolutely finished. We now have a window of 10 to 15 years (up to 2017–2022) to adopt a sustainable approach before we reach a global 'tipping point' – the point at which mankind loses the ability to command growth and development.[50]
>
> Jonathon Porritt, Founding Director, Forum for the Future, Chairman of the UK Sustainable Development Commission, and author of *Capitalism as if the World Matters*

As Jonathon Porritt so powerfully reflects, mankind is running the risk of losing the ability to 'command growth and development' without regard for natural systems. What makes the early 21st century such a time of urgency is the fact that not only is the scale of environmental pressure creating impacts that will threaten the Earth's ability to sustain the conditions we have grown accustomed to, the change in these conditions will have a meaningful impact on economies around the world. As can be seen from Figure 1.1 the trends in GDP are now being replicated in the growth of direct and indirect costs related to environmental damages.

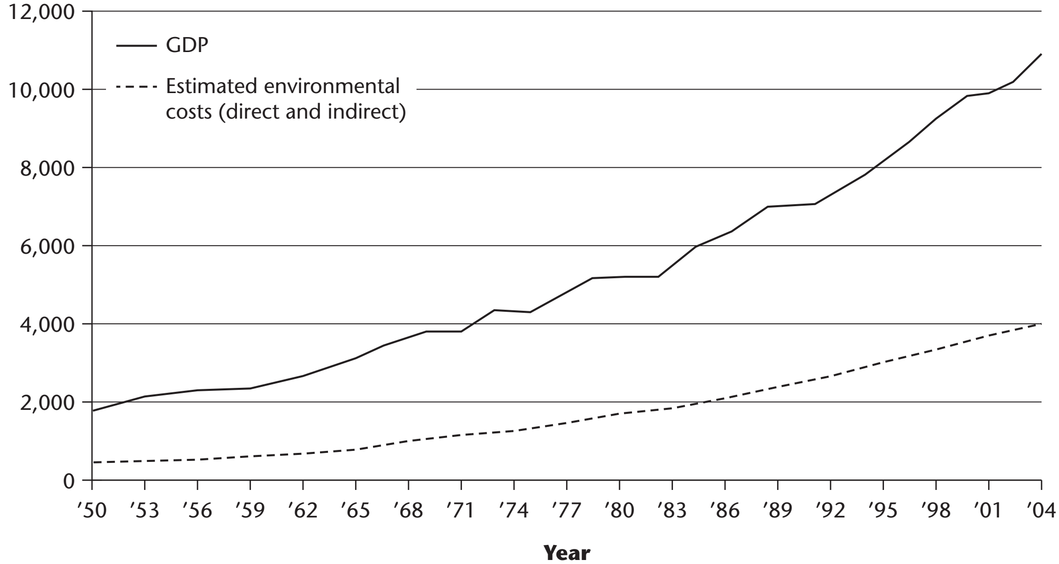

FIGURE 1.1 Gross Domestic Product vs. Estimated Environmental Costs (billions) for the US from 1950–2004

Source: Data reinterpreted by K. Hargroves from J. Talberth *et al.* (2006)[51], and presented in Smith, M., Hargroves, C. and Desha, C. (2010)[52]

This coupling of costs related to environmental pressures and economic growth is now evident across each of the key areas listed above. For brevity, we provide a sample of cases discussed in detail in *Cents and Sustainability*:[53]

- Greenhouse gas emissions: In 2006 a study on the economics of climate change estimated that each year on average the cost to the global economy of not acting to reduce greenhouse gas emissions could be in the order of 5–20% of GDP, compared to an estimated 1% cost of acting to stabilise emissions.[54]
- Biodiversity: In 2006 a study on biological diversity concluded that, 'The intensification of fishing has led to a decline of large fish. In the North Atlantic, their numbers have declined by 66% in the last 50 years,' with this having economic impacts on fisheries globally .[55]
- Water consumption: In 2004 a study on the millennium development goal of halving the population without access to water and sanitation by 2015 estimated that this would cost in the order of US$10 billion annually, and the cost of not achieving it would be in the order of US$130 billion annually.[56]
- Waste production: In 2001 leading environmental business advocate Amory Lovins stated that: 'It is extremely profitable to wring out waste, even today when nature is valued at approximately zero, because there is so much waste – quite an astonishing amount after several centuries of market capitalism.'[57]
- Air pollution: In 1996 a study found that the economic losses due to health costs of air pollution in India in 1995 was slightly over the amount of growth of GDP for that year, meaning the growth in GDP was invested in addressing health costs.[58] In 2006 a study on agricultural economics estimated that reductions in crop yields from tropospheric ozone in Europe was in the order of €4.4–9.3 billion/year.[59]

Growing levels of enforcement

History clearly shows that humanity takes time to acknowledge, accept and then deal with issues that have widespread and significant ramifications on daily life.[60] Over the last two decades there have been a number of declarations and action plans developed to encourage and assist the higher education sector to incorporate the imperative to reduce environmental pressures, as shown in Table 1.2.

> Universities educate most of the people who develop and manage society's institutions. For this reason, universities bear profound responsibilities to increase the awareness, knowledge, technologies and tools to create an environmentally sustainable future.[61]
>
> Talloires Declaration, 1990

According to the Copernicus Alliance in 2012

> Perhaps the greatest challenge of all is to reorient the higher education curriculum so that it aligns with sustainable development. This requires not just the inclusion of relevant subject matter and the pursuit of inter- and transdisciplinary approaches, but also the development of education for sustainable development competences of university and college educators as well as learners. Competences associated with: systemic thinking; critical reflective thinking; futures engagement and values clarification; the ability to deal with complex and contradictory situations; the capacity to work in partnership in order to facilitate transformative actions towards sustainability are vital . . . The curriculum gate-keepers, professional bodies, government agencies, student groups and academic development bodies as well as teaching colleagues have a key role to play to achieve this ambition.[62]

TABLE 1.2 Examples of declarations and action plans promoting education for sustainability

Date	*Declaration*	*Brief Description*
1990	The Talloires Declaration	A ten-point action plan for colleges and universities committed to promoting education for sustainability and environmental literacy in teaching, research, operations and outreach at colleges and universities.[63]
1992	Agenda 21	Chapter 36 articulated the need for education to play a key role in addressing the challenge of sustainable development.[64] This was subsequently acknowledged in a range of documentation around the world.[65]
1997	Thessaloniki Declaration	A declaration signed by 83 countries on the need for public awareness and education for sustainability.[66]
1998	World Declaration Higher Education in the 21st Century	A declaration that articulated the need for a critical mass of skilled and educated people to ensure sustainable development.[67]
2000	United Nations Earth Charter	Provided a statement of ethics and values for a sustainable future, including the need for education for sustainability.[68]
2001	Lüneburg Declaration	Endorsement of Agenda 21 and numerous other declarations around the role of higher education in education for sustainability in preparation for the 2002 World Summit on Sustainable Development.[69]
2002	Ubuntu Declaration	Declaration for all levels of education, highlighting the need for education in science and technology for sustainable development.[70]
2002	Decade of Education for Sustainable Development (DESD) 2005–2014	Led by Japan, the DESD created a global platform for dialogue in the higher education sector. Since the declaration there has been a rapid growth of education for sustainability literature around the role of universities in education, research, policy formation and information exchange necessary to make sustainable development possible.[71]
2009	G8 University Summit Declaration	Declaration on research and education for sustainable and responsible development, locally and globally.[72]
2009	World Conference on Higher Education Communiqué	A detailed account of what should be occurring in higher education institutions, and a call for action for member states and UNESCO.[73]
2010	AASHE Call to Action	A call to action for sustainability curriculum in higher education, by the Association for the Advancement of Sustainability in Higher Education, based in America.[74]
2012	People's Sustainability Treaty on Higher Education	Drafted by representatives from 25 higher education agencies, organisations, associations and student groups to create a consolidated platform for cooperation beyond the Rio+20 event in June 2012.[75]

Source: References noted within.

