Faculty of Humanities
Curtin University Sustainability Policy Institute

Carbon Structural Adjustment: Designing, Motivating, and Delivering an Economy-Wide Transition to Low Greenhouse Gas Emissions

Karlson James Hargroves

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature:

Date: 27 April 2015

Dedication

This thesis is dedicated to my amazing wife, Stacey Hargroves, our daughter Grace Elizabeth Hargroves and our son Tyson James Hargroves who were both born whilst I was working on the thesis. Being a husband and father is the most joyous experience of my life and this has galvanised my commitment to assisting the world to transition to sustainable development. The thesis is further dedicated to the countless people across all walks of life around the world that are working towards reducing our pressures on the environment and creating a vibrant and prosperous future for everyone son’s and daughter’s.

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Abstract

As the world comes to grips with the need to respond to human induced climate change, a number of questions are being asked about how to effectively transition the world's economies to low greenhouse gas emissions over the coming decades. A growing number of pressures are now being felt across a range of sectors to reduce emissions, in particular fossil fuel consumption, which is leading to autonomous structural changes – typically ad-hoc and business or community led. However in order to meet ambitious targets for the reduction of greenhouse gas emissions such structural changes need to be effectively underpinned and appropriately expedited by government in wide consultation and collaboration across society. This thesis asks the question how structural changes across economies can be accelerated to achieve a transition to low greenhouse gas emissions.

The thesis develops a new concept called '*Carbon Structural Adjustment*' as a response to climate change and economic development. The concept focuses on economy-wide structural changes intended to induce the greater uptake of low greenhouse gas emissions technologies, processes, and practices. Prior to this thesis the area of 'structural adjustment' had not been applied as a strategic approach to reduce greenhouse gas emissions. This is due in part to its track record for negative social and environmental outcomes. This new concept is presented in three steps:

1) The *design* of carbon structural adjustment interventions,
2) The *motivation* of a greater willingness to support and undertake such interventions, and
3) The demonstration that such motivation can lead to the *delivery* of structural changes that cost-effectively reduce greenhouse gas emission.

The thesis provides original contributions in each of these three areas, and particularly the overall approach of designing, motivating, and delivering carbon structural adjustment.

Associated Publications and Reports

Throughout the development of the thesis I have worked with a number of colleagues, in particular Dr Cheryl Desha and Dr Michael Smith, to contribute research to a number of co-authored academic, industry and government publications as listed below, while based at Griffith University (2007-2010) and Curtin University (2011-present).

<u>United Nations Publications</u>

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Table of Contents

Chapter 1: Preliminaries

1.1 BACKGROUND

In the 21st Century parts of the world will experience untold wealth and prosperity that could not have been conceived two centuries ago. Much of this prosperity has been based on rapid industrialisation, mechanisation, electrification, and digitisation beginning in the mid 1700's with the Industrial Revolution. However as with most, if not all, human civilisations over the last 5,000 years such increases in prosperity have accumulated significant environmental damages that threaten to result in what esteemed sustainable development expert Lester Brown refers to as '*environmentally induced economic decline*'(Brown, 2008).

Along with the promise of such prosperity continuing in the 21st Century, world leaders will face a range of serious global environmental, social, and economic challenges (Ward and Dubois, 1972; Smith, Hargroves and Desha 2010). One of the most pressing due to the fact that the fuel source that has underpinned the industrial revolution and allowed the staggering amounts of development to be undertaken in much of the world, namely fossil fuels, is now widely recognised to have a sinister legacy (UN General Assembly, 2007; IPCC, 2007b). The combustion of fossil fuels such as oil and coal has resulted in the generation of vast quantities of air pollution, a proportion of which that when combined with specific agricultural and industrial emissions are referred to as '*greenhouse gases*' (IPCC, 1990). Such emissions are in quantities that now threaten to impact the chemical balance of the global atmosphere, which is affecting global heat transfer processes. This is leading to increases in the average global temperature that can have devastating effects on the planet's biosphere and in turn on our vast and numerous developments and settlements (IPCC, 2013).

Following significant advances in technology in the mid to late 1700's efforts were focused on ever expanding development with little concern for the potential for environmental impacts. Apart from a few lone voices such as Svante Arrhenius, who in the late 1800's cautioned that increased burning of fossil fuels would add carbon dioxide gas to the Earth's atmosphere and raise the planet's average temperature

(Arrhenius, 1896), it was widely considered very unlikely that the activities of industrialising countries could generate enough pollution to affect the entire globe on a meaningful scale. At the time the idea must have sounded ludicrous.

> *Even in Nobel's time, there were a few warnings of the likely consequences. One of the very first winners of the Prize in chemistry worried that, 'We are evaporating our coal mines into the air'. After performing 10,000 equations by hand, Svante Arrhenius calculated that the Earth's average temperature would increase by many degrees if we doubled the amount of CO_2 in the atmosphere.* (Gore, 2007)

However these few voices became many by the late 1900's, leading to the build-up of scientific investigation and industry experimentation that has now led to the world entering the 2000's with much of its attention fixed on the issue of reducing pollution from the use of fossil fuels as a matter of urgency, among a number of other pressing challenges (Hargroves and Smith, 2005). For instance, the 1987 book 'Our Common Future', stated that '*We have in the past been concerned about the impacts of economic growth upon the environment. We are now forced to concern ourselves with the impacts of ecological stress … upon our economic prospects*.'(WCED, 1987, p61)

In the 1700's if it were possible to comprehend the future impacts of a fossil fuel based system it may have been a relatively simple task to take action to reduce such pollution with a global population of less than 700 million people. However, today in a world with over 7 billion people and a future where this could rise to as much as 10 billion by 2050, the potential for large scale change in the basis of the energy system is a seemingly overwhelming and complex challenge. Ironically it may also prove to be the case that without having first harnessed fossil energy to develop primary industries it may have been unlikely to be possible to develop technology required for a transition to large scale non-fossil based energy production (such as through solar photo-voltaic panels, solar thermal, wind turbines, ocean turbines, fuel cells, geothermal, cogeneration equipment etc…).

This highlights the fact that the early part of the 21st century is indeed an era of major transition, one that requires a long term strategic approach. However it may be the case that some of the tools and strategies that have led to the highly successful fossil fuel based economy may not be as useful to achieve reductions in greenhouse gas emissions and assist in a transition to a post fossil fuel economy, and new tools and strategies may be needed. However to complicate matters, as much of the World's economy is now based on fossil fuel there are many interests that are best served in the short term by not changing this basis as this may cause disruption to production and require upfront investment that may have medium to long term returns on investment. Hence should such a transition away from fossil fuels take place it will require a 'whole of society' approach that involves actors such as governments, business, universities, civil groups, and the community (Hargroves and Smith, 2005).

Changing an industrial economy to run on non-fossil energy will require significant investments in alternate energy generation, distribution, and storage. This may include investing in: installing solar panels on homes and buildings; developing large scale solar installations, wind farms, and ocean turbine arrays; expanding geothermal, tidal, and hydro-electric power options; and upgrading electricity distribution systems to be able to manage decentralised energy generation (Diesendorf, 2007). Such an agenda will need to be supported by rapidly reducing the energy intensity of a range of technologies, processes, and operations to reduce the rapidly growing demand for energy while contributing to economic development, particularly in developing countries (Smith, Hargroves, and Desha, 2010).

As the industrial revolution has been taking place for some 300 years there is now significant inertia that, when driven by a market economy to be profitable, has resulted in risk averse and short term focused economies – which does not place them well to deal with significant and far reaching challenges that will have impacts long into the future, such as poverty or environmental impacts. Even though awareness and understanding of the issue of climate change has been growing in the previous decades still many politicians, business leaders, and members of the public hold the view that nations need to broadly choose between the economy and the environment (Stern, 2006, p xvii). According to Smith, Hargroves, and Desha (2010), '*this argument plays perfectly into the hands of those that seek to hinder action on the environment in order to protect short term profits*'. Holding this view hinders the efforts of those that understand that not undertaking a transition process to re-align economies to protect the environment will significantly undermine the performance of economies in the coming decades.

I assume that in light of such considerations economy-wide changes will need to be made if the world's economies are to significantly reduce greenhouse gas emissions in the coming decades.

1.2 THEORETICAL FRAMEWORK

The field of research of this thesis is the examination of how structural changes can be designed, motivated, and delivered to achieve a transition in the world's economies away from fossil fuels and the associated greenhouse gas emissions. The justification for such a focus has been established through a comprehensive literature review (as presented in Chapters 2-4).

The overarching theoretical framework used to guide the research presented in the thesis is 'Waves of Innovation' (Hargroves and Smith, 2005). This theory is a form of '*macro-transitions and large scale systems theory*' that builds on early work by Kondratieff (1926) and Schumpeter (1939). The theory begins with the premise that the development of the industrial revolution has been characterised as a series of waves of technological innovation, as shown stylistically in Figure 1.1. The theory posits that the key characteristic of such waves is that they are based on a jump in technological innovation, building on the previous waves, which delivered significant economic development. The theory assumes that such technological innovations are created through a range of supporting social, cultural, institutional and business innovations that are critical to the new technology being swiftly taken up.

The relevance of the theory to the thesis is that it provides a lens to consider the response to human induced climate change through an approach to support and accelerate a wave of innovation to deliver strong economic growth while significantly reducing greenhouse gas emissions.

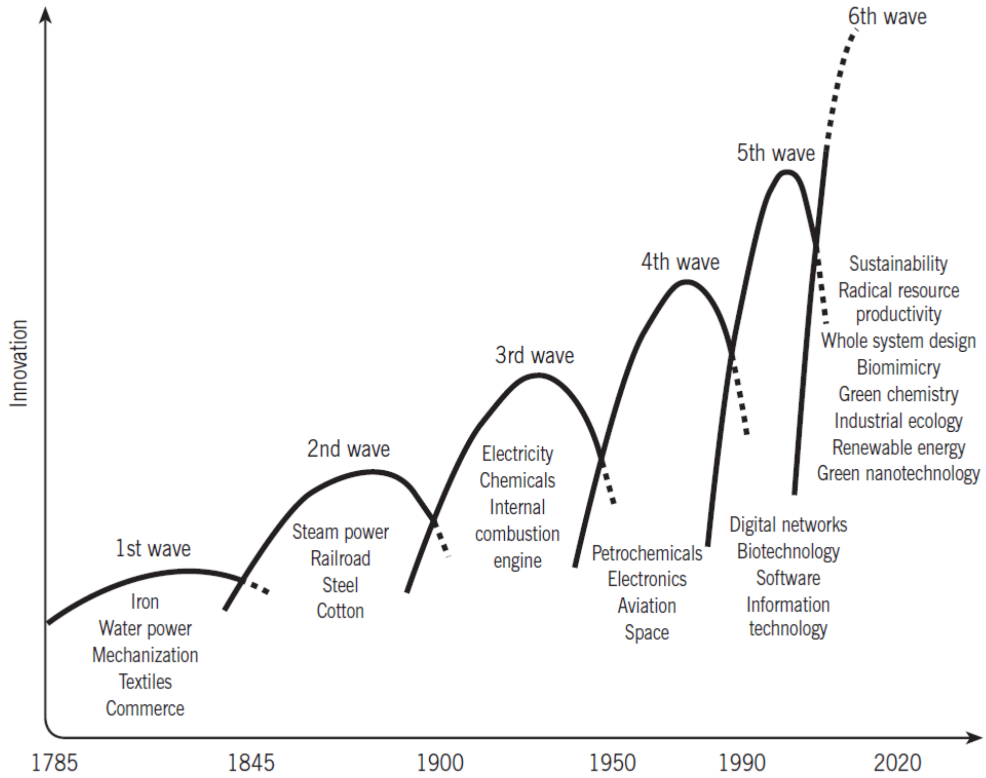


Figure 1.1: *A Stylised representation of the Waves of Innovation since the Industrial Revolution*

Source: Hargroves and Smith (2005)

The theoretical framework of the 'Waves of Innovation' has been complimented in the thesis by consideration of three components, brought together to create the overall theoretical scaffolding for the thesis research, namely the theories of: '*Decoupling Economic Growth from Environmental Pressure*' (Smith, Hargroves, and Desha, 2010) which provides a theoretical frame to structure the imperative to drive innovation to reduce environmental pressures in such a way as to strengthen economic growth of nations; '*Multi-Level Perspective on Socio-Technical Transitions*' (Geels, 2002) which builds from wave theory and provides a theoretical frame to identify leverage points in national economies for the greater uptake of such innovation, and '*Community Based Social Marketing*' (McKenzie-Mohr and Smith, 1999) which provides a theoretical framework for identifying strategic approaches to encouraging communities to undertake behaviour in line with the uptake of such innovations.

1) Decoupling Economic Growth from Environmental Pressures: Applied to the field of research of this thesis, the theory of 'Decoupling' begins with the

premise that economic growth can continue to increase while the associated pressure on the environment reduces, as shown in Figure 1.2. The theory posits that innovation can lead to economic development outcomes in a manner that reduces environmental pressures and the associated negative economic impacts. (Smith, Hargroves, Desha, 2010)

This component of the theoretical framework was selected for the thesis as it provides a structure to consider the imperative for innovation to support economic growth (and other preferred outcomes like jobs growth, improved well-being, and poverty eradication), while reducing a range of pressures on the environment (such as greenhouse gas emissions, air pollution, waste generation, and water extraction). (Smith, Hargroves, and Desha, 2010)

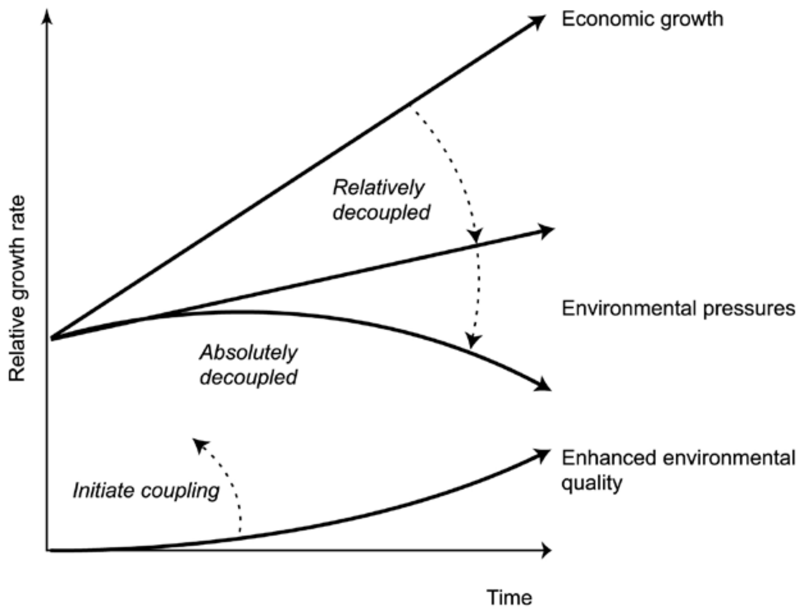


Figure 1.2: *Conceptual and stylised representation of a decoupling graph*
Source: Smith, Hargroves, Desha, 2010

2) <u>Multi-Level Perspective on Socio-Technical Transitions</u>: The 'Multi-Level Perspective' developed by Geels (2002), shown in Figure 1.3, is a '*sociotechnical systems theory*' that begins with the premise that activities at three levels affect the diffusion of innovation across an economy, namely, as described by Geels (2011):

   a) Socio-Technical Landscape: '*A range of contextual factors that influence technological development but that cannot be changed directly by actors*',

b) Socio-Technical Regimes (combining to form the Techno-Economic Paradigm): *'The locus of established practices and associated rules that stabilize existing systems',* containing *'Rule-sets that are built up around a dominant technology and grant it stability',* and

c) Niche Innovations: '*The locus for radical innovations', which 'creates protected spaces in which actors search and learn in various ways about new technologies and their use'.*

The theory posits that the development of niche innovations and their diffusion into an economy (via various socio-technical regimes) can be tracked along with the influence from, and on, overarching macro structures within the economy (referred to as the socio-technical landscape). Considering the challenge of responding to environmental imperatives, Geels (2011) suggests that '… *the core analytical puzzle is to understand how environmental innovations emerge and how these can replace, transform, or reconfigure existing systems.*' This component of the theoretical framework selected for the thesis provides a structure to consider various leverage points in the socio-technical regime that can be influenced to further underpin and potentially induce the development and uptake of innovative products, services, and processes across national economies. In the context of the area of research this component of the theoretical framework provides an important frame to consider:

- The investigation to design a strategic approach to adjust structures in national economies based on the understanding that socio-technical regimes need to be shifted to create a new techno-economic paradigm (or 'wave of innovation'). The structures identified in the thesis are: standards and codes, government requirements, taxation and subsidies, investment and procurement policies, professional accreditation requirements, and education program accreditation requirements.