Despite such declarations that highlight the significant impacts that our global society is having on the environment, and the ramifications this in turn will have on global economies, there is very little actual commitment to act on a meaningful scale. As with any new stage of development there are those who are first to act, and who take the early risks and position themselves well for the future. These leading efforts then inspire others to follow and demonstrate what can be achieved with dedicated effort. Again rather than outlining these leading efforts herein we provide a sample as presented in *Cents and Sustainability*:[76]

- Greenhouse gas emissions: The UK Government's 'Code for Sustainable Homes' is the first national legislation to set minimum standards for energy performance in new homes, calling for reductions in energy use compared to 2006 standards of 25% by 2010, 44% by 2013, and 100% (zero emissions) by 2016.[77]
- Biodiversity: When the Korean War ended, South Korea was largely deforested. Since the early 1960s the government has initiated programs to achieve some 6 million hectares of tree planting, nearly 65% of the country.[78]
- Water consumption: In Bogor, Indonesia, the water tariff was increased from US$0.15 to US$0.42 per cubic metre, resulting in households decreased demand by 30%. In São Paulo, when effluent charges for industry were introduced, three industries decreased their water consumption by 40–60%.[79]
- Waste production: In 2006 the European Union released its 'Restriction of Hazardous Substances'[80] (RoHS) directive that then triggered an international response with the percentage of RoHS-compliant manufacturers rising from 51% to over 93% in nine months,[81] and aligned policies were introduced in China in 2007[82] and in South Korea in 2008.[83]
- Atmospheric pollution: A succession of agreements by European countries has resulted in a decrease in sulphur and other air emissions. The 1983 'Convention of Long Range Trans-boundary Air Pollution' set a target for emission reduction of 30% compared to 1980 levels.[84] The Convention was updated twice, and was followed by the 1994 'UNECE Second Sulphur Protocol', which set a target for emission reduction of 50% by 2000, 70% by 2005, and 80% by 2010.[85] During 1980–1998, European sulphur dioxide emissions decreased by over 70%, while GDP grew by 44%.[86]

These and an increasing number of examples of leadership from governments are now creating real precedent for industry, business and society to act to reduce impacts on the environment.[87] Considering the economic impacts already being felt from the growing levels of environmental pressures, it is clear that the current low levels of compliance on environmental performance required by governments will rapidly increase in the near future, shown stylistically to begin at a hypothetical 'Time (t)' in Figure 1.2. Factors that will influence the timing of 'Time (t)' will include the level of perceived economic risk from environmental damage and potential collapse of ecological systems such as bee communities required for wide-scale pollination, fish stocks, storm surges and sea-level rises, increased natural disasters, and so on. Following 'Time (t)' the level of environmental performance of an organisation, business or education institution will dictate the pace at which action is taken to comply with enforcement. When requirements for change begin to ramp up in the near future, those institutions that have maintained 'compliance' or lower will have a very steep curve requiring significant action, while those that have improved performance in anticipation of the transition will have a stronger strategic position.

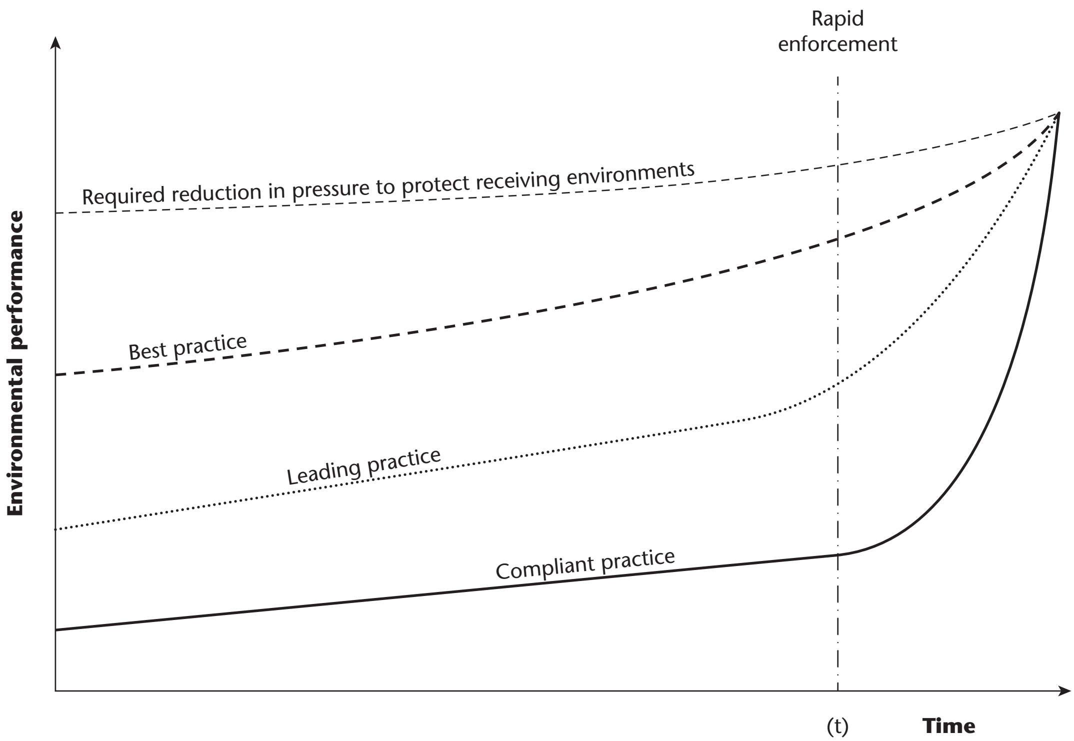

FIGURE 1.2 Stylistic representation of levels of commitment to reducing environmental pressures

Source: Smith, Hargroves and Desha (2010)[88]

> In its sixty years of existence, the IAU [International Association of Universities] has witnessed significant changes that are shaping higher education as well as the increasing pressure placed on higher education systems and institutions to change so that they meet national development objectives and individual aspirations. This pressure has probably never been as great as today . . . Higher education institutions retain their mission to educate, to train, to undertake research, and to serve their communities but are asked to do so in a rapidly changing environment . . . Higher education institutions are asked to equip increasing numbers of learners with the knowledge, skills, and critical thinking that will ensure their employability and respond to national sustainable development objectives . . . A very tall order – although I mentioned only some of the challenges that higher education institutions are facing – which attests to the vital contribution of higher education and its institutions to sustainable national development.[89]

Within the higher education sector, the anticipated rapid increase in compliance requirements will be evident in a range of ways, such as regulatory and policy changes to enforce improved environmental performance in industry and business practices requiring changes to graduate attributes; professional body and accreditation agency requirements for specific graduate attributes to be included in education programs; funding agencies requiring incorporation of related topics in research grant and capital funding applications; and a significant increase in demand from potential employers for graduates with associated graduate attributes.

Regulation and policy changes

Changes to regulations and policy will impact universities in a range of different ways including changes to research and teaching policies and through direct regulation of industry, business and organisational practices. Governments are increasingly modifying selection criteria for research funding to include clear and increasingly stringent requirements to demonstrate the contribution of the research proposal to assisting society to reduce environmental pressures. An example of this is the Australian Government's four National Research Priorities including 'an environmentally sustainable Australia' and 'frontier technologies for building and transforming Australian industries'. In relation to teaching policy, governments are likely to link federal funding for higher education institutions to their ability to address education for sustainability and to integrate associated knowledge and skills into curricula (in a similar manner to the way in which institutions currently track integration of priority areas such as indigenous knowledge and research-led teaching).

There are also a growing number of examples of increasingly stringent environmental reporting and performance requirements on business, such as the Australian Energy Efficiency Opportunities (EEO) program. The program was launched in July 2006 and required businesses that used more than 0.5 PJ (139,000 MWh, equivalent to the energy use of around 10,000 households) of energy per year – some 220 businesses representing around 45% of national energy demand – to undertake an energy efficiency assessment and report publicly on opportunities with a payback period of up to 4 years.[90] Extending this, the Victoria State Government was the first state to require all EPA license holders using more than 0.1 PJ (27,800 MWh per year) to implement opportunities with a payback period of up to 3 years in order to retain their licence.[91]

By imposing such public reporting, businesses were forced to undertake an internal process to identify energy efficiency opportunities knowing that the results would be publicly scrutinised by customers and shareholders. The value of the results was that managers and shareholders could see the range of potentially profitable activities that could be undertaken in a 4-year period to reduce energy demand. A 2008 progress report found that 'the 199 corporations reported that assessments had identified over 7,000 opportunities to improve energy efficiency with the potential to save 62.5 PJ of energy with a better than four year payback (the equivalent of 5.7 million tonnes of CO2-e) and $626 million in net annual financial savings'.[92] A significant finding of the program was that there was a lack of capacity in industry and business to understand the program requirements and report on energy efficiency opportunities. The program found that 'Almost 40% of survey participants did not consider the requirements of the EEO Legislation and associated reporting easy to understand'.[93]

Following this finding the government initiated an investigation into the development of a 'Long Term Training Strategy for the Development of Energy Efficiency Assessment Skills', across the energy-intensive industries, energy service providers and universities.[94] The findings of this study have been used to catalyse a number of other exploratory studies in vocational education and training (national context) and higher education (engineering and business), across departments including 'Resources, Energy and Tourism', 'Industry, Innovation, Climate Change Science, Research and Tertiary Education', and 'Sustainability, Environment, Water, Population and Communities'. It also informed the development of a National Energy Efficiency Advisory Group on engineering curriculum renewal (described further in Chapter 2), which has worked with the Institution of Engineers Australia to explore emerging expectations for undergraduate engineering education in the area of energy efficiency knowledge and skill development (led by the authors).