- The investigation of a selection of interventions intended to create motivation by increasing the willingness to adjust such structures based on the understanding that this will not only lead to accelerated action but also to the increased capacity of various actors to do so. The interventions selected are intended to demonstrate:

- The potential to motivate general willingness to support carbon structural adjustments through the case study of voluntary community behaviour change, (Chapter 7)

- The potential to motivate specific willingness to make changes to higher education accreditation requirements through the case study of curriculum renewal of higher education programs, (Chapter 8) and

- The potential for the creation of industry led performance assessment and reporting systems to motivate changes to public procurement of major infrastructure projects. (Chapter 9)

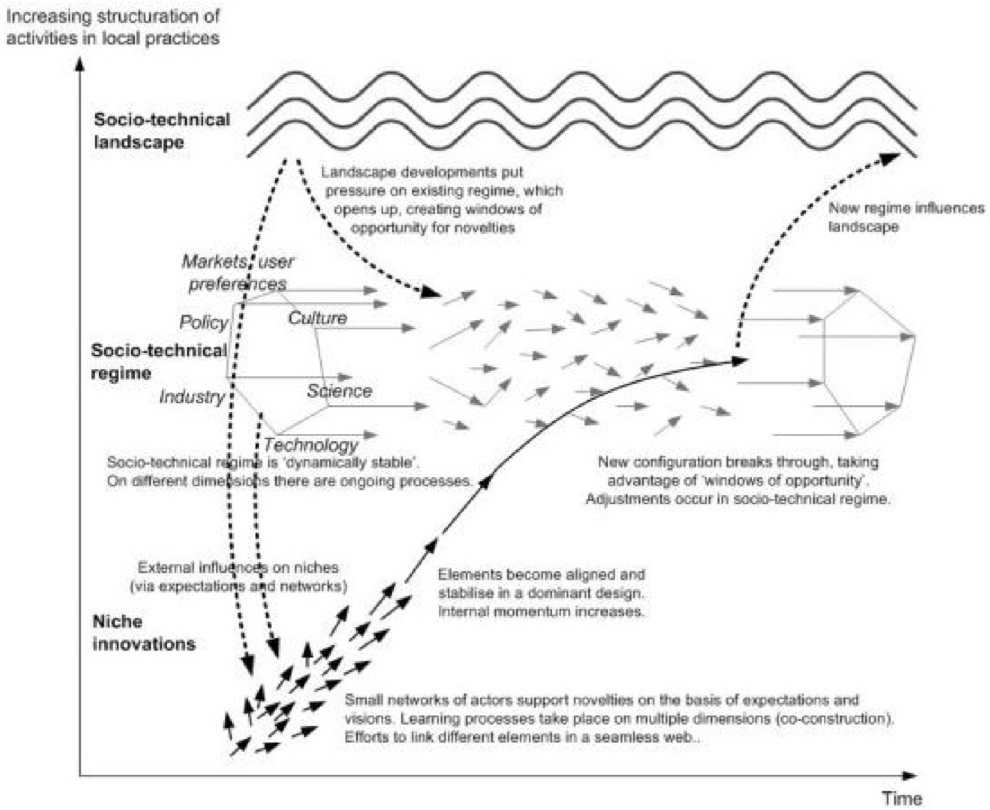


Figure 1.3: *A dynamic multi-level perspective on technology transitions*
Source: Geels (2011)

3) Community Based Social Marketing (CBSM): CBSM is a form of '*social systems theory*' that assumes behaviour change is most effectively achieved through initiatives delivered at the level of specific behaviours, informed by direct community/stakeholder engagement, especially when these behaviours cannot be directly observed. (McKenzie-Mohr and Smith, 1999)

In the context of the area of research this component of the theoretical framework provides a key frame to consider strategies to design programs that remove specific barriers (perceived and actual) to an activity while simultaneously enhancing the activity's benefits. More specifically the theory informed the research into how to increase the willingness of community members and stakeholders to change individual behaviours leading to a greater willingness to support both general (Chapter 7) and specific (Chapters 8 and 9) adjustments to associated structures across the economy.

Research in to all three of these theoretical frameworks enable greater understanding of the technological, social, cultural, institutional and business processes and practices to inform an agenda of structural level changes in economies to deliver significant reductions in greenhouse gas emissions.

1.3 RESEARCH QUESTION

Based on the theoretical frameworks outlined above and in response to the established imperative for the economies of the world to swiftly respond to human induced climate change by significantly reducing greenhouse gas emissions, the research question investigated in this thesis was:

Research Question: How can structural changes across economies to accelerate the transition to low greenhouse gas emissions be designed, motivated, and delivered?

Based on the findings of the literature review the research question was investigated in three stages, namely:

a. An investigation into various options to achieve structural level changes in economies to inform the *design* of strategies to achieve reductions in greenhouse gas emissions,

b. An investigation into opportunities to *motivate* an increased willingness to adjust structural areas both generally, through community behaviour change programs, and specifically, through a focus on higher education curriculum renewal.

c. An investigation into how efforts to increase the motivation to adjust structural areas can lead to interventions to *deliver* structural changes, through industry led performance tools influencing public procurement.

1.4 RESEARCH METHODOLOGY

In the conception of the research methodology it was identified that as the area of research encompasses three broad and somewhat non-interrelated areas of focus there would be a need to consider both a 'quantitative' and 'qualitative' approach. Such an approach is advocated by a growing number of researchers in areas that are not easily defined as either quantitative or qualitative (Creswell, 1994; Guba and Lincoln, 2005). However even though a merged approach can be shown to be an effective research methodology the literature highlights a number of discrete differences that have been considered in the development of the research methodology to minimise confusion and to maintain academic rigour (Creswell, 1994; Firestone, 1987). These differences include questions of:

- The nature of the reality in which the research is being considered, being either 'objective' for a quantitative investigation or 'subjective' for a qualitative investigation,
- The particular relationship the researchers themselves has to the area of research, being either 'independent' or 'interacting',
- The manner in which values and beliefs influence the research, being either 'unbiased and value-free' or 'biased and value laden',
- The choice of language for framing the research arguments and content, being either 'formal' or 'informal', and
- The overall process used, being either 'deductive' or 'inductive'.

Hence quantitative and qualitative research processes address each of these areas in different ways with the main requirement being that the findings of the research are presented with such an understanding of these various considerations as to ensure a significant contribution to the field of study. The following was used as the structure of the research methodology for the development of the thesis:

Question of Reality (Ontological Assumptions): In the research I have assumed that the most appropriate ontological approach to the research questions is to consider it as largely 'subjective', meaning that it tends to be more qualitative. This implies that the reality will be related to the way it is seen by those authors developing the key references that have informed the thesis, as it is seen by a number of experts consulted on various aspects of the research topic area, and as it is perceived by the persons participating in the focus groups and surveys. Hence the thesis heavily relies on documented research findings and accounts from a range of experts in the field, the results of stakeholder and community engagement activities, and the personal experiences of particular persons involved in the field as expressed to the researcher. However quantitative aspects are also included in the form of survey and focus group data.

Relationship with the area of research (Epistemological Assumptions): In the research I have assumed that the most appropriate epistemological approach to the research question is to consider myself as 'independent' of the area of research, meaning that it tends to be more quantitative. This implies that the approach to the research data and findings was a systematic enquiry and was considered to be independent of said data and findings. Hence although I have project experience as a researcher and consultant in the field of the research I have largely drawn on this experience indirectly to assist in setting the scope and depth of the research and to allow a personal interrogation of the various findings reviewed as part of the research.

The influence of my own values (Axiological Assumptions): Although I have personal values that align to achieving significant reductions in greenhouse gas emissions globally this bias was separated from the analysis of the literature, surveys and focus groups, and discussions with experts, to allow an 'unbiased and value-free' approach. I decided to undertake this approach to ensure that the thesis presented a well-balanced case and was not biased by my own personal views. This was particularly difficult to achieve and required a constant re-evaluation of the position developed based on the research, and in part it was not fully achieved with some bias and values infused in to the final thesis. This bias is seen to be inevitable and can only be minimised not completely removed.

The use of language to present the thesis (Rhetorical Assumptions): The rhetorical form used in the thesis is 'formal' however when presenting the thesis I was faced with the challenge that much of the language used to describe the field of research is emergent and varying across different professions and sectors, causing miss-communications and differing assumptions. This was particularly evident in the comparison of the rhetorical structures used to describe concepts in the field of economics, compared with the same or similar concept in engineering, and psychology. However I am confident that a cross-professions' language was used that will allow interpretation by a range of professions involved in the area.

The main process used through-out the research (Methodological Assumptions): In the research I have assumed that the most appropriate methodological approach to the research question is to consider it mostly as 'deductive' with an 'inductive' component. This means that when considering the various literature and findings the main focus was on a deductive process to consider the 'cause and effect' of various actions and interventions to inform the development of generalisations of the overlying context. Although the literature reviewed is considered to be accurate a process of comparison with comparable literature and results from surveys and focus groups that I have been directly involved with was used. To compliment this process an inductive process was also used to identify patterns across various aspects of the literature to enable the context to be further developed and understood to inform the findings and to call for further investigation.

Hence considering the selected approaches above, the research methodology used in this thesis is largely qualitative with aspects of a semi-quantitative process (particularly in the case of the assessment of various case studies and the analysis of the findings of surveys and focus groups) to uncover new knowledge to inform the field. The use of a semi-quantitative inquiry as part of the thesis was to consider the facts and figures to better understand potential for changing current practices and to provide precedent for a particular level of achievement (Wolcott, 1992). Furthermore this approach provides the basis for informing future actions that relate to the area of investigation rather than a wholly quantitative modelling exercise that would be very difficult to represent the various components and their dynamics.

In developing the research approach to investigate the questions of this thesis two main options were considered, namely:

1. An approach where the current situation related to the question is first investigated and then followed by an analysis of a wide set of literature. This approach would lead to a conceptual and theorized thesis.

2. An approach where field based research where the actions and experiences from the field (including survey and focus group results) are considered to investigate various strengths and weaknesses in implementation that can inform the thesis.

It was decided that a combination of both approaches would be used to show the context and to consider the reality of the situation. Given the strong interest in the questions of the thesis there has been a growing level of materials released by industry groups, companies, NGO's and other sources to be used to inform and critique a purely academic literature approach, as referenced throughout the thesis. If a purely academic literature approach was taken it would restrict access to current projects that are still largely commercial-in-confidence and are not fully published. The area is rapidly changing and needs to be tracked using all available means with appropriate consideration given to the rigour and integrity of such resources.

In the development of the thesis a number of key texts were studied that presented significant contributions to understanding the research question. This material was then balanced through a series of personal conversations and semi-structured interviews with leading advocates, experts and practitioners in the field, together with the work of numerous other R&D bodies, universities, NGOs, companies, organisations across the world that are expanding their understanding in this space, such as green building councils, sustainable business groups, and conservation foundations.

1.5 THESIS STRUCTURE

The thesis has been structured in the following way to allow an investigation of the research question of '*How can structural changes across economies to accelerate the transition to low greenhouse gas emissions be designed, motivated, and delivered?*'.

A summary of each chapter is provided at the end of the chapter along with an indication of the original contribution where appropriate.

- Section 1 (Chapters 2-4) provides a comprehensive literature review to develop an understanding of the imperative to respond to human induced climate change by significantly reducing greenhouse gas emissions globally. The literature review provided the basis for the original contribution of the thesis by:

  - Establishing the need for a swift response to climate change and the associated evidence,
  - Identifying the current level of understanding of challenges associated with such a response,
  - Investigating the costs of action and in-action of such a response, and
  - Investigating the feasibility of transitioning the world's economies to significantly reduced greenhouse gas emissions.
- Section 2 (Chapters 5-6) presents research into how structural changes across a nation's economy can be designed to lead to an acceleration of the transition to low greenhouse gas emissions. These chapters are based on an investigation of models of large system change, including structural adjustment, with the concept of 'carbon structural adjustment' being created (with the term 'carbon' being used as a recognised term to represent greenhouse gas emissions). A roadmap is presented to inform the design of strategic approaches to undertaking structural adjustments across an economy to achieve significant reductions in greenhouse gas emissions.
- Section 3 (Chapters 7, 8, and 9) presents research into options to motivate an increase in the willingness for carbon structural adjustment in order to achieve the transition to low greenhouse gas emissions. The chapters present the findings of extensive stakeholder engagement to identify opportunities to increase the willingness to adjust structural areas in three areas, namely: industry led performance assessment and reporting systems; voluntary community behaviour change programs; and curriculum renewal of higher education programs.
- Section 4 (Chapters 7 and 8) presents research into options to motivate an increase in the willingness for carbon structural adjustment in order to achieve the transition to low greenhouse gas emissions. The chapters present the findings of extensive stakeholder engagement to identify opportunities to increase the willingness to adjust structural areas in three areas, namely: industry led performance assessment and reporting systems; voluntary community behaviour change programs; and curriculum renewal of higher education programs.

- Section 4 (Chapter 9) presents research into options to motivate an increased in the willingness to adjust public procurement requirements that led to structural changes through the creation of industry led performance tools.

The final chapter, Chapter 10, presents the conclusion of the thesis, outlines the contribution to the area of research, and suggests areas for further research.

JUSTIFIYING THE IMPERATIVE TO RESPOND TO CLIMATE CHANGE: A LITERATURE REVIEW

Chapter 2: Is there a Need for a Swift Economy-Wide Response to Climate Change?

The co-authored book 'Cents and Sustainability' (Smith, Hargroves and Desha, 2010) includes parts of this chapter written by me. I wish to thank my co-authors of the book, Dr Michael Smith and Dr Cheryl Desha (a co-supervisor of the thesis) for stimulating through discussion the creation of some of the arguments contained in this chapter, identifying resources for consideration to develop such arguments, and for providing valuable peer review.

2.1 IDENTIFYING THE NEED TO RESPOND SWIFTLY TO CLIMATE CHANGE

For the average westerner life as we know it means getting up in the morning to a hot shower, enjoying a cooked breakfast, driving our air-conditioned cars to and from work, and looking forward to weekend Barbeques with friends, nights at the pub, our children's birthday parties, and drinking beer at sporting matches played on lush green ovals. Normality is a weekly pay-check; it is the consistency of the seasons, blue skies, green parks, clean beaches, fresh food, and protection from natural disasters. However, the motivation for the development of this thesis is the realisation that as a global society we may be reaching a point where what we can count on in the future about our lives is becoming less and less certain and more and more concerning.

It is uncertain to what extent living conditions will change in the future, but it is very likely that they will, and soon (UNEP, 2007). In considering the findings of the literature review I have not taken an alarmists approach, but rather one of a realist, coming to the conclusion that the reality is that the level of development achieved across the world, and the associated environmental pressures, is now on a scale large enough to affect the Earth's ability to handle it without resulting in major changes to the global biosphere, especially from greenhouse gas emissions (Smith, Hargroves and Desha, 2010). It appears to be clear that the lists of impacts and 'doom and gloom' that are mentioned again and again – sea-level rises, shifting rainfall patterns, reduced water availability, extended heat waves, damage to ecosystems, and the increasing intensity of storms and cyclones – are in fact real possibilities (WRI, 2005; UNEP, 2007; OECD, 2008a; World Bank, 2003; Brown, 2008) The research undertaken for this thesis suggests that as a species we have a small window of opportunity, perhaps a few decades, in which to lessen the environmental pressure of our societies to protect not only our own future, but the future of those who come after us. As George Monbiot (2006), laments, *‘Ours are the most fortunate generations that have ever lived. Ours might also be the most fortunate that ever will’.*

According to Sir Nicolas Stern (2006), *'Climate change is a result of the greatest market failure the world has seen. The evidence on the seriousness of the risks from inaction or delayed action is now overwhelming. We risk damages on a scale larger than the two world wars of the last century. The problem is global and the response must be a collaboration on a global scale.’* The consensus is quickly forming across the literature and in the media that the world has a relatively short period of time, a matter of 10-20 years, to significantly reduce the greenhouse gas emissions.

> *Two decades after Our Common Future emphasized the urgency of sustainable development, environmental degradation continues to threaten human well-being ... While progress towards sustainable development has been made through meetings, agreements and changes in environmental governance, real change has been slow.* (UNEP, 2007, p34)

As there is now a great deal of literature and publications demonstrating the imperative to respond to climate change it was not a major focus of the thesis other than to set the context for the later parts. In researching this important area it became clear that perhaps if the planet were twice or three times as large, or say as large at Jupiter which has a surface area 123 times bigger than Earth’s, the research question of this thesis would have little importance, and it would be another researcher long off in the future that would be concerned about the viability of our future on this planet.

However, the 21st Century may be seen as the period in the history of the Earth when the impacts of its civilisations on the world’s biosphere rose to a level where it changed the conditions of life on Earth - with the level of change dictated by the level of action to address the impacts in the early decades of the 21st century.

This is a massive realisation to truly comprehend, far too much for a single thesis to hope to encompass, and it is understandable why for so long so many would see this as a ridiculous notion. It is also understandable that so many would want to avoid admitting such an 'inconvenient truth', as former Vice President Al Gore (2006) refers to it, and would rather act as if we can continue on with business as usual without serious consideration of the risks. It seems that having now used the last two centuries to develop our global industrialised economy with little concern for the impacts on the environment, we are facing an imperative for swift and decisive change in order to reduce environmental pressures on a meaningful scale, and this thesis is intended to inform such an agenda in the area of transitioning the worlds economics to low greenhouse gas emissions in response to climate change, health concerns from associated air and water pollution, and growing costs associated with fossil fuel based energy generation.

The motivation for developing this thesis was the understanding that humanity is at a point in its development that offers the most sophisticated and technologically advanced platform upon which to tackle large scale complex problems, one that has the potential to underpin a transition in the coming decades to a global society that is able to sustain its preferred living conditions.

However, to achieve such a future this platform needs to be harnessed and directed to address the significant complexities involved in reducing greenhouse gas emissions, along with other pressing environmental and social challenges. Further it is crucial to understand that even if the impacts of global warming alone may be significantly mitigated, when combined with deforestation, the expansion of freshwater intensive modern agriculture, and increasing urban waste streams, the overall environmental pressures may still be too much for ecosystems to handle (Brown, 2008; OECD, 2008a).

Considering greenhouse gas emissions, according to UNEP (2007, p363), *'Even if atmospheric concentrations of greenhouse gases were to be stabilized today, increases in land and ocean temperatures due to these emissions would continue for decades, and sea levels would continue to rise for centuries, due to the time-lags associated with climate processes and feedbacks'*. Due to the complexity involved and scale of the research in this area amplification effects not explored in this thesis, please refer to key studies on amplification effects and the rate of occurrence (Brown, 2008).

2.2 EVIDENCE TO SUPPORT CALLS TO ACT ON REDUCING GREENHOUSE GAS EMISSIONS INTERNATIONALLY

The growing number of investigations and literature on climate change shows that the threat of rising greenhouse gas emissions may be the greatest threat mankind has ever faced. The basis of this claim is that relative to 1950 the change in average global temperature has been estimated to have oscillated between -9°C and +2°C for over 400,000 years (Petit, 1999). More recently our planet has reached a balance had been reached that had allowed life as we know it on our planet to flourish. This balance involves a certain amount of water remaining frozen at the poles, in glaciers, and in vast areas of permafrost where the land itself remains constantly frozen close to the poles (Zimov *et al*, 2006; Schuur *et al,* 2008; Lawrence and Slater, 2005), it involves the oceans finding a delicate balance of temperature and salinity that allows vibrant and diverse aquatic ecosystems to grow (such as coral reefs and marine life) with its waters circulating heat around the globe, and it involves the various locations that life has taken hold (the range of animal species, the endemic regions of plants, and so on…) (UNEP, 2007).

Beyond 1950, however, and into the coming century, the continued growth in greenhouse gas emissions stands to result in an increase in the average global temperature of greater than the +2°C oscillation, increasing to as much as +5°C, widely regarded as leading to unpredictable impacts on the biosphere. Calculations by NASA (2009) estimated that since 1950 the average global temperature in 2005 increased by 0.64°C, and when combined with the increase in temperature expected due to time-lags and from committed energy intensive infrastructure of an estimated 0.6°C, NASA estimates that we have already locked in a 1.24°C increase, meaning that we are fast approaching the +2°C historical oscillation, and entering uncharted territory.

Since 1988 the Intergovernmental Panel on Climate Change (IPCC) has released a series of assessment reports that have informed global debate and shaped understandings around the seriousness of the climate change situation. As Dr Rajendra Pachauri, the IPCC Chairperson explains in his Foreword to Smith, Hargroves, and Desha (2010), '*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 4^{th} 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 $2^{o}C$ at equilibrium'*

Further, NASA (Hansen, 2005), the European Parliament (European Council, 2007) and participants of the 2009 Copenhagen Meeting (International Alliance of Universities, 2009), have shown support for emissions to be reduced through a serious effort to prevent average global temperatures from exceeding +2°C. In 2010, Governments of the world responded to the objective of the UNFCCC to '*prevent dangerous anthropogenic interference with the climate system*' by setting a target of achieving a global rise in mean surface temperature of no more than 2°C higher than the pre-industrial average. This target has been adopted by the '*The Deep Decarbonization Pathways Project*' (SDSN and IDDRI, 2014), led by Professor Jeffery Sachs, initiated to support the United Nations Sustainable Development Goals, and will be adopted as the goal of this thesis.

However, the reality may be that even if we stop emissions levels growing as soon as 2015 and then gradually reduce them each year by as much as 3 percent - as Stern (2006) considers feasible - findings released in 2009 suggest that, '*there is still a 55 percent chance of exceeding a 2°C rise in global average temperatures, and a 1 in 3 chance that the world will still be more than 2°C warmer in 100 years' time'* (Lowe et al, 2009). Hence urgent action is needed if we are to remain within the 2°C historic oscillation.

In order to achieve such a goal, the IPCC, and many other bodies, are calling for reductions in emissions in the order 80 percent by the year 2050 (Smith, Hargroves, and Desha, 2010). Specifically, the emissions being referred to include both emissions of CO_2 gas, along with the emission of a range of other greenhouse gases. These 'non-CO_2' gases are represented as an equivalent volume of CO_2 gas based on their relative ability to contribute to warming the atmosphere, known as their Global Warming Potential, or 'GWP' (IPCC 1996c, p22). Carbon Dioxide is emitted primarily from fossil fuel related emissions, peat and permafrost releases, and deforestation, and using 2005 as a baseline an estimated 34 billion tons of CO_2 ($GtCO_2$) were emitted globally (IPCC, 2007a).

Other identified greenhouse gases, referred to as non-CO_2 greenhouse gases (CO_2e) and including Methane, Carbon dioxide, Methane, Nitrous oxide, Hydrofluoro-carbons, Perfluoro-carbons, and Sulphur hexafluoride, when converted to an equivalent volume of CO_2 contribute an estimated further 12 billion tons of CO_2e (IPCC, 2007a). Hence the total level of emissions in 2005 was in the order of 46 billion tons, and considering that the potential for the Earth's biosphere to assimilate CO_2 has been estimated at around 11.4 billion tons, give or take 4 billion tons (IPCC, 2007c, Ch 7), from natural loss of such gases as they escape the atmosphere, or are absorbed by plants and the ocean, we are emitting in the order of 80 percent more than the planet can handle without build up.

However, the IPCC has also clearly explained that even targets in the order of 80 percent may even be insufficient given the unpredictable potential for feedbacks (Cox *et al*, 2000; Jones *et al*, 2003) to increase emissions even further – such as the release of additional greenhouse emissions from the vast stores of carbon in nature being triggered by rising temperatures – stating that, '*It appears that, as climate warms, these feedbacks will lead to an overall increase in natural greenhouse gas abundances. For this reason, climate change is likely to be greater than the estimates we have given'* (IPCC, 1990). The occurrence of feedbacks means that efforts need to be accelerated before the feedbacks strengthen. Many now consider that going over the historic $+2^oC$ will result in such feedbacks becoming irreversible, and caution that it would then take centuries to allow the global average temperature to come back down (Lowe *et al*, 2009).

This imperative is not only an environmental one but is quickly becoming an economic and national security issue (Brown, 2008). For instance, oil reserves are estimated to have reached their peak in more than 60 countries (Hirsch, 2005), and such decline in production will lead to increases in energy costs and will heighten the potential for conflict over oil supplies (Smith, Hargroves, and Desha, 2010). The entire global economy is remarkably dependant on oil for transport fuels, fertilisers, plastics, chemicals, and pharmaceuticals. Sprawling cities across the world assume that cheap oil would continue (Rauland and Newman, 2015). This is set to be exacerbated by cautions by the International Energy Agency that, '*The rapidly growing appetite for fossil fuels in China and India is likely to help keep oil prices high for the foreseeable future - threatening a global economic slowdown'* (Kanter, 2007).

Surprisingly, despite the clear link between economic downturns and the price of oil in the past (Porritt, 2005), the typical response to a recession that has followed a period of high oil prices is not to focus on reducing demand for oil, but rather it is invariably the application of pressure from within governments and from powerful parts of the business sectors not to do so, due to the belief that such actions would harm economic growth and jobs – despite growing evidence to the contrary, even in the short term (Hawken, Lovins, and Lovins, 1997; Lovins *et al*, 2004) and growing understanding of the responsibility of business to contribute to responding to climate changes (AIG, 2007). Hence the irony is that such a 'business-as-usual' approach to protecting short term profits has actually allowed oil demand to increase to such a level that the greenhouse gas emissions generated from its use may well undermine the entire economy, which is quite a legacy.

According to the findings of the Stern Review, a slow response to climate change over the coming decades, '*could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes*' (Stern, 2006, p10). However, the business-as-usual assumption has persisted among decision-makers and as such has resulted in governments, research and development institutions and firms not having been encouraged to explore economically feasible and desirable paths to reduce emissions.

Given the perpetuation of the business-as-usual assumption it may seem as though calls to reduce greenhouse gas emissions are new, however, even as far back as 1987, *Our Common Future* showed that large greenhouse gas emissions reductions could be cost effectively achieved through a range of energy efficiency, demand management, and renewable energy approaches, and that done wisely this would make a positive contribution to the economy (WCED, 1987). In the 1991 book *Beyond Interdependence,* Jim MacNeill (former Secretary General of the World Commission on Environment and Development, and chief architect and lead author of *Our Common Future*), built on from *Our Common Future* with his colleagues and brought together further evidence to support ambitious commitments to emissions reduction targets, stating that '*an increasing number of studies show that industrialised nations can make substantial reductions in greenhouse gas emissions through energy efficiency and other measures that, at best, return a profit, and at worst, break even'*. (MacNeill, 1991)

MacNeill *et al* (1991) argued that the opportunities of improving energy efficiency in particular make it possible to achieve short term targets very cost effectively. For example, they quoted from a Canadian study which showed that 20 percent cuts could be achieved by 2005 with energy efficiency providing 75 percent of the reductions. The remainder of the target could be achieved through substituting competitive non-fossil fuel sources of energy. This study showed that an investment of C$74 billion would yield a net benefit of C$150 billion on the basis of energy savings alone (DPA Group, 1989). The team cited work by Lancaster University in the United Kingdom, stating in 1991 that they had, *'calculated that a combination of energy efficiency measures and high efficiency gas-fired electricity generation could reduce CO_2 emissions from the UK stationary sector (i.e. utilities and buildings) by 46.5 percent over current levels.'* (Jackson, 1991)

Further studies presented by MacNeill *et al* (1991) included a study by Swedish state power company Vattenfall and the University of Lund which showed that CO_2 emissions in Sweden from the heat and power sectors could be reduced by a third between 1987 and 2010, mainly though energy efficiency improvements and a shift to biomass-based power generation. MacNeill *et al* (1991) then outlined a range of studies showing that the structural adjustment costs to shift national economies to 50 percent reductions in greenhouse gas emissions or more over the longer term were affordable.

One of the first such studies discussed was the 1989 study by McKinsey and Company, commissioned by the Netherlands Ministry of Housing, Physical Planning, and Environment. According to MacNeill *et al* (1991), McKinsey & Company were commissioned '*to analyse the potential for reducing two greenhouse gases, CO_2 and CFCs, in three regions, OECD, Eastern Europe, and the rest of the world. These measures apply to approximately two-thirds of all greenhouse gas* *emissions and they cover a sufficiently broad range of actions to provide a fair assessment of policy opportunities… The most important conclusion of the study was that from a purely technical point of view it appears possible to reduce greenhouse gas emissions by almost 50 percent by the year 2005 relative to then-prevailing levels, and at the same time to continue economic growth at a realistic pace in each of the three target areas'*.

As a result of the investigation McKinsey concluded that many measures to mitigate greenhouse gas emissions will be quite profitable and would, '*more than offset the initial investment and incremental operational costs* [through] *a variety of energy efficiency measures in for example, transportation, space heating, and industrial process heat and significant net afforestation. Implementation of these measures might eventually result in a 30-40 percent reduction in greenhouse gas emissions over time'* (MacNeill, 1991). By the mid-1990s, these economic and technical results were further backed up by new and important technical studies by the IPCC and other experts (IPCC 1996a, 2006a; Nakicenovic et al, 1995; Lazarus, 1993) such as the book *Factor Four* in 1997 (von Weizsäcker *et al*, 1997). These new studies showed that significant reductions in greenhouse gas emissions would be cost effectively achievable over the longer term.

Since 1997 warnings against not acting to reduce environmental pressures have come from a range of organisations and groups, including:

– [1997] The Engineer's Response to Sustainable Development, The World Federation of Engineering Organizations (WFEO): "*Engineers around the world understand that they have a tremendous responsibility in the implementation of sustainable development. Many forecasts indicate there will be an additional five billion people in the world by the middle of the 21st century. This future 'built environment' must be developed while sustaining the natural resources of the world and enhancing the quality of life for all people*". (WFEO, 1997)

– [1997] Economists' Letter on Global Warming to American Economics Association with over 2000 signatories: '*The balance of evidence suggests a discernible human influence on global climate. As economists, we believe that global climate change carries with it significant environmental, economic, social, and geopolitical risks and that preventive steps are justified. Economic studies* *have found that there are many potential policies to reduce greenhouse gas emissions for which the total benefits outweigh the total costs.*' (Harris, and Roach, 2009)

- [1998] UNESCO World Declaration on Higher Education for the 21st Century: Considering the urgency of sustainable development, '*Higher education itself is confronted therefore with formidable challenges and must proceed to the most radical change and renewal it has ever been required to undertake'*. (UNESCO, 1998)
- [2000] United Nations, World Bank, and the World Resources Institute: '*There are considerable signs that the capacity of ecosystems, the biological engines of the planet, to produce many of the goods and services we depend on is rapidly declining.'* (WRI, 2005)
- [2001] Robert T. Watson, Chair, 2001 Intergovernmental Panel on Climate Change: '*The question is not whether climate will change further in the future in response to human activities, but rather by how much (magnitude), where (regional patterns), and when (the rate of change). It is also clear that climate change will, in many parts of the world, adversely affect socio-economic sectors, including water resources, agriculture, forestry, fisheries, and human settlements, ecological systems (particularly coral reefs) and human health (particularly vector-borne diseases). Indeed, the IPCC Third Assessment Report concluded that most people will be adversely affected by climate change.*' (Watson, 2001)
- [2005] World Economic Forum, Global Governance Initiative Report: '*The world's leaders have made solemn promises to humanity. They are breaking those promises. In multiple declarations spanning decades, the world's governments have agreed on a comprehensive agenda to turn the world away from environmental overload, unnecessary pandemics, pervasive malnutrition and poverty, and war. Some promises, such as the Millennium Development Goals, are specific commitments to achieve such targets as halving global poverty and hunger by 2015. Others, dealing with such topics as peace and security, are broader. But all are essential. They are the building blocks of global stability in what has become a tightly interconnected world. It is thus inexcusable*

that they are being honored far more in the breach than in the observance.' (WEF, 2005)

- [2005] United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) Ministerial Conference on Environment and Development: "*It is now an urgent challenge to find ways to ensure that the old paradigm 'grow first, clean up later' is replaced by an integrated approach that enables economic growth to support and reinforce sustainability rather than undermine it.*" (Kwon Chung, 2005)
- [2005] United Nation's Millennium Ecosystem Assessment: '*Although evidence remains incomplete, there is enough for the experts to warn that the ongoing degradation of 15 of the 24 ecosystem services examined is increasing the likelihood of potentially abrupt changes that will seriously affect human well-being*'. (WRI, 2005)
- [2006] UK Stern Review: '*Inaction now and over the coming decades could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes*.' (Stern, 2006)
- [2007] Achim Steiner, UN Under-Secretary General and UNEP Executive Director: '*The systematic destruction of the Earth's natural and nature-based resources has reached a point where the economic viability of economies is being challenged - and where the bill we hand on to our children may prove impossible to pay.*' (UNEP, 2007a)
- [2007] Dr Rajendra Pauchari, IPCC Chair: "*2015 was the last year in which the world could afford a net rise in greenhouse gas emissions, after which 'very sharp reductions' are required*." (Milmo, 2007)
- [2007] Robert Corell, Chairman of the Arctic Climate Impact Assessment: warning that Arctic ice is '*moving at 2 metres an hour on a front 5 kilometres (3 miles) long and 1,500 metres deep*'. (Brown, P 2007; cited in Brown, 2008)
- [2007] The Intergovernmental Panel on Climate Change 4th Assessment Report: '*to ensure that warming does not exceed 2–2.4°C* [widely regarded as the temperature at which there is a high risk of dangerous climate change], *global*

emissions must peak by 2015, and we must be on track to reduce global emissions by 50-85% by 2050'. (IPCC, 2007c)

- [2008] UNEP Year Book 2008: '*There is a critical need to substantially increase research investments for understanding the processes of climate change, assessing the likely impacts on people and places, and expanding the adaptive capabilities of human and natural systems…*' (Harrison *et al*, 2008, p47)
- [2008] OECD Environment Outlook (Organisation for Economic Co-operation and Development): '*The challenge for all countries is to put in motion a transition to a more secure, lower-carbon energy system, without undermining economic and social development. Vigorous, immediate and collective policy action by all governments is essential to move the world onto a more sustainable energy path*.' (OECD, 2008a)
- [2009] US President Barack Obama, address to the United Nations General Assembly: *'It is hard to change something as fundamental as how we use energy. It's even harder to do so in the midst of a global recession. Certainly, it will be tempting to sit back and wait for others to move first. But we cannot make this journey unless we all move forward together. As we head into Copenhagen, let us resolve to focus on what each of us can do for the sake of our common future.'* (Obama, 2009)

In response to such calls a number of comprehensive studies and investigations have been published which provide business and governments around the world with detailed guidance as to how to create strategies to achieve cost effective greenhouse gas emissions reductions across the economy, namely:

- *Scenarios for a Clean Energy Future*, Oak Ridge National Laboratory (Interlaboratory Working Group, 2000)
- *Steps towards a 2000 Watt Society – A White Paper on R&D of Energy- Efficient Technologies*, Fraunhofer Institute for Systems and Innovation Research (Jochem *et al*, 2002)
- *Walking the Talk, The Business Case for Sustainable Development*, World Business Council for Sustainable Development (Schmidheiny and Watts, 2002)

- *Kyoto and Beyond: the low emission path to innovation and efficiency*, Report for David Suzuki Foundation and Canadian Climate Action Network (Torrie, Parfett, and Steenhof, 2002)
- *Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size*, Rocky Mountain Institute (Lovins *et al*, *2*002)
- *Long-Term Greenhouse Gas Scenarios: a pilot study of how Australia can achieve deep cuts in emissions*, The Australia Institute (Turton *et al*, 2002)
- *US Energy Scenarios for the 21st Century*, Pew Center on Global Climate Change (Mintzer, Leonard, and Schwartz, 2003)
- *Our Energy Future – Creating a Low Carbon Economy*, UK Department of Trade and Industry (Department of Trade and Industry, 2003)
- *The Path to Carbon Dioxide-Free Power: Switching to Clean Energy in the Utility Sector*, A study by Tellus Institute and Center for Energy and Climate Solutions for the World Wildlife Fund (Bailie *et al*, 2003)
- *Steps Towards A Sustainable Development: A White Book of R&D for Energy Efficient Technologies*, Fraunhofer Institute for Systems and Innovation Research (ISI). (Jochem *eds*, 2004)
- *A Clean Energy Future for Australia Energy Strategies*, World Wildlife Federation (Saddler, Diesendorf, and Denniss, 2004)
- *Winning the Oil Endgame: Innovation for Profits, Jobs and Security*, Rocky Mountain Institute (Lovins *et al*, 2004)
- *Low Carbon Economy*, discussion paper for the European Regional Network on Sustainable Development workshop (Belhaj and Norrman, 2004)
- *Japan: Low Carbon Society Scenarios toward 2050*, National Institute for Environmental Studies, Japan. (National Institute for Environmental Studies, 2005)
- *The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century*, The Natural Edge Project (Hargroves and Smith *et al*, 2005)
- *The Stern Review: The Economics of Climate Change* (Stern, 2006)