Reflecting on the original EEO program and its ambitions, it is clear that the program has had a direct impact on the tertiary education sector in the topic area of energy efficiency education. In this example, regulation led to uncovering gaps in knowledge and skills, which catalysed the exploration of issues and subsequent federal interaction with professional organisations to address remedial action in the education sector. Budgets were also created within four federal departments for structural adjustment within the tertiary education sector around energy efficiency. Several programs then targeted capacity-building initiatives that directly involved collaboration between educational institutions, professional organisations and industry. In this particular 'Time (t)' transition, the half a dozen or so Australian higher education institutions with expertise and existing curriculum in energy efficiency positioned themselves well to receive funding and recognition, manoeuvring into a post-t leadership position in the sector.

In 2007, The Natural Edge Project collaborated with CSIRO and Griffith University to develop a comprehensive free access online resource to assist professionals and students to build capacity in energy efficiency – 'Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation', containing 30 lectures of peer reviewed materials.[95]

Professional body and accreditation agency requirements

Within regulated disciplines such as engineering, business and law, program accreditation is a strong driver of change, setting a review period of 3–6 years for universities to reflect on and demonstrate how they have addressed accreditation requirements in their program/s. Accreditation requirements are influenced by a range of factors including industry requirements, student demands, government policy, the regulatory environment and globalisation.

In the absence of a clear mandate for government to develop legislation to significantly reduce environmental pressures, and current legislative compliance levels being well below what is required (to mitigate climate change, etc.), government and society are increasingly looking to accreditation agencies to take a leadership role. In such a role, accreditation agencies would not only continue to ensure that programs meet compliance, they would also force higher education institutions to go beyond compliance and update programs to include an outcome-based approach to education for sustainability through an enhanced accreditation process. This aspirational role for accreditation agencies goes beyond being the 'professional police' that enforce compliance, to one that both ensures quality of graduates and actively contributes to shaping the future of the profession and its contribution to society.

In the past, accreditation agencies and professional bodies have been largely focused on ensuring compliance with government and industry regulations and expectations and were sound in the knowledge that this was the role society expected them to play. For example, in Australia a 2008 Review of Higher Education by the Australian Deans of Built Environment and Design (ADBED) concluded that accreditation was focused on compliance rather than innovation. Graduate outcomes desired by accreditation panels were those most needed for 'work-ready' graduates (who cater to current employer needs) rather than looking ahead to future expectations.[96] In the UK, a 2008 study by the Higher Education Funding Council found similar barriers to implementation, but also the added barrier of professional bodies themselves, whose perceived conservatism acted as a barrier.[97]

> For universities to maintain their role in the formation of leaders for the emerging Australia, its economies and businesses, the accreditation processes need to maintain a focus on innovation and leadership rather than 'training for work'.[98]

However, there are clear signs of changing attitudes regarding the role of accreditation, with a number of professional engineering institutions already embedding sustainability language into codes of ethics and graduate competency statements.

For example, the Royal Academy of Engineering (RAE) argues that 'the accreditation process for university engineering courses should be proactive in driving the development and updating of course content, rather than being a passive auditing exercise'.[99] Furthermore, it promotes sustainable development concepts through a published set of twelve 'Guiding Principles' for engineering for sustainable development in a document that also provides examples and applications for curriculum implementation.[100] It has sponsored a visiting professors scheme in the UK since 1998 to embed the topic of engineering for sustainable development into engineering courses, rather than creating a separate subject. The importance of accreditation as a driver for curriculum renewal is also reflected in countries such as Australia and the United States. In Australia, reviews of the Stage 1 (graduate) and Stage 2 (professional) Competency Standards that underpin program accreditation catalysed the embedding of sustainability elements throughout the competency statements. In America, the Accreditation Board for Engineering and Technology (ABET) has also embedded language regarding the design of systems, components or processes to meet desired needs within realistic constraints including sustainability considerations, supported by documents such as the Society for Civil Engineers' code of ethics, which embeds sustainability into its tenets of practice.

In 2010 we ran a workshop on engineering education and accreditation in Ireland with our Cork University colleagues, as part of the International Symposium on Engineering Education.[101] The focus was in ground-truthing an observed correlation between levels of sustainability-related curriculum renewal across certain regions and countries globally and the introduction of sustainability concepts within accreditation documentation of corresponding regional professional bodies. Findings of this workshop reinforced literature observations, showing at best a wide range of opinions and understandings and a general disparity among what key sustainability themes for engineering curricula should be among academics and practitioners. It did highlight several priority themes to consider regardless of discipline.

> At the 2010 International Symposium on Engineering Education workshop in Ireland, education about 'resources' was identified as the most common priority area for focus over the next 5 years. This was followed by renewable fuel sources, life cycle analysis/management and water. Other priority themes for embedding regardless of discipline included ethics and responsibility, design/systems thinking, and thermodynamics.[102]

Within this context, it is clear that the opportunity provided by accreditation processes is increasingly important, developing criteria and guidance for embedding sustainability into the curriculum. Moving forwards, the role becomes one of ensuring that the intentions of such criteria are embedded within the programs. This will require addressing a range of barriers to overcome challenges associated with understanding ways to meet new accreditation criteria, being able to evaluate sustainability-related competencies during accreditation reviews, and empowering accreditation panel members who are often volunteers with their own time and resourcing constraints.

Living in 'challenging' times

Following an appreciation of what it means to live in urgent times, it could be argued that this is fine, so long as we can address such issues quickly. However, in a number of global examples such as available fish stocks, access to fossil fuel and changing climate patterns, we can see that this has not been possible. With this in mind, we use the following several pages to reflect on the question, 'what are the issues with 21st-century living that are so challenging to address?'

Economy-scale efforts required in a short period of time

As the majority of the activity in the economy exerts some form of environmental pressure, economy-wide efforts will be required to reduce such pressure on a meaningful scale. Further, such efforts need to ensure that economic performance is maintained, referred to as the challenge to 'decouple economic growth from environmental pressure'.[103] This challenge, represented in Figure 1.3, calls for the growth of environmental pressures to be reduced 'relative' to economic growth and where possible completely

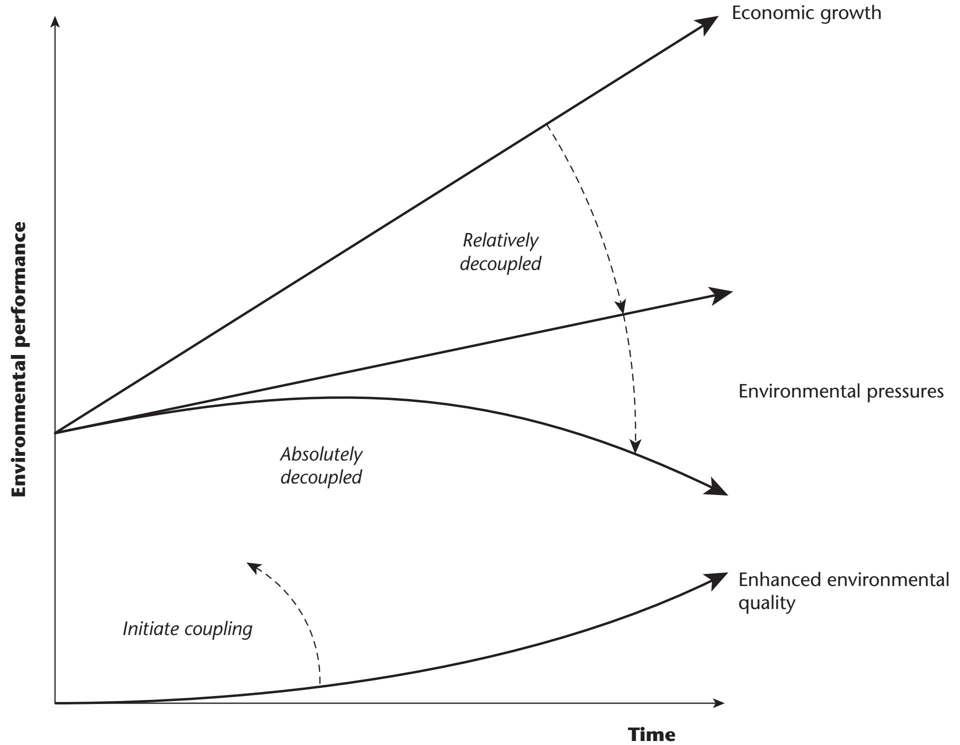

FIGURE 1.3 Conceptual and stylised representation of a decoupling graph

Source: Developed by Karlson Hargroves, Peter Stasinopoulos, Cheryl Desha and Michael Smith, in Smith, Hargroves and Desha (2010)[104]

– or 'absolutely' – decoupled from improved economic performance. Furthermore, positive environmental impacts (for example, reforestation, aquifer recharge, etc.) would be 'recoupled' to economic performance so that as development proceeds, environmental systems are restored.

> Action to achieve decoupling across entire economies will call for significant reorientation of systems, legislation, standards practices, etc. and may pose the most significant challenge to the human race in its history.