- *Carbon-Free and Nuclear-Free: A Roadmap for U.S. Energy Policy*, Nuclear Policy Research Institute and the Institute for Energy and Environmental Research. (Makhijani, 2007)
- *Analysis of the Costs of Inaction versus the Costs of Action on Climate Change for Australia*, a submission by TNEP to the *Garnaut Review*, The Natural Edge Project (Smith and Hargroves, 2007)
- *Paths to a Low Carbon Future Reducing Australia's Greenhouse Gas Emissions by 30 percent by 2020,* Sustainability Centre (Diesendorf, 2007)
- *Leader, follower or free rider? The economic impacts of different Australian emission targets by 2050,* The Climate Institute (Hatfield Dodds *et al,* 2007)
- *Zero Carbon Britain*, Centre for Alternative Technology (Helweg-Larsen and Bull, 2007)
- *Climate Change 2007: Mitigation of Climate Change* (IPCC, 2007)
- *Japan Scenarios towards a Low Carbon Society – Feasibility study for 70% CO2 emission reduction by 2050 below 1990 level*, National Institute for Environmental Studies. Japan (National Institute for Environmental Studies, 2007)
- *Energy Transformed: Sustainable Energy Solutions for Climate Change Mitigation*, The Natural Edge Project (Smith and Hargroves *et al*, 2007)
- *Meeting the Energy Challenge: A White Paper on Energy*, Department of Trade and Industry, UK. (Department of Trade and Industry, 2007)
- *80 percent challenge: Delivering a Low Carbon Britain*, Institute of Public Policy Research, WWF and RSPB, UK. (Institute of Public Policy Research, WWF and RSPB, 2007)
- *Curbing global energy demand growth: the energy productivity opportunity* (McKinsey & Company, 2007)
- *An Australian Cost Curve For Greenhouse Gas Reduction*, McKinsey Consulting (Gorner *et al*, 2008)

- *Deep Reductions, Strong Growth: An economic analysis showing that Canada can prosper economically while doing its share to prevent dangerous climate change*. (Pembina Institute and David Suzuki Foundation, 2008)
- *Factor 5: Transforming the Global Economy through 80% Improvements in Resource Productivity*, The Natural Edge Project (von Weizsäcker and Hargroves *et al*, 2009)
- *Cents and Sustainability: Securing Our Common Future by Decoupling Economic Growth from Environmental Pressures*, The Natural Edge Project (Smith, Hargroves, and Desha, 2010)

These studies and reports, published in the last 15 years, provide a wealth of knowledge and experience to inform the development of strategies to secure future economic growth while significantly reducing greenhouse gas emissions. On the whole, these studies demonstrate that the most effective strategies use a portfolio of options including energy efficiency, demand management, renewable energy, fuel switching, transport planning, and emissions trading (Young, 2008; Mori, Kikuyama, and Day, 2009; Newman and Kenworthy, 2015) and ecological taxation opportunities. Hence despite having missed the possibility of reducing emissions by some 50% by 2005 as McKinsey suggests above, this work now forms a body of knowledge to support ambitious targets for reductions in emissions in the order of at least 20-30 percent by 2020, and 60–80 percent by 2050, with strong economic and jobs growth.

This knowledge, combined with a growing level of experience in implementing solutions in economies around the world has led to ambitions targets being set by the end of 2014, as shown below, suggesting that our global community has a realistic chance of mounting a meaningful response to climate change in the coming century. By the end of 2014 the world's largest economies had set ambitious greenhouse gas emissions targets with:

- China committing to 40 to 45 per cent by 2020 (compared to 2005 levels),
- European Union committing to reducing emissions by at least 40 per cent by 2030 (compared to 1990 levels),

- United States of America committing to 26-28 per cent by 2025 (compared to 2005 levels),
- India committing to 20-25 per cent by 2020 (compared to 2005 levels), and
- Australia committing to 12 per cent by 2020 (compared to 2005 levels).

The key to achieving a rapid transition to low carbon will be the effective implementation of strategies that deliver reductions in greenhouse gas emissions in ways that deliver economic multipliers (von Weizsäcker, Hargroves, et al 2009). For instance investing in improvements to the efficiency and/or productivity of energy, water and other resources, can deliver flow on benefits such as reduced input costs, reduced running and maintenance costs, and reduced waste related costs, and hence can be recovered over a reasonable timeframe to then deliver ongoing cost savings that can then be invested to achieve even greater resource productivity improvements (Hawken, Lovins, and Lovins, 1999). Furthermore, as such investments can lead to reduced levels of consumption of resources, such as water and electricity, and this can lead to delays in, or even the avoidance of, costly investments in increasing the capacity of energy and water supply infrastructure, as well as plant and infrastructure in extractive industries (Lovins *et al*, 2002). Typically such investments are at a local level and can spur jobs growth and economic development, attracting companies and operations keen to be part of such initiatives (Lovins and Lovins, 1997).

It is not possible to consider strategies to reduce greenhouse gas emissions without considering the potential for such achievements to be overwhelmed by growth in overall energy demand, referred to as the 'Rebound Effect' (Jevons, 1865). This area of consideration is largely inspired by the work of William Jevons (1865) that found that the result of improving the efficiency of coal engines did not lead to an overall reduction in coal consumption, as many assumed it would, but rather a vast increase. The book pointed out that those who anticipated that a reduction in the amount of coal needed to produce a ton of iron by over two thirds in Scotland at the time would lead to a significant reduction in coal demand were mistaken. In reality the lower coal requirement to make iron meant that iron could be made more cheaply, and in an economy that could always use more iron, the overall consumption of coal grew tenfold between the years 1830 and 1863, which should have been predictable at the time. Applying this logic to modern energy demand reduction programs and initiatives many consider these rebound effects to be significant, but they need not be (Pears, 2004a).

Counteracting the rebound effect is based on the simple observation that, when a more efficient technology, process, or product is introduced into the market, it does not automatically imply that due to the lower consumption of the particular product there will be an overall reduction in resource consumption. This is due to the fact that as the product is more efficient it may be cheaper to purchase and/or to run, leading to the potential for more people being able to afford to use the product, or to use it more often, which introduces socio-economic considerations. In short, rather than suggesting that efficiency is not effective as some may suggest, the rebound effect highlights that as one would expect, a single intervention into a complex system will not necessarily lead to a preferred system wide change. This is why significant economy-wide reductions in greenhouse gas emissions cannot be achieved by a sole focus on the market driven uptake of low greenhouse gas emissions technologies and process, but must be part of a strategic approach that involves careful consideration of social (Jorgenson *et al*, 1995), economic (Stern, 2006), institutional, informational, technical, organisational, and other aspects (Hargroves and Smith, 2005).

2.3 UNDERSTANDING THE CHALLENGE OF REDUCING GREENHOUSE GAS EMISSIONS

When considering the now overwhelming and widely validated evidence of the negative impacts of greenhouse gas emissions on the environment (UNEP 2007; IPCC 2013), it is difficult to understand how a ‘business-as-usual’ assumption could still be held even by the most ardent sceptic, leading to the question raised by my colleagues and I in Smith, Hargroves, and Desha (2010) of, ‘*is it denial of the truth, or the fear of the ramifications of admitting the truth, that now holds us back?*’ Those frustrated with this assumption being held for so long call into question the activities of lobby groups and ‘blocking coalitions’ who continue to act to support ‘business-as-usual’. However, this may not be the only major reason for slow action.

Another plausible reason is ‘*complexity*’. Natural systems are complex, social systems are complex, institutional systems are complex… our 21st Century world is enormously complex. The question becomes ‘*are we overwhelmed by the complexity* *of our own problems… and is it even feasible to respond to them*?'. Former Vice President Al Gore described this reaction in his award winning and world changing film, *An Inconvenient Truth,* where he discussed the tendency for people making this realisation to jump from 'Denial' to 'Despair' (Gore, 2007). However, the purpose of the film, and of this thesis and the many references that have informed it, is to demonstrate that in light of such complexity, we have developed into a sophisticated species, and we have both the imperative and capability to significantly reduce our environmental pressures in a positive, innovative, and inclusive way.

As previously pointed out, the enormous amounts of economic growth and prosperity that the world has achieved to-date has been based on increasing levels of negative environmental pressure, accelerating over the last century. Continuing to avoid responding to these pressures in a meaningful way will lead to serious economic risks, as highlighted in the *Stern Review* in 2006, stating, '*The world does not need to choose between averting climate change and promoting growth and development... Indeed, ignoring climate change will eventually damage economic growth.'* (Stern, 2006, p xvii)

This sentiment was supported soon after the release of the Stern Review by the United Nations Secretary-General Ban Ki-moon stating in his 2007 UN Bali Climate Change Conference address, '*Action is possible now and it makes economic sense. The cost of inaction will far outweigh the cost of action'* (UN, 2007). Sir Nicolas Stern, speaking to *The Guardian* said, when considering the 2008 global financial crisis, that, '*We're going to have to grow out of this ... and this is an area which looks as though it could well grow strongly and with the right support could be one of the major engines of growth.*' (Jowit, 2008)

Agreeing with this position, the British Government made a landmark decision (passed by 463 votes to 3) in October 2008 to commit to increase its greenhouse gas target from 60 percent to around 80 percent by 2050, despite strong pressure to reduce such targets in light of the financial crisis, thus becoming the first country in the world to have such a legally binding framework on climate change (Moresco, 2008). Ed Miliband, Secretary for Energy and Climate Change, said at the time that, '*If you accept that what is required is an economic transition to deal with climate change then the problems in the financial system actually make a stronger case for* *pushing ahead with that transition… In our view it would be quite wrong to row back and those who say we should, misunderstand the relationship between the economic and environmental tasks we face.'* Miliband went on to say that, '*It's the first legislation of its kind in the world. It will tie this and future governments into legally binding emission targets - an 80 percent cut by 2050, with five-year carbon budgets along the way'* (The Age, 2008).

Across the Atlantic Ocean, the then President-elect Barack Obama, at the time boldly signalled a sea-change in the US Administration's attitude, stating in November 2008 that, '*Now is the time to confront this challenge once and for all… Delay is no longer an option. Denial is no longer an acceptable response'*. He went on to say that, '*My presidency will mark a new chapter in America's leadership on climate change that will strengthen our security and create millions of new jobs in the process… When I am president, any governor who's willing to promote clean energy will have a partner in the White House. Any company that's willing to invest in clean energy will have an ally in Washington. And any nation that's willing to join the cause of combating climate change will have an ally in the United States of America'* (Broder, 2008).

And as the People's Daily Newspaper reported: "*The recognition that economic growth is not equal to economic development and that growth is not the final goal of development, will be included in the 11th Five-Year Plan for the first time … Top leaders have criticized old concepts of economic growth many times, saying that 'economic development at the center' does not mean 'with speed at the center'. Blind pursuit of economic growth has led to blind investment, damage to the environment and false statistics. The country's helmsmen are worried that without changing China's concept of growth, the economy might develop an unbalanced structure with a lack of driving power*" (People's Daily Online, 2005).

The Chinese Deputy Minister of Environment, Pan Yue, stated in 2005 that: '*This [Chinese economic] miracle will end soon because the environment can no longer keep pace. Acid rain is falling on one third of the Chinese territory, half of the water in our seven largest rivers is completely useless, while one fourth of our citizens do not have access to clean drinking water. One third of the urban population is breathing polluted air, and less than 20% of the trash in cities is treated and* *processed in an environmentally sustainable manner. Finally, five of the ten most polluted cities worldwide are in China*' (Spiegel Online, 2005). Such realisations have led to a range of strategic responses by the Chinese government, including one that involves the government working with the 1000 largest heavy industry companies in China (estimated to represent 33 percent of the national energy consumption) to work towards contributing up to 25 percent of the savings required to achieve the overall Chinese government target of a 20 percent reduction in energy use per unit of GDP by 2010. (Lawrence Berkeley National Laboratory, 2009)

The success of such government commitment will determine the future economic impacts that climate change will have on nations of the world (Smith, Hargroves, and Desha, 2010). The longer action is delayed on a meaningful scale the higher the resulting costs from the environmental damage will be to future generations, adding to the already high cost of environment related costs to the economy. According to Stern (2006) estimated that '*the total cost of business-as-usual climate change to equate to an average reduction in global per capita consumption of 5 percent at a minimum now and forever*.' The *Stern Review* also describes that this cost would increase to as much as 20 percent per year if the modelling was to take into account the impacts related to human health, various amplifying effects, and the disproportionate burden of climate change on the poor and vulnerable globally.

Thus to pay for such costs governments in the future will need to raise taxes, privatise public assets, or borrow money. Some argue that future generations will be wealthier and more able to pay, but this assumes that the costs of inaction will not rise, and if they do it will be a predictable and manageable increase (Smith, Hargroves, and Desha, 2010). However, the *Stern Review* is clear that due to the complexity of natural systems and the potential for feedbacks and amplification effects the costs on inaction will continue to rise in an unpredictable manner unless action is taken. Those moving early to respond to this challenge are demonstrating that there are a number of ways that reducing pressure on natural systems can underpin continued economic growth – which is possibly the most important finding, or 'convenient truth', of the 21st Century. (von Weizsäcker, Hargroves, *et al*, 2009)

However, the timeframe for action is short and the consequences for inaction will be severe and long lasting. In order to ensure that the most cost effective, efficient, and successful transition to low greenhouse gas emissions is achieved it is crucial that a range of structural adjustments are made to economies - and further that efforts from societies around the world are monitored and quickly learned from to inform further efforts. The number of countries now developing 'National Strategies for Sustainable Development' is an encouraging sign of the creation of national level frameworks to support a transition to low greenhouse gas emissions, such as Cameroon, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Latvia, Mauritius, Mexico, Moldova, Netherlands, Norway, Philippines, South Korea, Sweden, Switzerland, The Czech Republic, United Kingdom, and the European Union.

Economists have pondered for many years the thought that perhaps if the world stopped focusing on continually increasing economic growth then the unsustainable growth in demands on the environment would slow to a point that it would be sustainable without changing much about the way the economies operate (Jackson, T. 2009). The challenge is that most of the national economies of the world are built on the predication that there will be strong economic growth, and further that in its absence the economy will be bailed out by government, as in many countries following the 2008 global financial crisis. This assumption underpins many economies, which in reality are incredibly complex systems that operate on a balance of numerous factors. This fragile balance sets the level of taxation, the price of commodities and products, the spending and saving habits of residents, and affects levels of investment, insurance, interest rates, public spending, private development, education, research, etc…

The reality is that on any given day the complexity of the average economy is in itself overwhelming, and trying to incorporate future impacts from environmental pressures is an even higher order level of complexity – one that will not be achieved by reducing the level of economic growth alone, or by taking isolated actions in parts of the economy. Such complexity needs to be taken in to consideration when deciding on structural changes to promote reduced greenhouse gas emissions. Donella Meadows, a highly respected sustainable development expert, explains that actions that lead to changes in the demand for products, such as increased fuel taxes that affect the demand for cars, for instance, can lead to impacts throughout the system with uncertain outcomes that can self-perpetuate. She points out that, '*orders for more or fewer cars affect production not only at assembly plants and parts* *factories, but also at steel mills, rubber and glass plants, textile producers, and energy producers … increased production increases the number of jobs allowing more people to buy cars … which also works in the opposite direction … less production, fewer jobs, fewer car sales, less production.'* (Meadows, 2009, p58)

However, it is of course obvious that there can be too much economic growth, more than is truly needed to underpin the economy, however, finding the right level of economic growth is also an incredibly complex and political process. The discussion around the level of economic growth that is needed is not the focus of this thesis, however as Kenneth Ruffing, former Deputy Director of the OECD Environment Directive, points out that,

> *Buoyant economic growth underpins national economies by ensuring employment opportunities, creating favourable conditions for business investment, increasing revenue for public good investment by governments (such as in education, health and research and development), and enabling higher levels of foreign investment and aid, and thus* [reducing economic growth] *is not an option.* (Smith, Hargroves, and Desha, 2010, Foreword by Kenneth Ruffing)

In order to respond to climate change a significant effort needs to be made in the coming decades to adjust the many structures that control economies to significantly reduce greenhouse gas emissions while supporting economic growth and increased well-being. This will be one of the most complex and wide reaching challenges of the human race (Stern, 2006, Summary of Conclusions). If done effectively the nations of the world have the opportunity to work together to achieve significant reductions in greenhouse gas emissions while maintaining strong economic activity and jobs growth, if done poorly we will see environmental refugees (Brown 1976; Vattenfall, 2006), resource wars (Klare, 2002), and dramatic changes to the world's climate (UNEP 2007).

2.4 CHAPTER SUMMARY AND CONTRIBUTION TO THESIS

The chapter began by stating concerns about how current trends of environmental pressure may affect the future of life on Earth, and that society has a small window of opportunity to respond, especially to human induced climate change through the generation of greenhouse gas emissions pollution.

The second part of the chapter presented evidence of a call to action to respond to climate change and outlined compelling evidence to support this, including the suggestion that we face '*damages on a scale larger than the two world wars of the last century*'. The chapter then outlined the past and projected changes to the average global temperature and highlighted calls for the increase compared to 1950 to be limited to 2°C, such as the '*Deep Decarbonisation Pathways Project*' led by Professor Jeffery Sachs to support the United Nations Sustainable Development Goals.

The chapter then outlined that such a goal will require in the order of 80% reductions in greenhouse gas emissions by 2050, and cautioned that this may not be sufficient due to unknown natural feedbacks and thresholds. The chapter then linked greenhouse gas emissions to economic considerations both of potential economic risks from inaction on reducing greenhouse gas emissions and of potential economic gains from taking such action. The chapter pointed out that strategies to reduce greenhouse gas emissions will need to deliver economic multipliers and a range of multiple benefits, and briefly reflected on the 'Rebound Effect' to highlight the need for a systemic approach rather than one off interventions (an area that is often miss-understood and miss-interpreted).

The third part of the chapter then outlined the argument that complexity is a key barrier to taking action on responding to climate change and presented evidence to suggest that the world's leaders are considering a range of options for taking action, such as the UK Government committing to 80% reductions in greenhouse gas emissions by 2050, and the Chinese Government seriously reconsidering their understanding of how to achieve economic growth. The chapter then considered calls for slowing or even halting economic growth in response to growing environmental pressures and concluded that this is not a valid option for a number of reasons.