In the following paragraphs we provide a summary of the example of reducing environmental pressures, as detailed in *Cents and Sustainability*.[105]

It is now well established that absolute decoupling is required to achieve a stabilisation of atmospheric concentrations of greenhouse gases in the order or 450–550 parts per million (ppm) by 2050, to avoid dangerous climate change.[106] There is a range of scenarios for achieving this goal that are affected by the rate at which emissions are reduced over time. In each scenario, the current growth in emissions needs to be stopped to create the peak of the absolute decoupling curve requiring a focus on short-term performance, and the levels of emissions across entire economies need to be gradually reduced each year over some 30 to 50 years, requiring a medium- to long-term strategy. The level of sustained reduction is dictated by the timing and height of the peak with Figure 1.4 showing that peak in say

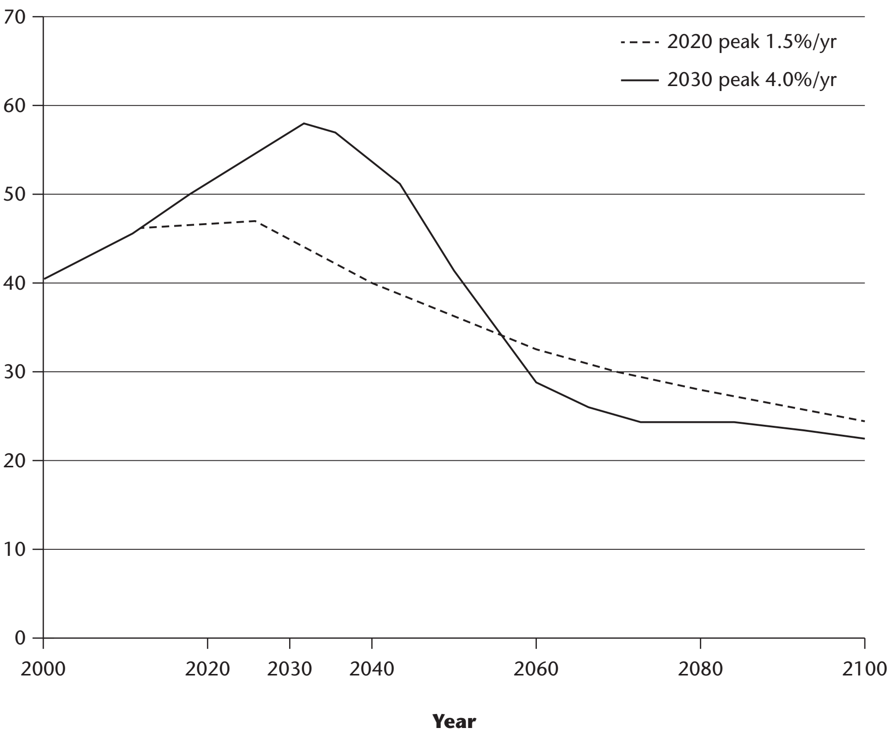

FIGURE 1.4 Illustrative pathways to stabilising greenhouse gas emissions at 550ppm CO_2e

Source: Based on data from Stern, N. (2006)[107]

2020 will result in a lower annual reduction target than a peak in 2030 with both curves achieving 550ppm.

Hence the challenge for economies around the world is to rapidly achieve a low peaking in emissions, around 2020, to then allow a more manageable annual reduction target. The challenge of the higher education sector is that the timeframe to achieve peaking does not allow for the required knowledge and skills,[108] which are largely yet to be incorporated into undergraduate programs, to be developed over the standard curriculum renewal timeline, meaning that it will be largely a postgraduate and professional development challenge. Further, in order to prepare undergraduates to contribute to society achieving gradual sustained reductions after the peaking is achieved, the standard curriculum renewal process will need to be improved and accelerated.

In practice this calls for a dual focus, both on engaging with current practitioners and decision makers around knowledge and skills required to peak greenhouse gas emissions (such as postgraduate certificates, diplomas and Master's programs, along with professional development seminars and short courses), and also focusing on undergraduate programs to develop knowledge and skills required to both continue to maintain the peaking and to then achieve gradual sustained reductions balanced across each sector. In order to achieve absolute decoupling a short-term/long-term approach will be required for each of the major environmental pressures, such as:

- Greenhouse gas emissions: In the short term, highly energy-inefficient processes and appliances can be improved to continue to deliver products and services while using significantly less energy, in many cases as much as 80% less as outlined in *Factor 5*.[109] In preparation for long-term sustained reductions in emissions, low-carbon energy generation technologies need to be innovated, commercialised and brought to scale.
- Biodiversity: In the short term, significant reductions to species loss are required with as much as 40% of species being already lost between 1970 and 2000.[110] In preparation for long-term sustained reductions in pressure on biodiversity and natural systems, a range of approaches to deforestation, fisheries management and control of invasive species need to be developed and implemented.
- Water consumption: In the short term, significant reductions to freshwater withdrawal considering that groundwater extraction rates are exceeding replenishment rates by 25% in China and over 50% in parts of northwest India.[111] In preparation for long-term sustained reductions in water consumption, a range of forestry, agriculture and natural resource management strategies and practices need to be developed, trialled and brought to scale, such as advanced deficit irrigation strategies,[112] holistic resource management methods,[113] and water-sensitive urban design.[114]
- Waste production: In the short term, significant reductions to waste generation are required considering that since 1980 the levels of annual global resource extraction have increased by 36% and are expected to grow to 80 billion tons in 2020.[115] In preparation for long-term sustained reductions in waste generation, a range of design, manufacturing and recycling processes are needed to underpin structural adjustments in a range of industries.
- Atmospheric pollution: In the short term, significant reductions to air pollution are required considering that in 1999 some 10,000 people died prematurely in Delhi due to air pollution, equivalent to one death every 52 minutes.[116] In preparation for long-term sustained reductions in air pollution, a range of new processes and methods are required to reduce emissions of sulphur dioxide, nitrous oxide, lead and particulate matter.

Such dual-track approaches present a significant challenge to the higher education sector, as graduates and professionals need to be up-skilled in areas to contribute to both agendas. As highlighted in a United

Nations Environment Program report on working in a low-carbon world, 'companies in the fledgling green economy are struggling to find workers with the skills needed to perform the work that needs to be done. Indeed, there are signs that shortages of skilled labor could put the brakes on green expansion . . . There is thus a need to put appropriate education and training arrangements in place.'[117]

The pace of technological innovation is increasing

As outlined in *The Natural Advantage of Nations* in 2005, following the industrial revolution society has experienced a series of major waves of technical innovation, with the sixth and current wave underway, which is providing 'a critical mass of enabling eco-innovations making integrated approaches to sustainable development economically viable'.[118]

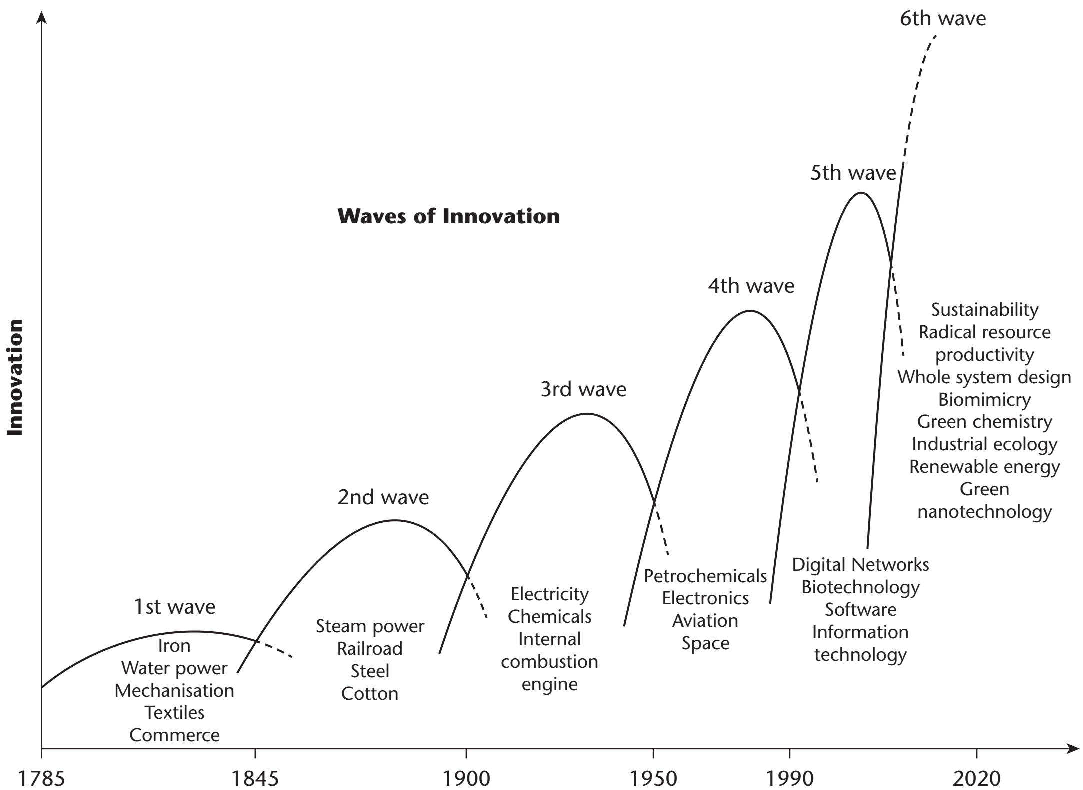

FIGURE 1.5 Waves of Innovation Diagram, showing the associated characteristic technologies