This section of the literature review creates the premise that human kind has a strong imperative to reduce a range of environmental pressures associated with development and that this must be done in the coming 2-3 decades if we are to avoid economic, social and environmental impacts. This is a critical premise to base the *response to the research question as it demonstrates the emerging consensus that action must be taken and that it must be taken in a manner that strengthens economic growth.*

Chapter 3: Considering the Costs of Action and In-Action on Responding to Climate Change

The co-authored book 'Cents and Sustainability' (Smith, Hargroves and Desha, 2010) includes parts of this chapter written by me. I wish to thank my co-authors of the book, Dr Michael Smith and Dr Cheryl Desha (a co-supervisor of the thesis) for stimulating through discussion the creation of some of the arguments contained in this chapter, identifying resources for consideration to develop such arguments, and for providing valuable peer review.

3.1 CONSIDERING GREENHOUSE GAS EMISSIONS STABILISATION TRAJECTORIES AS THE BASIS FOR ACTION ON CLIMATE CHANGE

Given the complexity of broad scale changes to industrial economies, there is a need for a greater level of urgency and sophistication around the realities of developing cost effective strategies and policies to transition economies to low greenhouse gas emissions. The *Stern Review* explored in detail the concept of '*stabilisation trajectories*' and pointed out that there are two distinct phases: 1) global emissions need to stop growing, i.e. emissions levels would peak; and 2) there would need to be a sustained reduction of annual greenhouse gas emissions across the entire global economy of anywhere between 3 to 5 percent per annum depending on the timing of the peak and the requirement for emissions reductions (Stern, 2006). In Figure 3.1 Stern (2006) suggests that there are a range of potential trajectories, each that will achieve a different final stabilisation of greenhouse gas emissions concentrations.

However, before considering these findings further a number of assumptions must be clarified around the levels of greenhouse gas emissions, how they are arrived at, and the units used to represent them. For instance the X-Axis of Figure 3.1 shows the '*Global Emissions*' in units of $GtCO_2e$, meaning 'Billion (Giga) Tons of Carbon Dioxide equivalent'. As described previously, the 2005 amount for the 'business-as-usual' trajectory of around 46 $GtCO_2e$ is arrived at by combining the IPCC (2007a) estimates of around 26 $GtCO_2$ from fossil fuel related emissions only (equivalent to 7.2 GtC which is used as the current level by Pascala and Socolow in Figure 3.4), with around 8 $GtCO_2$ from peat and permafrost releases combined with deforestation related emissions, and then with around 12 $GtCO_2e$ from emissions of non-CO_2 greenhouse gases.

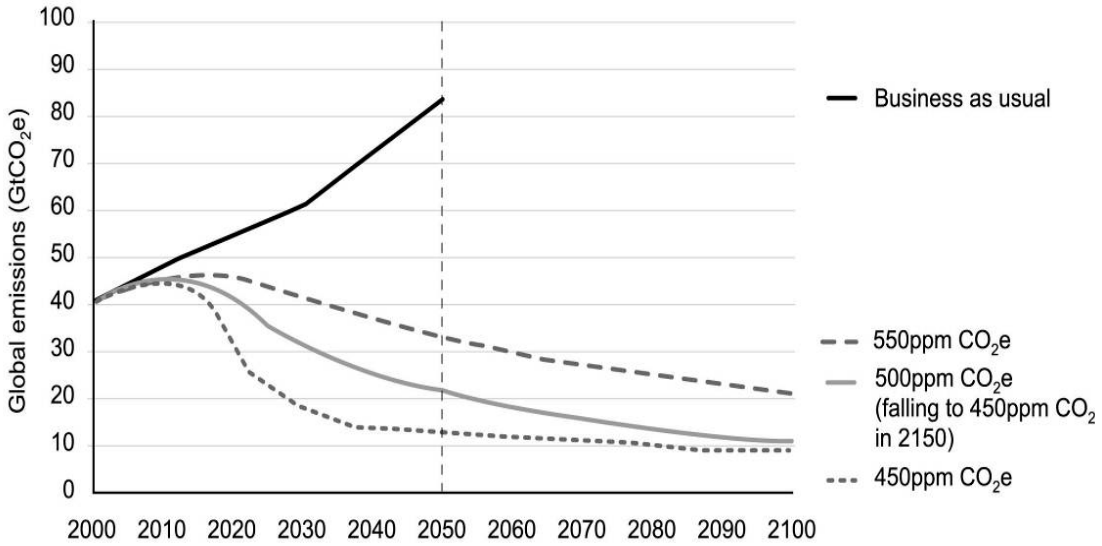


Figure 3.1: *BAU emissions and stabilisation trajectories for 450 - 550ppm CO_2e*

Source: Based on data from Stern (2006)

This last category is an important one and is calculated as the equivalent volume of CO_2 based on each of the non-CO_2 gas's 'global warming potential' (GWP), such as the volume of methane being multiplied by 21, as it is 21 times better at warming the atmosphere than carbon dioxide, and sulphur hexafluoride being multiplied by 16,300 times, meaning that its limited emissions levels actually carry quite a global warming potential.

When considering how low the emissions need to be the best case scenario of around 8-10 $GtCO_2e$ is reached by assuming firstly that by 2050 the high GWP non-CO_2 gases will be mostly removed from industrial activity as there is no way to absorb them from the atmosphere; and secondly that the current level of removal from the atmosphere of CO_2 and CH_4 of around 11.7 $GtCO_2$/year will be reduced due to environmental factors to around 9 $GtCO_2$ by 2050.

Now looking again at Figure 3.1, each of the trajectories peak between 2012 – 2018, with the IPCC (2007b) calling for the peak by 2015 to '*limit global temperature rises to 2.0 to 2.4 Celsius over pre-industrial times*.' Modelling undertaken for the *Stern Review* indicated that a 450ppm trajectory with a peak in emissions by 2010 would need to be followed by a sustained reduction of 7.0 percent per annum, while the 550pmm trajectory with a peak in 2030 would need to be followed by a sustained reduction of 2.5-3.0 percent as shown in Table 3.1. Stern (2006) pointed out that '*Paths requiring very rapid emissions cuts are unlikely to be economically viable…* [however] *early abatement paths offer the option to switch to a lower emissions path if at a later date the world decides this is desirable. This might occur for example, if natural carbon absorption weakened considerably or the damages associated with a stabilisation goal were found to be greater than originally thought. Similarly, aiming for a lower stabilisation trajectory may be a sensible hedging strategy, as it is easier to adjust upwards to a higher trajectory than downwards to a lower one'*.

Table 3.1: *Illustrative Emissions Paths to Stabilisation*

Stabilisation Level (CO_2-e	Date of peak global emissions	Global emissions reduction rate (% per year)
450 ppm	2010	7.0
500 ppm (falling to 450 ppm in 2150)	2010	3.0
	2020	4.0 - 6.0
	2030	5.0 - 5.5
550 ppm	2015	1.0
	2020	1.5 - 2.5
	2030	2.4 - 4.0
	2040	3.0 - 4.5

Source: Stern (2006)

As can be seem from the forecasts in Table 3.1 the date of the peaking in global emissions has a significant impact on the level of sustained annual reductions then required to achieve the desired global stabilisation goal. Stern (2006) states that: '*The longer action is delayed, the harder it will become. Delaying the peak in global emissions from 2020 to 2030 would almost double the rate of* [annual] *reduction needed to stabilise at 550ppm CO_2e. A further ten-year delay could make stabilisation at 550ppm CO_2e impractical, unless early actions were taken to dramatically slow the growth in emissions prior to the peak.*' Since 2006 however the growth in global CO_2e emissions has exceeded the projected business as usual trend shown in Figure 3.1, placing further urgency on the issue.

Hence the main focus of climate change related strategies at the sector and national level needs to be to achieve a balance in the timing of the emissions peak and the corresponding requirement for a tailing off of emissions annually. According to Stern (2006), '*Pathways involving a late peak in emissions may effectively rule out lower stabilisation trajectories and give less margin for error, making the world more vulnerable to unforeseen changes in the Earth's system*'. The challenge is the range of combinations of 'Peaks' and corresponding 'Tails' (i.e. trajectories), that may deliver a given stabilisation level, especially when considering that each trajectory may have a different impact on the economy. A late peak will allow short term reduction levels to be relaxed but will then require a greater level of annual sustained reduction to meet the overall target placing undue pressure on industry and the community. An early peak will require a rapid short term reduction level, but these efforts will be rewarded by a lower level of required sustained annual reductions, providing greater flexibility.

There are a range of 'Peaks' and corresponding 'Tails' that may deliver any given stabilisation level, as shown in Figure 3.2. Both sets of trajectories in the figure are the result of modelling a stabilisation level of 550ppm, however, each will have a different impact on the economy. A late peak, shown by the '2040 High Peak' curve, will allow a slow short term reduction level, but will require a 4.5 percent annual sustained reduction, whereas an early peak, shown by the '2020 Low Peak' curve, will require a rapid short term reduction level but will afford a level of sustained reduction at 1.5 percent per annum.

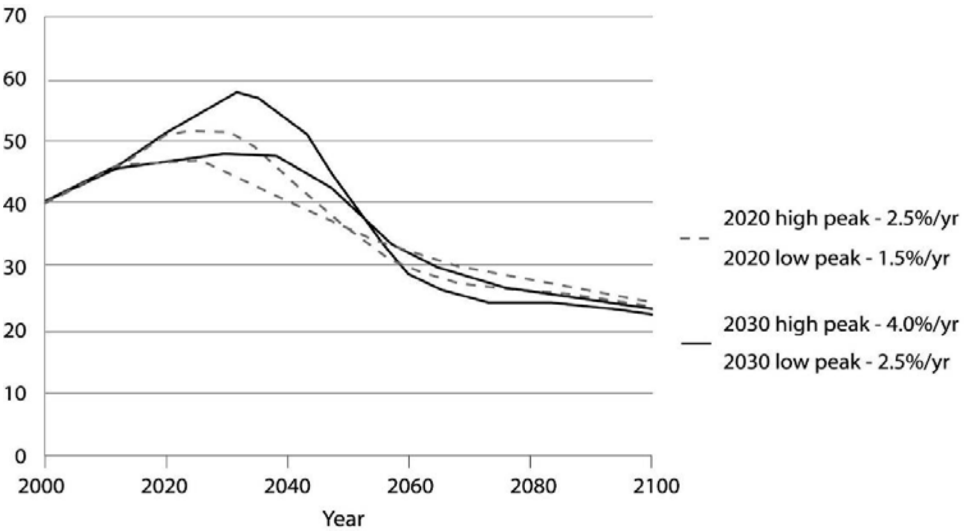


Figure 3.2: Illustrative emissions paths to stabilise at 550ppm CO_2e
Source: Stern, N. (2006)

It is crucial that economic modelling to inform climate change response strategies considers the delicate balance that is needed to be reached between the short term peaking of emissions and the long term sustained reduction levels. If the peak is too soon it may overstress the economy and undermine efforts to sustain gradual reductions over time, and if the peak is too late the corresponding annual reductions may be too much for the economy to bear. Stern (2006) points out that, *'Given that it is likely to be difficult to reduce emissions faster than around 3% per year, this emphasises the importance of urgent action now to slow the growth of global emissions, and therefore lower the peak.'* As it is unavoidable that global emissions must be reduced, if we are to maintain the climatic and environmental conditions that we have grown accustomed to, nations that set ambitious shorter term targets will position themselves well for the future.

The benefit of using stabilisation trajectories as the basis for economic development is that it allows nations to capitalise on the already abundant opportunities for short term reductions to achieve the peak, while also building the experience and economies of scale to seriously tackle the issue of sustained reductions. The beauty of the sustained reductions model (i.e. tailing) is that it allows an economy to stage out the activities it undertakes to allow for certain industries, or even nations, to be given more time, or 'head room', to respond, while the industries or nations that can make short and medium term gains contribute to achieving the average overall reduction.

As Stern (2006) points out, '*It will be cheaper, per tonne of GHG, to cut emissions from some sectors rather than others because there will be a larger selection of better-developed technologies in some… However, this does not mean that the sectors with a lack of technology options do nothing in the meantime. Indeed, innovation policies will be crucial in bringing forward clean technologies so that they are ready for introduction in the long term.'* Hence strategies and policies to achieve stabilisation trajectories will no doubt dominate national economic development strategies in the coming decades, and informing such efforts was a key intention of the development of this thesis.

When considering each country's role in the global community the situation becomes even more complex as firstly efforts across the economy of each country need to be balanced and combined to meet the preferred stabilisation trajectory, and then the efforts of each country need to be aggregated to achieve the global stabilisation curve. The Australian *Garnaut Review Interim Report* outlined the need to develop country specific trajectory curves based on per capita emissions to be aggregated to achieve the overall global stabilisation trajectory, as shown in Figure

3.3. (Garnaut, 2008)

As the report pointed out, a '*Broad international agreement will require acceptance of global limits on emissions, sharing of rights to emissions across countries within these limits, and international collaboration to help achieve the national restrictions.'* (Garnaut, 2008, p27) Furthermore, such per-capita allowances may be weighed against the economic activity of a particular country to further allow a meaningful allocation.

Expecting the rapidly developing countries such as China and India to halt their fossil fuel consumption is unreasonable considering that developed countries have capitalised on fossil fuels for decades to underpin their development. The strength of the stylised scenario presented by Professor Garnaut is that it provides head room for both China and India.

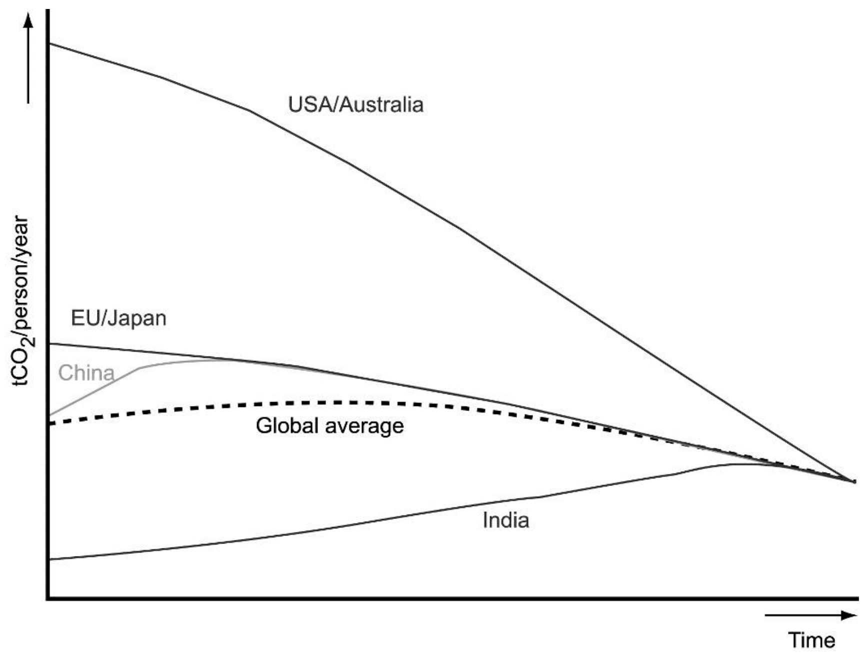


Figure 3.3: *Contraction and convergence for different countries, with 'head room' for the rapidly developing economies: a stylised, illustrative scenario*

Source: Garnaut, R (2008)

China (Levine, Zhou and Price, 2009; Liu, 2005) and India (Raina, 2002) are both now making increasingly significant commitments to improving energy performance, some being the most stringent in the world, these efforts when combined with the rest of the world following a set of agreed country specific curves, could actually make a global transition to low greenhouse gas emissions a reality. For instance, a major 2009 analysis entitled '*2050 China Energy and CO_2 Emissions Report*' (Hepeng, 2009). by China's National Development and Reform Commission and the Development Research Center of the State Council, shows that energy demand growth in China will significantly slow by 2020 and energy demand growth and greenhouse gas emissions will peak around 2030 if the government continues to be serious about 'strengthened measures' to improve energy efficiency and accelerates exploration of renewable energy.

A number of countries now have industry programs focused on the reduction of GHG emissions, such as:

- Canada: Industry Program for Energy Conservation (McKenzie, 1994)
- Denmark: Agreements on Industrial Energy Efficiency (Togeby *et al*, 1999)
- France: Energy Efficiency Action Plan for France (French Republic, 2008)
- Germany: Declaration of German Industry on Global Warming Prevention (Ramesohl and Kristof, 1999); National Energy Efficiency Action Plan (EEAP) of the Federal Republic of Germany (German Federal Ministry of Economic Affairs and Technology, 2007)
- India: National Action Plan For Climate Change (Government of India, 2008)
- Japan: Keidanren Voluntary Action Plan on the Environment (Worrell and Price, 2001)
- UK: Climate Change Agreement (CCA) (House of Commons, 2005)
- China: Top-1000 Energy-Consuming Enterprises Program (Price, Wang, and Jiang, 2008) (*An initial review in 2008 by the Lawrence Berkeley National Laboratory showed that the program is proceeding well and could even achieve 50 percent more savings than planned by 2010.)*
- Australia:
    - Energy Efficiency Opportunities Program (*with the Victorian Government the only state to place mandatory requirements on businesses above a*

certain size to identify and implement energy efficiency opportunities of 3 years or less.)

- National Greenhouse and Energy Reporting (NGER) Scheme (*The scheme was introduced in 2007 by the Australian Government to 'provide data and accounting in relation to greenhouse gas emissions and energy consumption and production'*.)