Source: The Natural Edge Project, in Hargroves and Smith (2005)[119]

As Figure 1.5 suggests, the level of innovation has been increasing in each subsequent wave and the timeframe over which the innovations are conceived, trialled, adopted and then form the basis of the next wave, is getting shorter for each new wave. By the early 20th century the world had most of the scientific understanding, enabling technologies and methodologies needed to underpin a number of significant developmental feats. For example, advances in mobility led to trains, cars and planes moving people at a pace and over distances scarcely imaginable when the century began.[120] Air transport connected the world and continued to expand into the 21st century as one of the fastest-rising transport modes – with an 80% increase in kilometres flown between 1990 and 2003.[121] As a result of agricultural innovation and the use of pesticides and inorganic fertilisers, the world grain harvest has quadrupled, and with continued advances in chemistry, global chemical production is projected to increase by 85% by 2020.[122] Humans now have unprecedented access to raw materials and processed goods from around the world, with shipping alone rising from 4 billion tons in 1990 to 7.1 billion tons total goods loaded in 2005.[123]

With this perspective in mind, Table 1.3 outlines how each new wave of innovation calls for the world's economies to be 'upgraded' resulting in significant changes across industry, governance and, in due course, the higher education system. For example, the shift to electrification during the third wave called for education and capacity building in many new areas across the professions, such as engineers and designers learning how to generate and distribute electricity and manufacture electrical fittings and appliances; economists and policy makers learning how to set energy prices; lawyers learning how to consider the new liabilities and risks to infrastructure and equipment from electricity.

TABLE 1.3 Examples of significant capacity-building requirements associated with subsequent waves of innovation

First Wave: Iron, water power, mechanisation, textiles, commerce

- *Canal Design and Construction*: Before the invention of the steam engine, canals proved a vital part of Europe's freight transport network, with canal design and construction a core part of engineering education.[124] At the time, water transport was able to carry bulk goods and freight at a significantly lower cost than was possible on land, with horse power deployed to tow barges on rivers or canals and nearly 2,000km of navigable river by the mid 1700s.[125] However, from the 1830s canal building gradually diminished with the rise of the coal-powered steam railways soon superseding the need for canals.
- *The iron bridge*: The development of a method to economically smelt iron in large quantities in 1709[126] and the production of wrought iron in 1783[127] led to a rapid rise in the popularity of iron bridges. During this time, engineers learnt much about the material properties of iron and its behaviour in compression and tension. However, iron bridges suffered some of the most catastrophic failures in bridge history, including the Tay Bridge Disaster in Scotland where the supporting wrought iron girders collapsed in high winds, killing 75 people.[128] The arrival of economically competitive steel as part of the second wave – a far superior bridge building material – led to the sudden demise of building iron bridges. Engineers turned their attention to steel arches, steel trusses and wire suspension bridges.

Second Wave: Steam power, railroad, steel, cotton

- *Kerosene lamps*: Kerosene lamps became popular in the mid 1850s, when oil wells drilled in America caused the price of oil to fall sharply. As engineers and scientists realised the potential of this light source, nearly 100 patents were granted to fund research and improvements to kerosene-burning lamps.[129] The most promising development to emerge from this research was the incandescent mantle. Unfortunately, the patent for this innovation arrived just as major cities were beginning the switch to the electric light bulb. Although kerosene lamps are still used today, the uptake of electricity led to the demise of research and development into this once promising innovation.
- *The steam locomotive*: Steam technology revolutionised land transport and sparked some of the largest industrial development in human history. Experimentation with steam-powered engines began in 1765, but it wasn't until 20 years later that a Welsh ironworks commissioned a steam locomotive.[130] Steam locomotives subsequently transformed society;[131] however, it was inherently inefficient, expensive to build and maintenance-heavy. This changed with the introduction of the diesel engine, most notably the Pioneer Zephyr by General Motors in 1934.[132] The transition to diesel had an enormous impact on the railways,[133] and by the 1950s it became difficult to find steam locomotives in operation even in America.[134]

TABLE 1.3 Continued

Third Wave: Electricity, chemicals, internal combustion engine

- *Printing and photography*: A retired French military officer took the first photograph of the view outside his workroom in 1826, using recent developments in photochemistry to develop a 'heliograph' – a pewter plate coated with bitumen. The bitumen hardened when exposed to light, resulting in a faint positive image after an 8-hour exposure.[135] Further developments from the 1850s by chemical and process engineers resulted in developments from a plate to a film technology, as well as the development of Polaroid and colour films. These developments went hand in hand with a rapidly increasing knowledge of chemistry and optical physics.[136] Today this technology is almost completely superseded by digital and electronic processes, where cameras have more in common with television and capture live images by converting light into electrical impulses.
- *The LeBlanc soda process*: The LeBlanc soda process refers to the 19th-century production of soda ash, caustic soda and chlorine. The application of these chemicals is extremely diverse, and includes the productions of soap and detergents, fibres and plastics, glass, petrochemicals, pulp and paper, fertilisers and explosives.[137] The process was developed by Nicolas LeBlanc, and later a family of iron founders. Subsequently a Belgian chemist developed a more direct process using ammonia (the 'Solvay process'), which reduced the price of soda ash almost one-third. At first, the Solvay process had difficulty competing with the well-established LeBlanc industry; however, by 1915 the new ammonia-soda process had completely displaced the LeBlanc.[138]

Fourth Wave: Petrochemical, electronics, aviation, space

- *Printing press*: One of the early major breakthroughs in distributing the printed word was the system of moveable type, coupled with the printing press, developed in the 14th century by inventor Gutenberg.[139] The replacement of the hand-operated Gutenberg-style press occurred in the 19th century with the introduction of steam powered rotary presses.[140] Offset printing then caused another revolution in modern commercial printing technology,[141] followed by digital technology and the computer which changed the very mechanisms of printing.[142] Many printing technologies from the fourth – and fifth – waves are now close to being obsolete, such as typewriters, daisy wheel printers and dot matrix printers.[143] These innovations have had significant implications for design, from the way that services are provided to clients, through to the design and manufacture of the machinery.
- *Communications technology*: Communications technology had its beginnings in signalling systems for the emerging British railway lines.[144] Subsequent research and innovation contributed to an impressive progression of technologies, including the development of Morse code (1843) and the electric telephone (1876).[145] Two scientists (Faraday and Maxwell) transformed the basis of communications technology forever with their research into electromagnetism and electromagnetic wave theory, and in 1901 the first wireless message was transmitted across the Atlantic.[146] The emergence of the electronic calculator during the Second World War marked the beginning of a new age of communications technology and education platforms.[147] These developments also sparked major changes in education, from the rise of long-distance education (via radio and telephone) to basic lecture recording and information sharing.

Fifth Wave: Digital networks, biotechnology, software information technology

- *Information technology*: Information technology innovations occurred in parallel with computing power. For engineers and teachers of engineering, this had huge technical implications. For example, prior to the era of personal computers, engineering students spent large amounts of class time learning technical drawing skills, using technology such as slide rules and drawing tables, and handbooks with tables of values. The release of drawing programs such as AutoCAD in 1982 at a trade show in Las Vegas signalled the beginning of a new era in engineering drawing and drafting and the rapid industry take-up led to changes in engineering coursework.[148] Other software such as MODFLOW has also significantly changed the scope of modelling and programming that is taught. Software advances have created jobs in consulting, design and marketing, and graduates now require different personal and professional competencies. Most engineering programs have added to or even redesigned theoretical coursework to incorporate the new engineering design skills, with courses in technology studies and programming.[149]

TABLE 1.3 Continued

Sixth Wave: Sustainability, radical resource productivity, whole system design, biomimicry, green chemistry, industrial ecology, renewable energy, green nanotechnology

Engineering programs already or in the future will incorporate these concepts and successful built environment professionals will incorporate them throughout the life of a project. For example:

- *Energy efficiency in buildings*: Buildings have continually evolved to address social needs. The arrival of the skyscraper a century ago, for instance, was due to the scarcity of space in congested American cities.[150] The face of real estate changed, enabling extraordinary accommodation of people in a contained footprint. Today, the building industry is entering yet another era of change, with a focus on minimising the energy, carbon and environmental footprint of residential and commercial buildings. Forty per cent of global greenhouse gases is attributed to the building sector, along with 12% of global water use, and significant material flows.[151] Transformative technologies could hold the answer to curbing the challenges of greenhouse gas emissions. Energy efficiency has been the centre of engineering–economics discussions with regard to the extent of possible cost-effective savings, from 10–30% in the mid 1970s to 50–80% in the mid 1980s. By the mid 1990s, practitioners were achieving 90–99% improvements in some situations.[152] Factor Four has previously argued, later supported by the IPCC 4th Assessment's Mitigation Working Group findings, that 75% enhanced improvement in energy efficiency could be made in building design.[153] Today, designers, developers and owners are scouting for ways to reduce environmental impacts and operating costs of buildings, as well as enhancing their functionality and appeal to residents.[154]
- *Project management*: Project management is an ancient profession, evident in many of the ancient civilisations such as Ancient Greece and Egypt.[155] Modern project management is a product of detailed examinations of 'work study' that was completed in the United States at the end of the 19th century that evolved into industrial administration, organisation and method, and managerial techniques. These techniques were crucial in converting the small workshops and cottage industries of the 19th century into the giant engineering establishments of the 20th century, with their mass-production and assembly-line techniques.[156] In the 21st century, this process is undergoing another transition from a construction paradigm that was all about more and bigger, to 'less is more' and streamlined resource use.

  The 6th wave is about upgrading to a lifestyle that improves environmental circumstances (i.e. decoupling economic growth from environmental pressure). Courses already or in the future will incorporate concepts such as resource productivity and whole system design. The most successful built environment professionals will incorporate these sustainably concepts throughout the life of a project as they are uniquely placed to ensure that sustainability can be practised throughout the construction industry.

Source: References noted within table.

The curriculum renewal process must be improved and accelerated

Shaping the Education of Tomorrow – Report on the UN Decade of Education for Sustainable Development:

> The boundaries between schools, universities, communities and the private sector are blurring as a result of a number of trends, including the call for lifelong learning; globalization; information and communication technology (ICT)-mediated (social) networking education; the call for relevance in higher education and education in general; and the private sector's growing interest in human resource development . . . This new dynamic provides a source of energy and creativity in education, teaching and learning, which itself provides a powerful entry point for education for sustainable development.[157]

Building on the previous waves, the fifth wave of innovation provided a new technological platform and numerous tools for enhancing communications, computation, design, drafting, and data analysis and storage, allowing operations to be significantly improved; however, the associated environmental pressures from the accelerated development were largely ignored.[158] With the significant environmental impacts outlined above, the sixth wave is focused on innovations that both build on the previous waves and deliver significantly lower environmental pressures.

In essence, while the fifth wave was driven by the economic opportunity of reducing transaction costs and enhancing communications, the sixth wave is driven by the economic risk of failing to reduce environmental pressures from the previous waves.

Each wave has called for significant updating of education and capacity building programs, as shown stylistically in Figure 1.6. Following the emergence of each wave, in general, education programs undertook a curriculum renewal transition to renew courses with the new innovations and apply them to what employers needed from graduates. As the level of innovation in knowledge and skills has progressively increased with each wave, this has called for increasingly larger-scale efforts – and shorter time constraints – to achieve associated curriculum renewal.

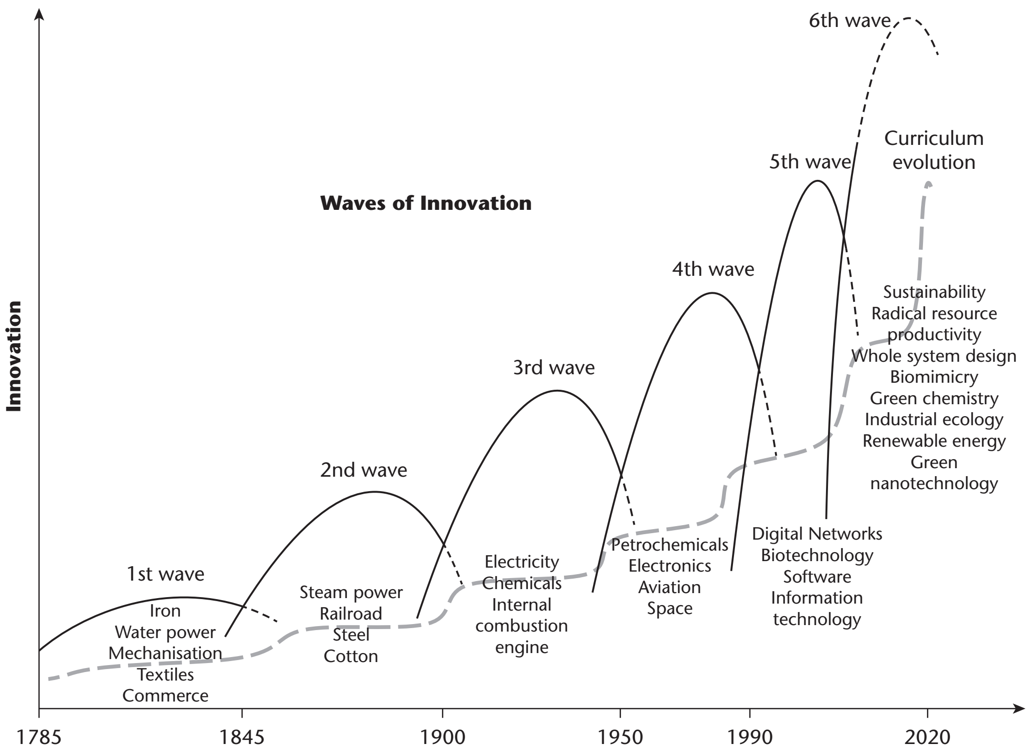

FIGURE 1.6 Stylistic representation of curriculum renewal transitions (dashed line) accompanying the waves of innovation since the industrial revolution

Source: Desha and Hargroves (2011), adapted from Hargroves and Smith (2005)[159]

earthscan from Routledge

The Natural Edge PROJECT

As mentioned earlier in this chapter, although the higher education sector is still predominantly operating in an environment of low pressure to renew courses for sustainability, governments around the world have been increasingly vocal about action towards curriculum renewal around this sixth wave, providing early signals of a changing requirements. For example, in 2001 the South African National Quality Framework emphasised environmental education for a wide range of education institutions including higher education.[160] In New Zealand, the 2002 Tertiary Education Strategy included sustainability as one of six national development objectives.[161] In the same year in the UK, the government's Sustainable Development Education Panel required all UK further and higher education institutions to have faculty fully trained in sustainability and providing relevant learning opportunities to students by 2010.[162]

Looking forward, given the time imperative to achieve significant reductions across a number of environmental pressures, the current curriculum renewal challenge may be the greatest the modern education system has ever faced.

Given that a typical (or 'standard') process of undergraduate curriculum renewal for an accredited program – including, for example, engineering, architecture, planning, law, business or education – may take 3–4 accreditation cycles (of approximately 5-year intervals), the time to fully integrate a substantial new set of knowledge and skills within all year levels of a degree will be in the order of 15–20 years. Further, as the average pathway for a graduate is approximately 2–4 years from enrolment to graduation, followed by 3–5 years of on-the-job graduate development, if institutions take the typical approach to fully renew such bachelor programs, this will result in a time lag of around 20–28 years; hence it will be some 2–3 decades before students graduating from fully integrated programs will be in decision-making positions using current methods. For postgraduate students the time lag will be shorter as students may already be practising in their field and will return to positions of influence; however, accounting for the time to renew programs, the time lag is in the order of 8–12 years, depending on the pace and effectiveness of curriculum renewal efforts.

Looking across the higher education sector, a number of disciplines have examples of timely and program-wide curriculum renewal, from law (embedding skills training) to business (embedding corporate social responsibility), nursing (embedding evidence-based practice) and medicine (embedding technological advances).[163] Although each discipline can point to leading efforts in particular programs, these efforts are isolated and largely *ad hoc*. Indeed, there appears to be a need to improve curriculum renewal processes across many disciplines of study. Broadly speaking, the standard timeframes to renew undergraduate and postgraduate programs are well beyond the timeframes needed to significantly reduce a range of environmental pressures as outlined previously. We refer to this as a 'time lag dilemma' where the usual or 'standard' timeframe to update curriculum for professional disciplines is too long to meet changing market and regulatory requirements for emerging knowledge and skills.

A 'time lag dilemma' for the higher education sector exists where the usual or 'standard' timeframe to update curriculum for professional disciplines is too long to meet changing market and regulatory requirements for emerging knowledge and skills.