Understanding this imperative to move early, businesses across the globe have begun to build strategies and make commitments to sustained reductions, as with the inaugural members of the Chicago Climate Exchange in 2005 (including DuPont, ST Microelectronics, Baxter Health Care, the City of Chicago, Natural Capitalism Inc and 12 other businesses) contracting to reduce their emissions by 1 percent a year. In 2008 CCX had over 330 members, companies, cities, states, counties, universities, NGOs and others, with new members being required to reduce their emissions 2 percent a year. (Lovins, 2007)

Salt Lake City's Mayor Rocky Anderson stated in a letter to the Seattle Mayor: '*In Salt Lake City we have been working diligently since 2002 to meet the greenhouse gas emissions reduction goal set forth in the Kyoto Protocol. If every local and state government entity, every business, and every individual takes available, effective measures to significantly reduce greenhouse gas emissions, we can reverse the trend toward global warming. If we do not, the consequences will be devastating*.' Salt Lake City set a goal to reduce emissions by 3 percent per year for a 10 year period, with its long term goals to reduce emissions 70 percent by 2040 - by 2007 the city had already achieved a 31 percent reduction in carbon dioxide emissions in its municipal operations over the 2001 baseline, surpassing its goal to meet the Kyoto Protocol standard by 148 percent, and seven years early. (Salt Lake City Green, undated)

3.2 CONSIDERING THE COSTS OF DELAYED ACTION TO REDUCE GREENHOUSE GAS EMISSIONS

Efforts to-date to reduce environmental pressures, such as greenhouse gas emissions, have been motivated by a wide range of factors, including improving productivity, reducing impacts on public health, reducing dependence on fossil fuels, acting to improve brand recognition, and working to capture new markets (Hargroves and

Smith, 2005). However, according to the OECD, one of the leading drivers for change in the coming decades will be the costs to economies across the world of not acting to reduce a range of environmental pressures (OECD, 2008b). There is currently a growing level of cost associated with environmental impacts from development activities that are often hidden in measures such as ‘Gross Domestic Product’.

For instance considering findings of research by the US public policy think tank, *Redefining Progress*, Figure 3.4 shows a growing component of GDP related to paying for the impacts of economic activity on the environment.

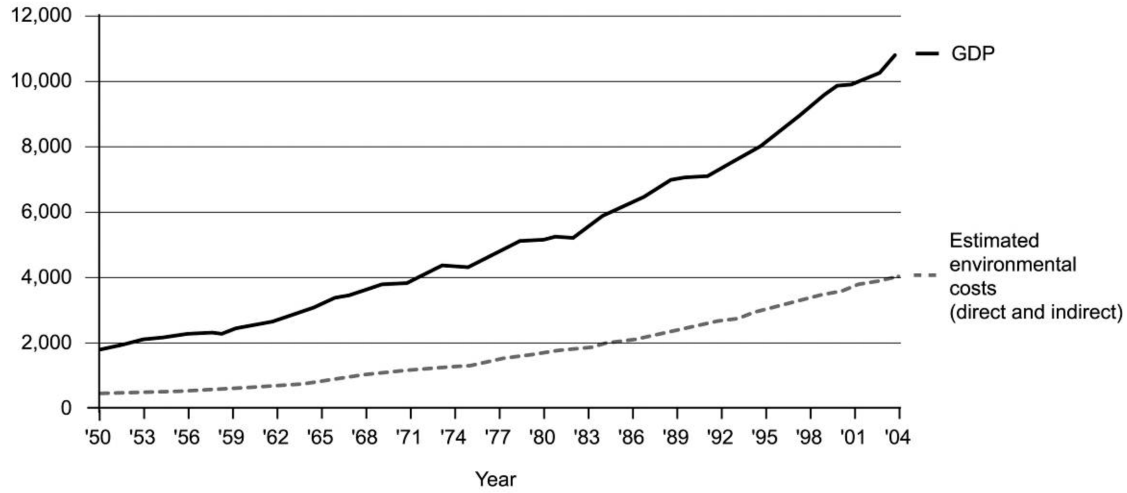


Figure 3.4: *Gross Domestic Product vs. Estimated Environmental Costs (billions) for the United States of America from 1950-2004*

Source: Data reinterpreted by K. Hargroves from Talberth *et al* (2006)

As Figure 3.4 shows, even though GDP is shown to rise, the costs related to environmental pressures is also rising, effectively offsetting a growing proportion of the gain in GDP - with costs related to impacts on the environment rising from 22 percent of GDP in 1950, to 37 percent in 2004. These costs included: household pollution abatement, water pollution, air pollution, loss of wetlands, loss of farmland, loss of primary forests, resource depletion, carbon dioxide emissions damage, and ozone depletion (Talberth *et al*, 2006).

This simplified example is complicated by a number of factors related to measurement and assumptions regarding the distribution of costs, however, it provides a clear picture of the trends associated with economic growth and costs related to environmental pressures. The findings suggest that in order to monitor the overall economic progress of a society the GDP must be held against the level of environmental damage it creates, and in particular the direct and indirect costs associated with this damage. This will then provide an indication of both the economic progress and the level of reliance on damaging the environment that is required to deliver it, potentially providing a strong indicator of a nation's risk of maintaining future economic growth.

In the case of greenhouse gas emissions, valuing the costs of delayed action for nations and the global economy is a very complex task, and few studies proclaim to have achieved it. The 2006 *Stern Review* is one of the few studies that have made a solid attempt at this, resulting in significant international attention (Stern, 2006). This area was further investigated in 2008 by a study by the OECD (2008a) on the '*The Costs of Inaction on Key Environmental Challenges*'. As I outlined in the book '*Cents and Sustainability*' (Smith, Hargroves, and Desha, 2010), costs from inaction to reduce greenhouse gas emissions, and hence allowing further human induced climate change to occur, will come from a wide range of causes, including:

- Damage to infrastructure from an increase in frequency and intensity of natural disasters, including fires, storms, hailstorms, ocean surges, flooding, and cyclones,
- Health related costs due to more frequent heat waves and extreme cold, along with the spread of communicable diseases, such as Dengue Fever and Ross River virus,
- Reduced agricultural production from increased temperature affecting crops along with more intense and less frequent rainfall,
- Reduced revenue from nature based tourism, such as coral reefs, forests and alpine regions,
- Costs related to relocation or protection from rising sea levels and enhanced storm surges,
- Reductions to the carrying capacity of grazing land for livestock due to higher temperatures and lower availability of water,
- Increases in peak electricity loading due to the use of air-conditioners in response to rising temperatures, along with more frequent 'heat waves',

- Increased losses from forest fires due to reduced water availability and higher average temperatures, and
- Increased risk of conflict over resources such as oil, water and timber, and declining food production - to name but a few.

After analysing a broad range of such costs of delayed action, Stern (2006) concluded that each year on average, '*the costs of action to the global economy would be roughly 1% of GDP, while the costs of inaction could be from 5-20% of GDP*'. This work is one of the first and certainly the most well-known to place an economic value to the option of not acting to reduce greenhouse gases, and upon its release it captured the attention of economists, policy makers, and business leaders *around the world.* The power of the findings is that it marked the moment in time when a reputable economist shifted the cost of not acting from somewhat incomprehensible impacts - such as the sea rising some 12 metres, and the global average temperature rising more than 5°C and leading to massive storms, melting glaciers and lost coral reef and eventually another ice age - to a tangible and significant percentage of GDP. According to Stern (2006), '*The investment that takes place in the next 10-20 years will have a profound effect on the climate in the second half of this century.*'

The challenge, however, is that these reductions in GDP will hit hardest in the future, while political attention and business strategy is firmly focused on performance in the very short term. Balancing the conflict between short and long term imperatives will be a significant challenge for nations in the coming century, one that if not met, may well lead to significant impacts on economies.

As many commentators and researchers have pointed out a large part of the challenge to understand the economic reality of the situation is that many of the impacts are not included in the financial system, meaning they are not usually given an economic value, and hence as far as the models are concerned they are hidden or don't exist (Hohmeyer, 1988; Koomey, 1990; Ottinger et al 1990; Koomey and Krause, 1997); Economists have explained for decades that our high pollution levels and current unsustainable development paths arise largely from the fact that the environmental and social costs of development are not reflected in the costs of products and services on the market (Aylward et al, 1991; Conway, 1991). For instance, as Stern (2006) points out, '*Those who create greenhouse gas emissions as they generate electricity, power their factories, flare off gases, cut down forests, fly in planes, heat their homes or drive their cars, do not have to pay for the costs of the climate change that results from their contribution to the accumulation of those gases in the atmosphere'*.

Hence with such uncertainty around assigning prices to such environmental pressures it is very difficult to accurately estimate the effect on the economy, either positive or negative, from actions to reduce them. Furthermore, as well as the difficulty in assigning economic value, the literature also highlights that a range of government interventions, such as subsidies, can lead to an even further reduction in the price of a range of emissions intensive goods and services that result in their increased uptake, and lead to the increase in the environmental pressures associated with them (OECD 2013).

In order to make certain industries more viable, governments often provide subsidises, particularly to the agricultural sector in response to international competition, and to fossil fuel based industries in response to high costs for infrastructure development and maintenance. The intended result is that the product or service is made more affordable to the consumer and economic development is accelerated, however, the unintended result is that the product or service are able to be sold with little consideration of the environmental pressure they may create, and the associated real costs to the economy in the short and long terms. In 2009 the OECD released a declaration on green growth in which some 34 countries agreed to '*encourage domestic policy reform, with the aim of avoiding or removing environmentally harmful policies that might thwart green growth, such as subsidies: to fossil fuel consumption or production that increase greenhouse gas emissions*.' (OECD 2009)

For example, despite the fact that subsidising chemical companies to produce fertiliser has led to improved agricultural yields, the low cost has often led to excessive and poorly controlled use, which in turn can lead to contaminated groundwater and waterways. Further examples include: the overuse and wastage of water due to subsidies for the use of water; wastage of electricity, with appliances, equipment and lights being left on when not needed because of the subsidies for electricity making it cheaper for households and industry; and by making fossil based energy cheaper subsidies distort the market and make it harder for renewable and low greenhouse gas emissions options to compete.

Hence the lower cost not only increases the uptake of the product or service (which is after all the point of a subsidy), it may also lead to it inefficient or wasteful use, further compounding the environmental pressure, and hence the costs of inaction. According to the OECD, three months after the release of the declaration '*G-20 leaders committed to 'rationalise and phase out over the medium term inefficient fossil fuel subsidies that encourage wasteful consumption'*. (OECD, 2013a) A proportion of the costs that result from the increased environmental pressures from subsidised activities (with Roodman (2009) estimating such subsidies to be as much as US$650 billion per annum globally), are borne directly by governments - and therefore citizens - through healthcare costs and public taxes. The remaining burden is borne by individuals through health related impacts, and by the environment itself as the increased levels of toxins and pollution lead to the degradation of ecosystems.

From a study of the literature in this area it is clear that when considering an intervention into the market by providing subsidies, governments need to understand the broader implications in the short and long term, and where possible assign a price to these implications. The challenge here is that any economy exists as part of a very complex balance, and increasing the cost of electricity without reducing costs elsewhere may result in an undue burden for citizens – which may then affect voter preferences. As Ernst von Weizsäcker *et al* (2009) point, '*Ultimately, resource consumption should be so expensive that total resource consumption rests in a perfect balance with sustainable supplies of renewable (or recycled) resources, and the resulting ability of the biosphere to assimilate the associated pollution and by-products*'. However, this is not the case in our current society, where the major reason why environmental degradation occurs is because the current balance reached in many economies around the world makes it cheaper to degrade nature than to appropriately manage its use. (Daily and Ellison, 2002)

3.3 CONSIDERATIONS RELATED TO MODELLING THE COST OF REDUCING GREENHOUSE GAS EMISSIONS

The content in the following chapter has been written by myself, with parts contributed to the co-authored book, 'Cents and Sustainability' (Smith, Hargroves and Desha, 2010) during the candidacy period. I wish to thank my co-authors of the book, Dr Michael Smith and Dr Cheryl Desha (a co-

supervisor of the thesis), and research assistant David Sparks, for informing through discussion the creation of some of the arguments contained in this chapter, identifying resources for consideration to develop such arguments, and for providing valuable peer review; the material herein however is my own writing.

Along with the uncertainty around assigning a price to environment pressures, another key reason for a lack of action to reduce greenhouse gas emissions has been the variability in estimates of the associated costs, which is directly related to impacts on profitability and jobs, both being very political issues. The reason that estimates vary so much is that action is required across the entire economy, to differing levels, and over medium to long time frames (Smith, Hargroves, and Desha, 2010). In order to model this intricacy and complexity, a number of assumptions need to be made, and it is in these assumptions that much of the variability is created. Such assumptions are necessary, as estimating costs to industry and the economy of action to reduce greenhouse gas emissions, and indeed many other environmental pressures, is a very complicated process, and may not even be entirely possible.

Nevertheless, assumptions must be made about variables, such as: the potential economic benefits of various options in both the short and long term, how the cost of alternatives may vary in the future, and the rate that new technologies and practices will be taken up in the marketplace. George Monbiot (2006) reflects on his understanding of the debate around the cost of action in saying that: '*I have not come across such wildly varying claims in any other field. Bjorn Lomborg's extraordinarily accurate figure - US$37,632 billion – occupies one extreme; at the other end are people who claim that cutting carbon emissions will actually make us money* [mentioning Amory Lovins]*, as the requirement to invest in new technologies will stimulate economic growth and energy efficiency will lead to financial efficiency.'*

As mentioned above, Stern (2006) investigated a range of costs of action and inaction on addressing climate change, and concluded that costs of action to the global economy would be roughly 1 percent of GDP, while the costs of inaction could range from 5-20 percent of GDP. Stern (2006) explains that the range of potential costs of inaction I based on assumptions about the level of direct and indirect impacts on environmental and human health, the effects of positive feedbacks being triggered, and the disproportionate burden on the poor and vulnerable. According to Stern (2006) most economic modelling of the costs of stabilising greenhouse gas levels find that it would cost the economy anywhere between -1.0 percent and +3.5 percent of GDP by 2050.

Stern (2006) explains in detail how this is due to the choice of assumptions made by economists upon which they build their economic models. In other words, depending on the assumptions modellers make about how rapid and how costly different strategies and actions will be, economic modelling has shown a range of outcomes leading to either slightly higher or slightly lower economic growth. Thus the interrogation by decision makers of cost estimates in this area based on the validity of particular assumptions is important to ensure that policies and strategies encourage investment which can lead to significant greenhouse gas reductions, while contributing to economic and jobs growth.

When developing a set of assumptions to underpin economic modelling economists need to be informed by knowledge and understanding in a range of areas related to research and development, education and capacity building, construction and implementation, operation and maintenance, financing etc. Hence in order to improve the estimates of the cost of action from economic models, economists need to work with a range of other professionals to inform efforts. In particular, economic modelling must be well informed by science and engineering if it is to make assumptions about the potential for engineered systems to simultaneously contribute to both economic growth and the reduction of greenhouse gas emissions – such as the potential for renewable energy to replace fossil based energy for both peak and base load electricity.

In order to demonstrate this for specific set of assumptions the following part focuses on the work of Repetto and Austin (1997) of the World Resources Institute, in which they identified seven underlying assumptions that were found to explain 80 percent of the differences in the results of various economic climate models at the time, focusing on carbon dioxide emissions.[1] Repetto and Austin found that in when modelling the cost of action to achieve a 60 percent carbon dioxide reduction by 2020 assumptions made in the seven areas could lead to a possible increase in GDP of 5% or a decrease 7%, a swing of 12 percent. It is the intention of this part to use

[1] The work of Repetto and Austin was brought to my attention Dr Michael Smith as part of the research to develop Smith, Hargroves, and Desha (2010) that was supported by research assistant David Sparks.

the findings of this study as a framework to investigate the grounds for each of the seven assumptions, as a conservative approach to these assumptions can lead to an over-estimate of the costs of action to reduce greenhouse gas emissions, and hence may require a high level of scrutiny before the results are used to inform policy and investments.

The power of the findings shown in Figure 3.5 is that it indicates that if strategies can lead to outcomes close to the best case scenario in each of the seven areas, this can lead to increasing economic growth, as suggested by Stern (2006). Furthermore the more ambitious the emissions reduction target the greater the estimated economic growth. The results of course also indicate that if efforts to reduce greenhouse gas emissions are not close to the best case scenario, for instance through poor strategy and implementation, leaving efforts too late, or the impact of conflict and corruption, then the greater the target for reduction the greater the negative impact on the economy. However, in the absence of such disruptive influences, and assuming that most nations can achieve close to the best case scenario, even if the strategies lead to a net decrease in GDP (as the most pessimistic economic models predict), this will only slightly delay reaching levels of economic growth over the coming century. (OECD, 2008a)

Therefore, as the scientific and economic literature on the subject is clearly showing that the direct costs of inaction stand to increase in the future, it stands to reason that targeted efforts need to be focused on achieving the best case scenarios in each of the seven areas of assumption to provide the best long term economic growth strategies for the world’s economies.

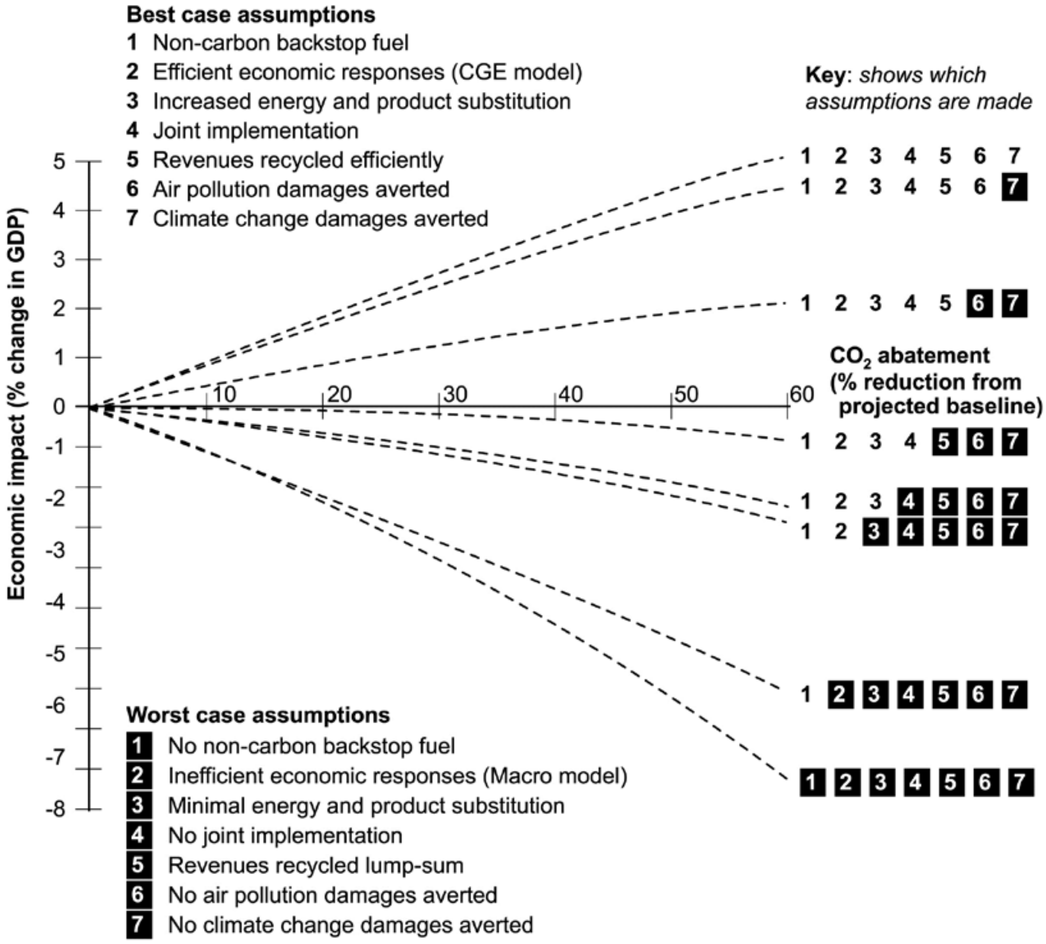


Figure 3.5: *Predicted impacts on GDP for various CO_2 abatement targets in 2020 - the effects of changing underlying assumptions one-by-one*

Source: Repetto and Austin (1997)

The seven underlying assumptions identified by Repetto and Austin (1997) as significantly affecting the outcomes of economic modelling on the costs of CO_2 abatement are as follows:

1. ***Assumptions about the availability of non-carbon backstop fuels:*** *Does the economic model assume non-fossil energy alternatives will become available in the future at a competitive price?*

Repetto and Austin (1997) found that some economic models completely excluded renewable technologies and thus massively overestimated the costs of action to reduce emissions. Even though renewable energy currently provides a small percentage of the current world energy demand, which was estimated by the EIA

(2206) to be in the order of 138 PWh (or 138 trillion KWh) in 2006[2], estimates up to 2009 of the technical potential for harnessing renewable energy range from 152–1,205 PWh annually, without the use of nuclear energy (see Figure 3.6). Hence if the majority of the world's energy services were delivered using electricity, rather than oil, petroleum, and natural gas, even the lowest estimate of 152 PWh would be greater than the 2006 global energy demand, and slightly lower than the 2010 demand of 154 PWh (EIA 2013). Furthermore, if energy efficiency and demand management opportunities are harnessed (Schaltegger and Synnestvedt, 2002), world energy demand could be reduced in the order of 40–80 percent (von Weizsäcker and Hargroves *et al* 2009), significantly reducing the demand to be met by renewable sources.

Up to 2009 many studies had been released that showed staggering potential for expansion of the renewable energy sector, such as by 'The Renewable Energy Policy Network for the 21st Century' (REN21), suggesting that, *Targets for renewable energy now exist in at least 58 countries worldwide, including 13 developing countries, all EU countries, and in many states/provinces in the US and Canada'.* (REN21, 2007). More recently the 2013 update of the REN21 'Global Status Report' highlighted that '*Renewable energy provided an estimated 19% of global final energy consumption in 2012*', and that in 2013 some 72 percent of new electricity generation in the European Union was from renewable energy sources. The report also estimates that the investment in renewables was in the order of US$249 billion in 2013.

Over the last two decades the cost of renewables has consistently been reduced with NREL (2010) estimating that the cost of solar photovoltaic energy has dropped 87 percent between 1980 and 2009. Further according to DoE (2013) the cost of energy generated by wind turbines has dropped from around 90 percent between 1980 and 2012.

[2] This research was undertaken in 2009 and was based on the most current data at the time. At the time of completion of the thesis in 2014 the most current estimate from the EIA (2013) was for 2010 with an estimated global energy consumption at 154 PWh, and hence the argument remains sound. Further the estimates of feasible renewable energy production have increased since 2009.

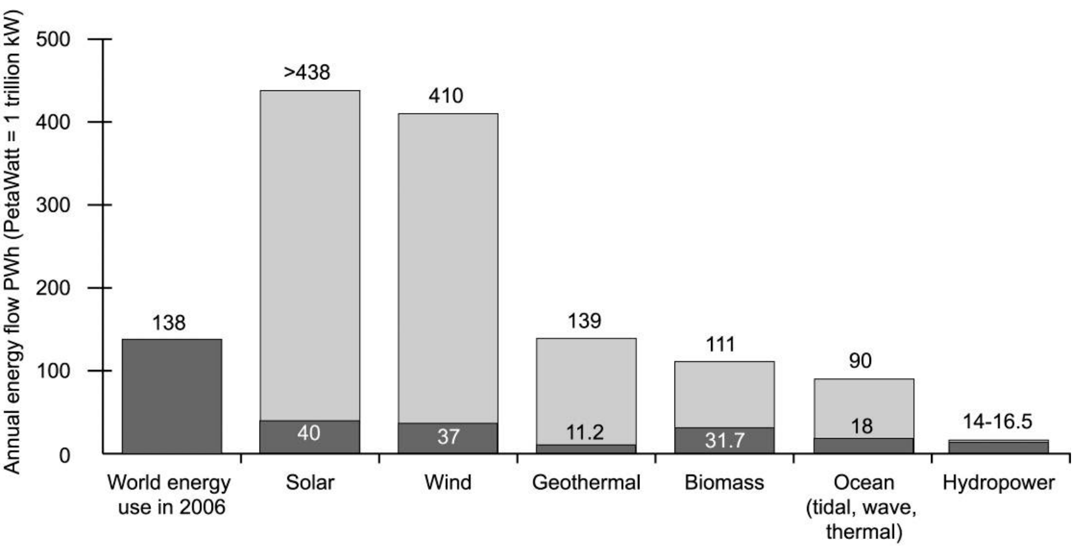


Figure 3.6: *Current technical potential of renewable resources relative to world demand (showing both the lower and upper bound of the estimates)*

Source: Research on data undertaken by David Sparks, based on data for World Energy Use,[3] Solar,[4] Wind,[5] Geothermal,[6] Biomass,[7] Ocean,[8] and Hydro.[9]

Repetto and Austin found that even though some of the economic models investigated recognised non-fossil energy sources, they assumed, '*that their availability is limited so that their prices will rise when used in greater volumes*' (Dean and Hoeller, 1992, cited in Repetto and Austin, 1997). However in practice this is not the case, especially since 1997, as recent innovations are enabling rapid improvements and cost reductions in the renewable energy sector. Also economies of scale and increased skill development tend to help bring down the manufacturing costs of different low greenhouse gas emissions technologies (US EPA, 2007).

2. ***Assumptions about the efficiency of economic responses:*** *Does the model assume that firms and consumers will reallocate their expenditures efficiently as energy prices increase?*

[3] EIA (2006b).

[4] Gross, Leach, and Bauen (2003) estimating 40 PWh/y; Fridleifsson (2003) estimating 438 PWh/y.

[5] Hoogwijk *et al* (2004) 37 PWh/y; Gross *et al* (2003) 40 PWh/y; de Vries *et al* (2007) 61 PWh/y); Hoogwijk *et al* (2004) 96 PWh/y; Fridleifsson (2003) 178 PWh/y; Sovacool and Watts (2009) 410 PWh/y; Jacobson (2009) 410 PWh/y.

[6] IGA (2001) 11.2 PWh/y; Stefansson (2000) 22.4 PWh/y; Gross *et al* (2003) 40 PWh/y; Bertani (2003) 41.7 PWh/y; WEA (2000) 139 PWh/y.

[7] Yamamoto *et al* (2001) 31.7 PWh/y; IEA Bioenergy (2007) 55.6 PWh/y; de Vries *et al* (2007) 59 PWh/y; Fischer and Schrattenholzer (2000) 62.5 PWh/y; Fridleifsson (2003) 76.7 PWh/y; and Rockefeller Foundation (2008) 111 PWh/y.

[8] IEA (2007a)

[9] Fridleifsson (2003) 13.9 PWh/y; Sovacool and Watts (2009) 14.4 PWh/y; IHA (2000) 14.4 PWh/y; Boyle (2004) 15 PWh/y; Bartle (2002) 15 PWh/y; Jacobson (2009) 16.5 PWh/y.

This assumption involves the reallocation of resources to reduce energy demand as the price of energy is increased, and the availability of opportunities to do so. There is a common assumption that most of the cost-effective improvements in energy efficiency and demand management have already been realised, however this assumption is flawed as there are in fact significant opportunities across the global economy as now detailed by a range of technical investigations and analysis showing that 30-90 percent energy reduction opportunities commonly exist throughout most sectors of the economy.[10]

For instance, as von Weizsäcker and Hargroves, *et al* (2009) point out, and is summarised in Table 4.1, improvements in resource productivity in the order of 80 percent can be achieved across each of the major energy intensive sectors including: residential (McKinsey Global Institute, 2007; Clinton Climate Initiative, 2008) and commercial (Jennings *et al*, 2000; Bodart and Herde, 2002; US EPA, 2004; Eichholtz *et al*, 2008; BOMA, 2009) buildings (Sherman and Jump, 1997; Romm and Browning, 1998); heavy industry such as steel (De Beer *et al*, 1998; Fenton, 1998; Martin, Worrell and Price, 1999a; Worrel *et al,* 2004; Okazaki *et al*, 2004; Blanch, 2004; AISI, 2005; Yamaguchi, 2005; Nucor Corporation, 2007; IISI, 2008; Zhu, 2008; AISI, 2008; WSA, 2008) and cement (Davidovits, 1991; Martin, Worrell and Price, 1999b; Worrell *et* al, 2001; Humphreys and Mahasenan, 2002; Davidovits, 2002; Zongrin *et* al, 2004; Josa *et al*, 2004; Hendriks *et al*, 2004; JCA, 2006; Price, 2006; Cui and Wang, 2006; Duxson, 2008; Müller and Harnisch, 2008; Wang, 2008; TNEP, 2009); light industry such as data centres (Google, 2009) and pulp and paper (Catalyst Paper Corporation, undated); agriculture (UK Carbon Trust, 2006); the food and hospitality sector, including supermarkets (Tesco, 2008) and restaurants (Bordeaux Quay, undated; Whole Foods Market, 2008); and the transportation sector, including vehicle design (Lovins, 2007), discouraging car use (Diaz, 2001), increased public transport (WBCSD, 2004; Northern Territory Government, 2007), and modal shifts for freight carriage (Freight on Rail, 2009; Xinhua News Agency, 2008; Frey and Kuo, 2007).

[10] Schmidheiny (1992); Halliday *et al* (1996); von Weizsäcker *et al* (1997); Lovins and Lovins (1997); Hawken, Lovins and Lovins (1999); Schaltegger and Synnestvedt (2002); Schmidheiny and Watts (2002); McDonough and Braungart (2002); Innovest Strategic Value Advisors (2004); Jochem (*ed*) (2004); Hargroves and Smith (2005); von Weizsäcker and Hargroves, *et al* (2009).

As Repetto and Austin point out, '*Most models assume a steady annual percentage improvement in energy efficiency, constant across all industries and over time*.' (Repetto and Austin, 1997, citing Manne and Richels, 1990). Hence modelling can easily underestimate the potential for energy savings, leading to an overestimate of the cost of action to reduce greenhouse gas emissions (De Canio, 1993). Reducing energy demand can also lead to significant infrastructure cost reductions. For instance reductions to the level of electricity demand, particularly during peak periods, could effectively delay or even avoid the need to build new power stations, and reduce maintenance requirements on the electricity grid.

This is particularly important as in practice given that work by Rocky Mountain Institute shows that in order to deliver 1 kilowatt to the end-user the power station may actually need to generate in the order of 6-10 kilowatts to overcome the losses throughout the distribution system (Lovins, 2005). In response to this and other concerns governments across the world have been investigating ways to improve the existing regulatory frameworks to reward electricity utilities for helping their customers to use electricity more efficiently and effectively for over a decade (Kushler, 2006).

A particular area to be considered under this assumption is transportation. Economic models and strategies for economic development often assume that building roads and highways for cities is a sounder economic option than encouraging and supporting the use of sustainable transport modes – railways, buses, cycling and walking. However, a report to the World Bank prepared by Australian transport experts Professor Peter Newman and Professor Jeff Kenworthy found that governments and cities that emphasise public transport, cycling and walking, can actually deliver stronger economic growth than a focus on providing roads for private vehicles and freight (Kenworthy *et al*, 1997; Newman, 1998; Newman and Kenworthy, 1999).

Supporting such findings is the identification of a number of economic benefits that can result from a transition to low greenhouse gas emissions transportation, including: reducing transportation costs to business, particularly through better freight vehicle design and modal shifting (Chrisafis, 2007); along with increasing video conferencing (Porteous, 2009), reducing congestion costs that are currently costing nations billions of dollars and set to rise significantly by 2020 (BTE, 2007); reducing health costs, absenteeism and improving productivity, with the risk of obesity and diabetes halving (WHO, 2000) and a reduction in absenteeism of as much as 80 percent in staff members that choose to cycle to work (Rowell and Fergusson, 1993); and direct financial benefits to households (including avoiding a second car (NRMA, 2002).

3. ***Assumptions about energy and product substitution:*** *To what extent does the model assume substitution among energy sources, energy technologies, products and production methods?*

A number of studies and investigations have been undertaken since the early 1980's that provide a wealth of information to support the proposal that renewable energy generation can not only contribute to peak demand periods throughout the day but can also make a meaningful contribution to base load power, assuming electricity grids are retrofitted appropriately (Diesendorf, 2007). The main misunderstanding is that renewable forms of energy generation are at the whim of weather conditions. However, a range of options exist that are not dependant on weather conditions, such as co-generation, geothermal, biomass, wave, and types of hydro-electric power (Dickson and Fanelli, 2004). And even weather dependant options such as solar panels, wind tubines, or tidal generators can be connected to a grid to allow them to be located across a state or region and thus able to be subject to differing wind, wave or tidal regimes (Outhred, 2003; Focken *et al,* 2002). After an extensive study of weather patterns for the UK, Graham Sinden (2005) from Oxford University found that, '*between 1970 and 2003, there was not an hour, let alone a day or a week, with no wind across the UK.*'

To enable the integration of small scale renewable energy plants into the grid a number of changes need to be made to develop what is referred to as a 'Smart Grid', and the overall balance of various levels of power generation will be affected, such as the optimal mix of conventional base, intermediate, and peak load power stations (Martin and Diesendorf, 1982; LTI-Research Group, 1998). However, to maintain the reliability of the generating system at the same level, some additional peak load plant may be needed, along with allocation of back-up options for base and intermediate supply (Dale *et al*, 2004).

Furthermore, if the back-up is a peak load gas turbine plant, it does not have to be run continuously and can quickly be shut off while renewable options are generating adequate electricity. The need for backup supply can be further reduced through the use of a range of emerging options for energy storage. Additionally, by taking a small scale distributed approach to energy generation a range of benefits can be achieved, with Rocky Mountain Institute demonstrating that there are over 200 benefits compared to centralised energy plants that are rarely factored into economic models (Lovins *et al,* 2002, p173). Such benefits include: reduced demand overshoot through shorter projected demand periods (Swisher, 2005), particularly as the various government initiatives are set to at least slow the growth in demand for energy, having already flattened in California (Shirley, 2006), Sweden (Miljo, 2005), and the Netherlands (NEAA and NIPHE, 2004); shorter lead times leading to shorter return on investment periods (Hoff and Herig, 1997, Fig 7); and a decreased burden on utility cash-flow (Kahn, 1978, p333; Lovins, 1981; Lovins, 1982).

As Repetto and Austin (1997) explain, '*Economic models differ in the degree to which they represent these substitution possibilities. Highly aggregated models cannot incorporate the possibility of substituting one product for another*.' However over time residents, businesses, and governments replace appliances, cars, equipment and infrastructure with new models. Purposeful and effective government policies and business strategies can ensure that when this occurs, the new models purchased are more energy efficient to run, and have less embodied energy in the manufacture, than the models they are replacing. Furthermore, targeting the reduction in non-CO_2 greenhouse gases through design or substitution, can be a cost effective way to reduce overall emissions, with modelling by MIT suggesting that strategies to reduce non-CO_2 emissions can reduce the costs of climate change abatement by up to two-thirds (Reilly, Jacoby, and Prinn, 2008). Thus economic models that fail to adequately model substitution effects, a very important strategy, will overestimate the costs of reducing greenhouse gas emissions.

4. ***Assumptions about involvement in joint implementation:*** *Does the model assume that nations will take advantage opportunities to collaborate internationally?*

An international approach to modelling allows for consideration of the potential for major multinational companies to achieve a targeted emissions reduction by energy-saving measures at any of its facilities around the world, or at partner facilities, hence providing greater flexibility. Since CO_2 has the same effect on climate wherever it is released, companies should be incentivised to find the lowest-cost abatement possibilities wherever they occur, as this will also build knowhow and understanding for more systemic changes. As part of the Kyoto Protocol, the Clean Development Mechanism (CDM) is an opportunity for corporations to create tradable carbon credits through investment in greenhouse gas reduction projects in the developing world, such as wind power in Brazil (Dutra and Szkloa, 2008).

As Environment Business Australia explains, '*Australia's efficiency in mining (both resource extraction and metals processing) and power generation is high. Now that Australia has ratified Kyoto, this efficiency would become a strong positive. Australia is highly regarded in these areas and the skills of heavy industry are exportable to developing countries that need to either build or modernise entire industry sectors. For example transforming Chinese power stations into efficient and less emissions-intensive sources of energy would provide a winning combination. Australia would be well-placed to embark on CDM projects of this nature'* (EBA, 2002). This can then provide a cost effective way to help developing countries rapidly achieve reductions in their greenhouse gas emissions, particularly through efforts to stop deforestation, the cheapest form of greenhouse abatement after energy efficiency, as shown in Figure 4.5 (Stern, 2006).