In hindsight, if institutions had acted on previous calls for capacity building related to sustainability, such as in *Our Common Future* in 1987, then the standard processes may have been sufficient over the subsequent 20–30 years. However, this window for such a response has well and truly closed. Hence the urgency and complexity of the challenge to reduce environmental pressures, combined with the scope of associated knowledge and skills required, calls for both an improvement in, and acceleration of, the standard approach to curriculum renewal across higher education. Whether in under- or postgraduate education, curriculum renewal towards education for sustainable development requires immediate attention.

How can the higher education sector respond?

Given that at some time in the next decade there is likely to be an increase in enforcement related to reducing environmental pressures, as with all organisations, higher education institutions will have a choice as to whether they move early or wait until enforcement ('Time (t)' as indicated in Figure 1.2). This decision will affect the level of risk and reward for the institution, with a low commitment delivering high future risks and low future rewards, and a high commitment positioning institutions to capture future rewards and avoid risks, as illustrated in Figure 1.7. Furthermore, the benefits curve may also be affected as the supply of graduates with sustainability knowledge and skills subsequently catches up with employer demand, flattening over time. As more institutions develop graduates with desired traits, a department's efforts in curriculum renewal may actually just be keeping up, rather than creating market niche.

> Institutional risks of inaction include, for instance, falling student numbers, increasing accreditation difficulties, ineligibility for research grants, and poaching of key faculty. Rewards for action include, for example, attracting the best students and staff, staying ahead of accreditation requirements, attracting research funding, securing key academic appointments and industry funding.

Those institutions with a high commitment will have access to greater rewards before and after enforcement, whereas those following wrestle for reduced rewards, referred to as 'first mover advantage'. Further, those who maintain a low commitment will see risks increasing before enforcement as efforts to reduce environmental pressures ramp up, and after enforcement as enforcement efforts become more stringent (see Figure 1.7).

Consider an example of introducing a carbon-trading scheme. If the cost of petrol rises significantly, large companies currently producing high levels of emissions will likely require carbon-related competencies in their recruitment strategies. This includes rapid innovation to address the manufacture and supply of goods and services; mechanical and electrical engineers will be expected to design more efficient processes, equipment and vehicles; and civil engineers will be expected to design more efficient transport systems and infrastructure. In the face of such rapid employer shifts in demand, education departments that are unprepared could face increasing accreditation difficulties, falling student numbers, with the potential for faculty loss and restricted research opportunities even before the period of enforcement. In addition, their graduates will be competing with others who are better equipped.

This situation presents significant cause for universities and departments to rethink their strategies related to curriculum renewal, to minimise the current and future risks and position themselves to

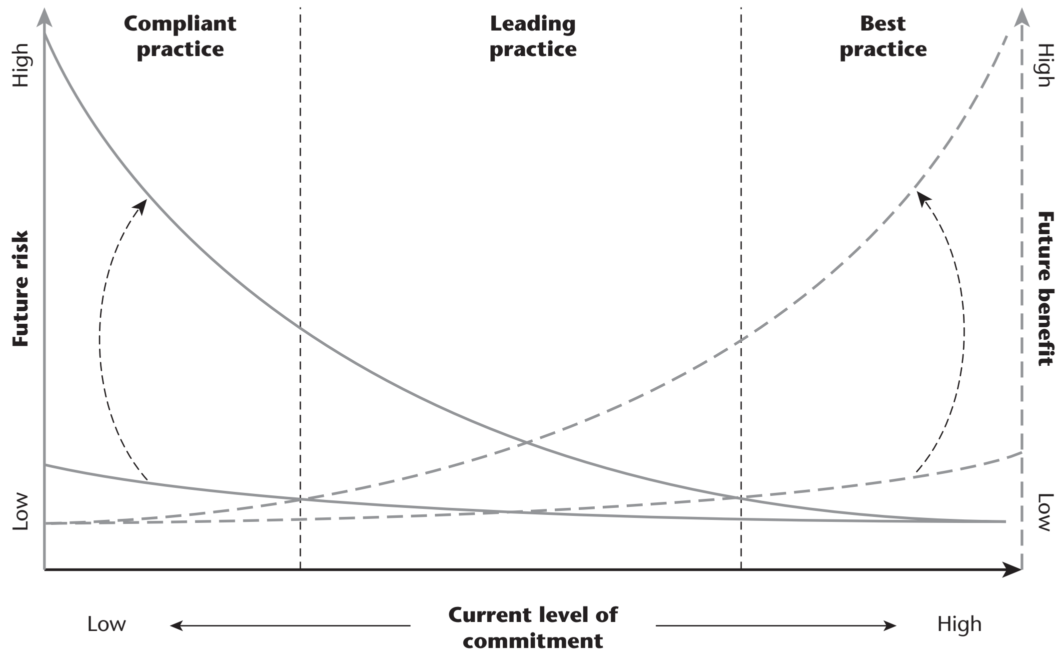

FIGURE 1.7 Risk and reward scenarios for curriculum renewal in higher education

Source: Desha and Hargroves (2009)[164]

capture the growing rewards. In short, over the coming years, departments who do not transition their programs to incorporate sustainability are likely to find it increasingly difficult to operate. Furthermore, their traditional roles as professional education providers may be usurped by private training providers capturing niche opportunities in capacity building, along with firms and government departments developing in-house capacity building programs.

For faculty who are personally committed to sustainability, there are two trends: continuing to influence at the level of individual courses; or leaving to join an institution with a stronger level of commitment, working on systemic integration.

In the UK, the Higher Education Funding Council (HEFC) has funded a number of Leadership, Governance and Management (LGM) projects over the last several years totalling £2.1 million, ranging from developing future leaders to learning in future environments.[165]

In 2012 the UK Higher Education Academy held its first policy 'think tank' to investigate how the higher education sector can contribute to 'greening the economy'. The think tank:[166]

- acknowledged the significance of the emerging green economy policy to the role of universities in furthering the education of their graduates and in preparing them for active and participative socioeconomic roles;
- stressed that the purpose of universities in educating graduates includes more than just the green economy;
- found the UK Government's definition of a green economy limited in not emphasising planetary boundaries and resource scarcity;
- concluded that the green economy (by any definition) is not yet a strategic issue for many universities, in part because of the lack of clarity within many of the national policy documents.

When an institution or department commits to education for sustainability, one of the first considerations is the timeframe in which curriculum renewal can be undertaken. We could imagine an envelope of opportunity with a minimum and maximum timeframe for transitioning the curriculum as shown in Figure 1.8. First, institutions could wait until enforcement (i.e. adopting 'standard curriculum renewal' or 'SCR' processes) and then move rapidly (i.e. through 'rapid curriculum renewal' or 'RCR' processes) to comply along with the rest of the sector – shown as the 'post-t transition'. Alternatively, institutions could move rapidly ahead of future compliance and capture the associated

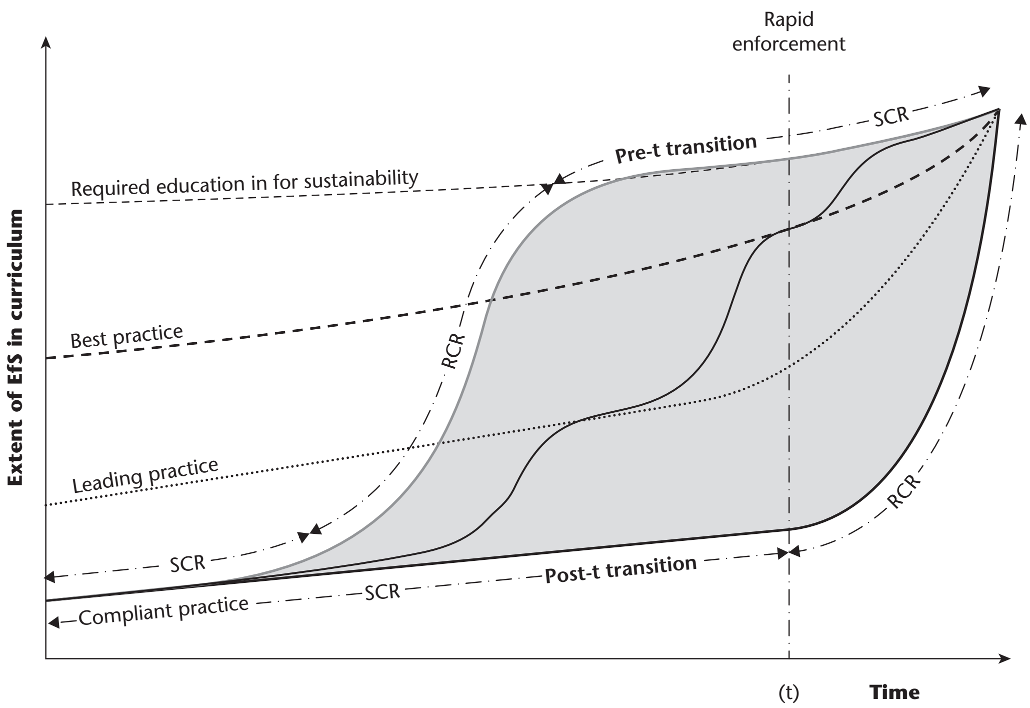

FIGURE 1.8 A stylistic representation of possible curriculum renewal transition curves for education institutions ('SCR' Standard Curriculum Renewal; 'RCR' Rapid Curriculum Renewal)

Source: Desha and Hargroves (2012)[167] benefits, shown as the 'pre-t transition'. Within the shaded area inside the upper and lower bounds of this envelope, there are a number of possible transitions, including a staged stepping up from 'compliance' to 'leading practice' to 'best practice', as shown in the figure.

A growing number of organisations, alliances and networks have emerged over the last decade, committed to integrating sustainability into the curriculum, as highlighted in Table 1.4.

There are a number of emerging non-profit partnerships that are working to facilitate capacity building for sustainability, extending beyond higher education institutions into professional associations, industry and government. For example, 'Second Nature' is a US non-profit organisation that since 1993 has worked with more than 4,000 faculties and administrators at more than 500 colleges and universities to help incorporate the principles of sustainability in higher education programs. Led by one of the world's leading education for sustainability experts, Dr Anthony Cortese, the organisation's successes include advancing networks at the state, regional and national levels, and conducting a multi-

TABLE 1.4 Examples of university alliances promoting education for sustainability

Alliance	*Brief description*
University Leaders for a Sustainable Future (ULSF)	Since 1992, ULSF has served as the secretariat for signatories of the Talloires Declaration, a ten-point action plan committing institutions to sustainability and environmental literacy in teaching and practice. Over 350 university presidents and chancellors in more than 40 countries have joined by signing the declaration.
Higher Education Partnership for Sustainability (HEPS) programme	One of the earlier university alliance initiatives was a three-year UK partnership (2001–2003) of 18 higher education institutions committed to sustainability supported by the funding councils of England, Northern Ireland, Scotland and Wales. Co-ordinated by Forum for the Future, the partnership worked to generate transferable tools, guidance and inspiration to demonstrate the potential for integrating sustainability in the higher education sector.[168]
Global Higher Education for Sustainability Partnership (GHESP)	Comprising the International Association of Universities (IAU), the University Leaders for a Sustainable Future (ULSF), Copernicus-Campus and UNESCO, GHESP aims to mobilise higher education institutions to support EfS, focusing on responding to Chapter 36 of Agenda 21 regarding the role of education.
Association for the Advancement of Sustainability in Higher Education (AASHE)	AASHE is a member organisation of colleges and universities in the United States and Canada working to create a sustainable future. The *AASHE Bulletin* is the leading news source for campus sustainability in North America, and the *AASHE Digest* is an annual compilation of bulletin items. AASHE has developed a standardised campus sustainability rating system called STARS (Sustainability Assessment, Tracking and Rating System), launched in 2009.
American College and University Presidents Climate Commitment (ACUPCC)	The ACUPCC is an initiative of presidents and chancellors to address global warming by committing to climate-neutral campuses and by providing the education and research to enable society to do the same. Nearly 600 US college and university presidents have signed the commitment and are publicly reporting progress, including greenhouse gas emission reports and climate action plans.
Higher Education Associations Sustainability Consortium (HEASC)	HEASC is an informal network of higher education associations with a commitment to advancing sustainability within their constituencies and within the system of higher education itself. This includes developing in-depth capability to address sustainability issues.

Source: References noted within the table.

million dollar, 10-year advocacy and outreach effort that was instrumental in launching and maintaining momentum for education for sustainability within higher education in the United States, through AASHE and the HEASC (see Table 1.4).

The US Partnership on Education for Sustainable Development was formed to leverage the UN Decade to foster education for sustainability in the US.[169] Led by another of the world's education for sustainability leaders, Dr Debra Rowe, it comprises individuals, organisations and institutions with a vision of sustainable development being fully integrated into education and learning in the country. One of its actions has been to initiate and sponsor the Disciplinary Associations Network for Sustainability (DANS), an informal network of professional associations working on professional development, public education, curricula, standards and tenure requirements to reflect sustainability, and legislative briefings on what higher education can bring to sustainability-related policies.[170]

> The choice and strategy for transitioning the curriculum will depend on a number of factors that are usually part of institutional risk management and business planning; this is not specific to the education for sustainability and we have not found the silver-bullet for moving forward. However, in understanding the 'what's so' of the sixth wave of innovation, institutions gain access to positioning themselves in the emerging education marketplace.

In this sixth-wave transition, it is important to contribute graduates who can lead, but not be too far ahead of the reality, at their time of graduation. The balance of 'old' and 'new' needs to be carefully managed to consider to the need to reduce environmental pressures, the needs of society and employer demands, as indicated in Figure 1.9. As there is a large amount of embedded infrastructure (for example roads, bridges, coal-fired power stations, electricity grids, etc.) to be managed, maintained and transitioned, requiring 'old industry' education, integrating 'new industry' content too quickly could be problematic if graduates don't have the skills that the employment market needs at the time that they graduate.

At the level of the institution, targeted effort will be required to incorporate sustainability into existing operational frameworks across the breadth of the institution or department – including governance and management, curriculum design and innovation, operations and facilities, marketing, human relations and stakeholder relations (see Chapter 4). Departments will also need to direct efforts to support the transition, including increasing internal professional capacity, and addressing knowledge gaps to deliver the required curriculum. It will also need to promote such opportunities to potential students, and anticipate shifts in student enrolment.

Throughout government, industry and the higher education sector itself, there are persistent and growing calls for increased capacity building towards sustainability. There is also an emerging awareness of the complexity of this challenge, and the urgent need for curriculum renewal for institutions to meet employer demand for graduates over the coming years. In the current working environment where market and regulatory enforcement of education for sustainability is present but highly variable, we have asked ourselves, 'is it possible for the education sector to engage in transformative curriculum renewal within the decade?' In the following chapter we focus on one of the major professional disciplines in higher education – engineering – to consider the current capacity for such curriculum renewal, and opportunities for educators to engage.

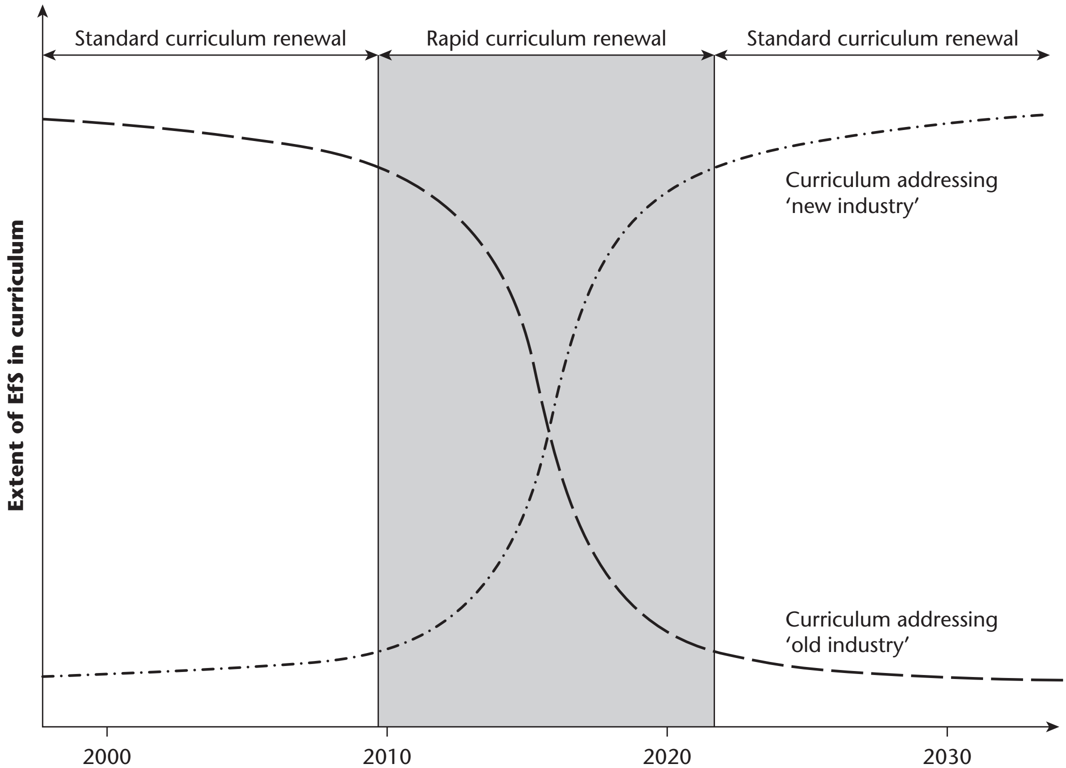

FIGURE 1.9 An illustrative curriculum transition curve, showing a period of rapid curriculum renewal from 'old' to 'new' industry

Source: Desha and Hargroves (2011)[171]