5. ***Assumptions about revenue recycling:*** *What does the model assume about the use of revenues raised from energy taxes or auctioned-off permits?*

Economic models usually assume that new revenue gained by carbon taxes or emission trading permits will be distributed evenly across government spending. However, as Repetto and Austin (1997) show in detail, if '*revenues are used to reduce existing taxes that penalize work, savings, and investment this would lower the net cost of reducing emissions and even have a net economic benefit. Some economic models even suggest that the substitution of a carbon tax for other taxes could provide net economic benefits, irrespective of the environmental gains*'.

One of the early examples of revenue recycling is the UK Climate Change Levy, which applied only to business energy use and was introduced in 2001. Under the levy most of the revenues gained from the slight increase to energy costs to business were returned to business by way of a 0.3 percentage point cut in employers' national insurance contributions for each employee. In a study of the performance of the program, Cambridge University (2006) found in 2005 that the program brought business investment forward on energy efficiency, and estimated that it will reduce overall unit costs for business by 0.13 percent by 2010 (UK Treasury, 2006). As part of the levy program, the Government also introduced other measures to help business raise energy efficiency levels, including Climate Change Agreements, enhanced capital allowances for energy-saving technologies, and funding for the UK Carbon Trust to provide education and training in energy efficiency and low carbon sustainable energy to UK businesses (UK Treasury, 2006).

6. ***Assumptions about air pollution damages:*** *Does the model assume that reductions in fossil fuel consumption will decrease air pollution damages?*

Action on climate change will also reduce other significant environmental pressures such as air pollution (US EPA, 1999; Smith, Hargroves, and Desha, 2010). Costs related to air pollution have been estimated to range from 2-4 percent of GDP (OECD, 2008a), with the World Bank estimating in 2007 that Chinese air pollution health costs were in the order of 3.8 percent of GDP (World Bank, 2007). Studies in Europe and the United States estimate that the non-climate benefits of reducing greenhouse gases emissions, many associated with air pollution, would probably be as large, or larger, than the benefits of avoiding climate change (Ekins, 1995).

These studies, quoted in IPCC (1996), reported that the estimated economic savings from reduced air pollution damages may be sufficiently large enough to offset between 30-100 percent of greenhouse gas reduction costs (IPCC, 1996b). Further to this, the OECD's *2030 Environmental Outlook* points out other sources of air pollution will also be reduced by strong action on climate change, stating that, '*Ambitious climate change policies would also lead to reductions in sulphur oxides of 20-30% and in nitrogen oxides of 30-40% by 2030'*. (OECD, 2008a)

7. ***Assumptions about climate change damages:*** *Does the model assume that reductions in fossil fuel consumption will avert damages associated with climate change?*

As Repetto and Austin (1997) explain, '*Most models used to simulate the economic impacts of carbon taxes and emission trading schemes have been adaptations of existing models designed for energy planning or for general macroeconomic* *forecasting, and were not able to incorporate the benefits of preventing climate change, or equivalently, the costs of doing nothing*.' There are a range of costs of in-action to economies, as highlighted in the previous part, including increasingly frequent and more intense natural disasters, reduced agricultural production, reduced revenue from nature based tourism, relocation or protection from rising sea levels and storm surges, reductions to the carrying capacity of grazing land for livestock, increases in peak electricity use, increased losses from forest fires, increased risk of conflict over resources, and increased health related costs (TNEP, 2008).

Hence, understanding these and other key considerations, economic modelling therefore is most useful to policy and decision makers when it is clear about the assumptions that it makes, and when it provides a range of estimates of potential costs and benefits to the economy, based on such assumptions. Decision makers and policy makers can then use this understanding about the effects of assumptions on the economic models to better design policy - in particular to improve performance in the areas that were assumed to have a low positive impact but have been identified as having potential for improvement – and to focus efforts on the most cost effective ways to reduce greenhouse gas emissions with the fastest rates of return on investment.

3.4 CHAPTER SUMMARY AND CONTRIBUTION TO THESIS

The first part of the chapter clarified some misconceptions around greenhouse gas emissions metrics and nomenclature, and introduced the metric of parts per million to measure emissions concentrations in the atmosphere. The chapter presented greenhouse gas emissions trajectories, based on the work presented in the Stern (2006), as a model for the consideration of efforts to reduce emissions and explores the various ramifications of different trajectories. The chapter pointed out that in order to achieve stabilisation of emissions a dual track approach is needed that first peaks global emissions in the short term and then achieves a sustained level of reduction over a number of decades to achieve a tailing off of emissions, with consideration given to per capita emissions levels to set country specific trajectories.

The second part of the chapter then looked into the costs of delayed action to reduce greenhouse gas emissions. The part began by highlighting the growing proportion of GDP that is being used to offset the environmental damage associated with its generation, and then presented a number of significant areas of cost related to delayed action to reduce greenhouse gas emissions. The part highlighted evidence to suggest that the cost of taking action is significantly less than the cost of delayed action. The part then considered how a revision of financial subsidies has the potential to significantly change the economics of environmental damage.

The final part of the chapter presented evidence to understand the rationale for past estimates of the cost of acting to reduce greenhouse gas emissions and shows how seven main assumptions of such models have a significant impact on the cost estimates. The chapter then concluded by demonstrating that in each case there is compelling evidence for each of the seven main assumptions that suggests that the economic impact of taking action to reduce greenhouse gas emissions can be an increase in GDP if designed effectively, rather than a decrease as many assume.

This section of the literature review creates the premise that a focus on greenhouse gas stabilisation trajectories will be a useful element of strategies to reduce emission, and calls for a dual approach to both achieve a peak in global emissions in the coming decade and a tailing off of emissions up to 2050. This is an important premise to base the response to the research question as provides a medium term model to allow a structural level consideration of how to underpin and accelerate efforts to reduce greenhouse gas emissions across the sectors of economies.

This section of the literature review also creates the premise that the costs of delayed action to reduce greenhouse gas emissions will be significant and that taking action can not only lead to reducing such costs but can lead to a strengthening of the economy. This is an important premise to base the response to the research question as provides the understanding that taking strategic economy-wide action to reduce emissions stands to deliver greater economic growth and jobs creation.

Chapter 4: The Feasibility of Transitioning Economies to Low Greenhouse Gas Emissions

The co-authored books 'Cents and Sustainability' (Smith, Hargroves and Desha, 2010) and 'Factor 5' (von Weizsäcker, E., Hargroves, K., et al, 2009) include parts of this chapter written by me. I wish to thank my co-authors Prof Ernst von Weizsäcker, Dr Michael Smith, Dr Cheryl Desha (a co-supervisor of the thesis), and Dr Peter Stasinopoulos for stimulating through discussion the creation of some of the arguments contained in this chapter, identifying resources for consideration to develop such arguments, and for providing valuable peer review.

4.1 EVIDENCE TO SUGGEST THAT GREENHOUSE GASES CAN BE SIGNIFICATNLY REDUCED

In order to significantly reduce greenhouse gas emissions in the coming decades a strong case needs to be presented to show that significant reductions in the energy consumption of our economies can not only be achieved, but can be done so in a cost effectively and timely manner. The findings of the literature review suggest that this case has been made and this chapter presents an overview of such a case, and highlights such opportunities in one of the highest energy intensive sectors of the economy, that of the buildings sector, to demonstrate that in the order of 60-80% improvements in energy productivity can and are being achieved.

When considering energy consumption, it may be apparent that if nations can source energy from renewable sources then there may be no need to reduce demand. This position is defendable however a there are a number of reasons for promoting a reduction in the demand for energy. The main reason is that in order to cost-effectively transition the energy sector away from fossil fuel based energy generation and towards renewable decentralised options, the demand for energy needs to be significantly reduced. This is due to the fact that once the demand is reduced, potentially by as much as 60-80 percent, the task to meet this demand using renewable options will be much more feasible in the short term, and thus will assist in delivering the significant reductions in greenhouse gas emissions required globally (Smith, Hargroves, and Desha, 2010).

A critical barrier to the achievement of improvements in energy productivity is that designers, engineers, architects and technicians of today are not versed in taking a systems based approach (Stasinopoulos, Smith, Hargroves, and Desha, 2008). The reality that the engineering and design professions now face is that even with significant advances being made by designers across the world, the shift from an incremental approach to a systems approach is in its early stages and will require a concerted effort to advance it (Desha and Hargroves, 2014). This is a problem as our amazing Earth cannot wait for many years of trial and error, research and debate, publications and text books, before steps are taken to significantly reduce greenhouse gas emissions.

Hence we need to learn from what is being done in all corners of the world and rapidly bring this knowledge together to inform efforts. In researching evidence to support the feasibility of significant greenhouse gas emissions reductions it has become clear that in each of the successful examples of such improvements a common set of questions has been raised, namely:

- Is the current method of delivering the product or service the only way to do so? (*Often the first thought when answering this question is 'yes', however, further investigation can lead to a range of alternatives - from system upgrades, such as energy efficient motors in an industrial application, to completely new processes, such as shifting to a process to predominantly use scrap metal rather than processing primary resources to make steel).* (Von Weizsäcker and Hargroves et al 2009)

- If it is the only way, what are the major areas of energy, water, and materials usage, and a) what options are available to reduce the need for such inputs, and b) what alternatives are available to provide these inputs? (*The search for such alternative options and inputs can be driven by a requirement to reduce environmental impacts, but also as part of a strategy to improve competitive advantage by reducing input costs, which are inevitably set to increase in the future as availability and impact are factored in*.) (Hargroves and Smith, 2005)

- If it is not the only way, what alternatives to the system currently used can be used to profitably deliver the product or service with less resource intensity and environmental pressure? (*For instance, geo-polymers can be used to create* *cement with as much as 80 percent less energy intensity than Portland cement, by significantly reducing the kiln temperatures required, and eliminating the process emissions of carbon dioxide associated with production of Portland Cement*.) (Von Weizsäcker and Hargroves et al 2009)

When considering strategies to support such a pragmatic enquiry into design it is important to understand that once such questions as to the best way to meet the design requirement have been answered the conceived system needs to be benchmarked against best practice in order to understand the potential for performance improvements.

However, in many cases the new design concept will be part of an emerging wave of innovation (see Figure 1.1) and hence there may be little precedent to provide a benchmark. Further, even if there are established examples of the new design, such processes and methodologies are unlikely to have had time to be incorporated into university or professional development courses. It is of crucial importance that the feasibility of widespread implementation of low greenhouse gas emissions technologies and processes is established across all sectors of the economy.

It is important to learn from lessons from the past, as what at first can be seen as a stunning innovation and contribution to society can in fact turn out to be ill-suited to the environment and have devastating consequences. Two of the most recognised and well published examples of this come from designer Thomas Midgley, Jr. (1889–1944), who developed Freon, a type of chlorofluorocarbon, or CFC, to initially replace the use of sulphur dioxide, ammonia, or chloroform as refrigerants in household refrigerators (as these gases are toxic and were causing fatalities), and later to be used in aerosol cans and air-conditioners that resulted in depletion of the Ozone layer and was later mostly phased out, and the tetra-ethyl lead additive to slow the rate of combustion of petrol in order to reduce engine damage, that resulted in significant human health issues and was phased out (Jacobson, 2011).

Further to the understanding from these examples, Rachel Carson's *Silent Spring* was the first book to sound the alarm over the bio-accumulation of DDT in the food chain in 1962, and this single work may have done more than any other to awaken the world to the environmental and health risks from the use of new technologies and substances without proper assessment, testing and safeguards (Carson, 1962). In

1987, the seminal work *Our Common Future* stated that, '*National and international institutional mechanisms are needed to assess potential impacts of new technologies before they are widely used, in order to ensure that their production, use and disposal do not overstress environmental resources'* (WCED, 1987). Given such an imperative, significant effort has gone into developing methodologies for sustainable technology assessment to help foresee and prevent problems before they are allowed to occur (Cetron and Connor, 1972).

Concerned consumer groups and organisations are increasingly performing assessments on new and existing products in the market. However, even today new technologies are entering the market without effective consideration of the wider environmental impacts. For instance, it was only in June 2008 that scientists for the first time warned that there is a significant risk of increased global warming from the use of nitrogen trifluoride (NF_3) in flat screen TVs (Prather and Hsu, 2008). The gas, NF_3, is estimated to have a global warming potential 17,000 times aseffective as carbon dioxide, but as it was only produced in small quantities in 1997 it was not included in the Kyoto protocol, however, more recently the market for flat screen TVs has dramatically increased, and thus the increased levels of NF_3 in the atmosphere are causing concern, although they are yet to be monitored.

There is growing evidence that with appropriate government and industry leadership solutions can be found that deliver significant reductions in the greenhouse gas emissions intensity of GDP. For instance as highlighted in Smith, Hargroves and Desha (2010) since 1970 the GDP of the UK has roughly doubled with only a slight increase in energy consumption and carbon dioxide emissions growth, as Figure 4.1. (UK Cabinet Office, 2001)

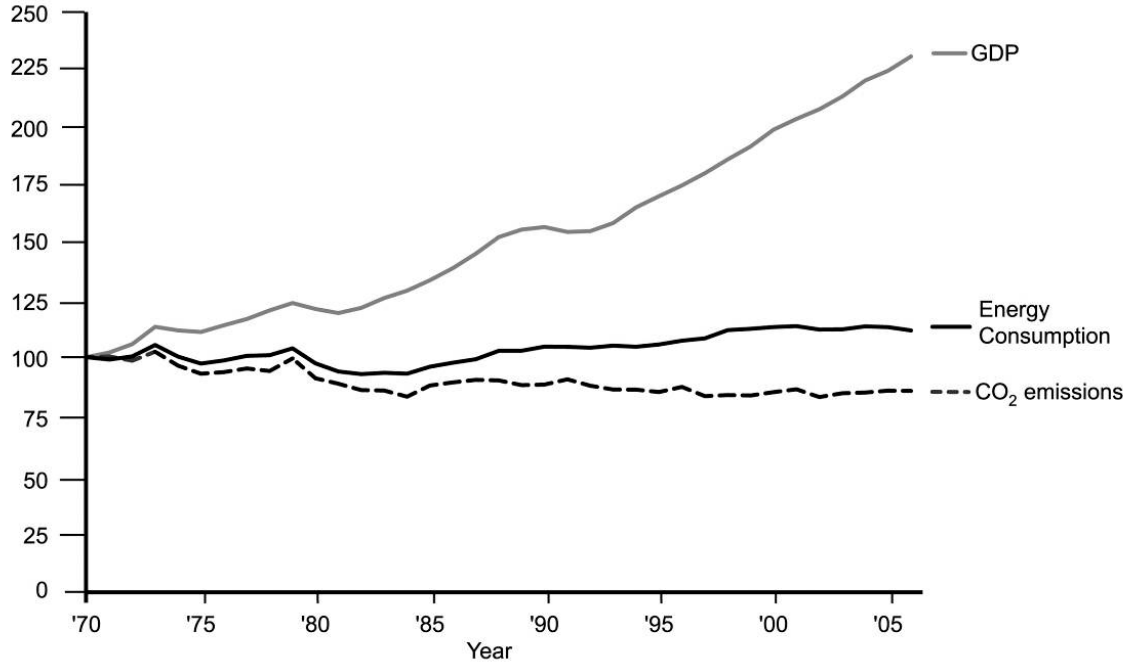


Figure 4.1: *UK GDP, energy use and carbon dioxide emissions trends since 1970*

Source: Data from the UK Department for Environment, Food and Rural Affairs (DETR, 2000), and the World Resource Institute (WRI, 2009a)

Further, for the past 25 years Denmark has experienced an economic growth of 75 percent without increasing their CO_2 emissions, as shown in Figure 4.2.

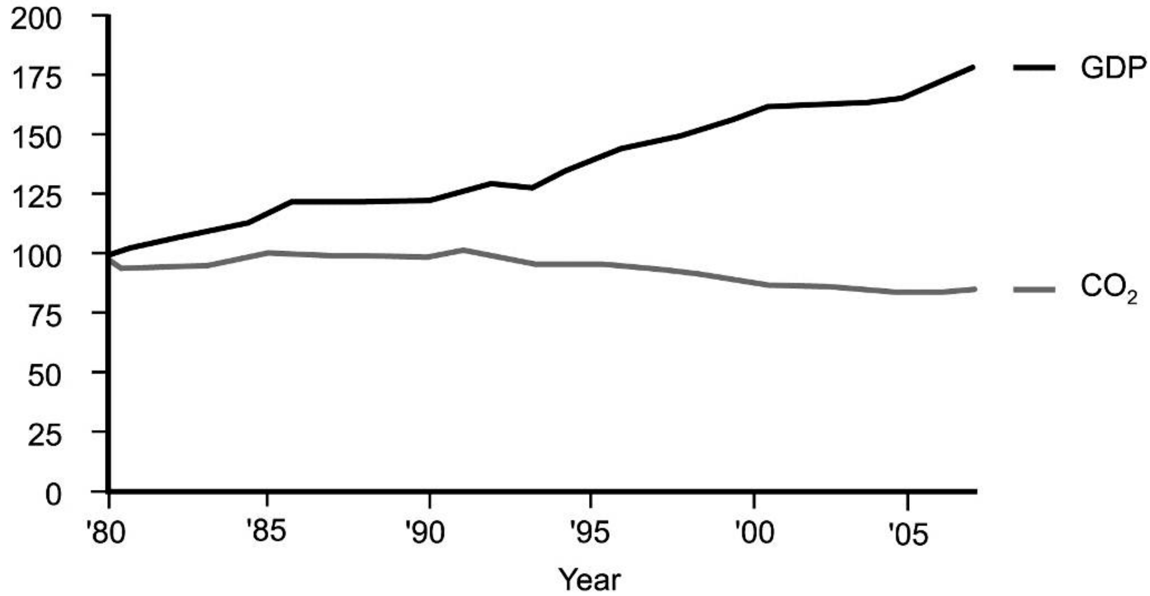


Figure 4.2: *Decoupling GHG from Greenhouse Gas Emissions in Denmark from 1980-2005*

Source: Based on data from the World Resources Institute (WRI, 2009b)

The leading example of a nation reducing environmental pressures comes from the Netherlands, as shown in Figure 4.3.

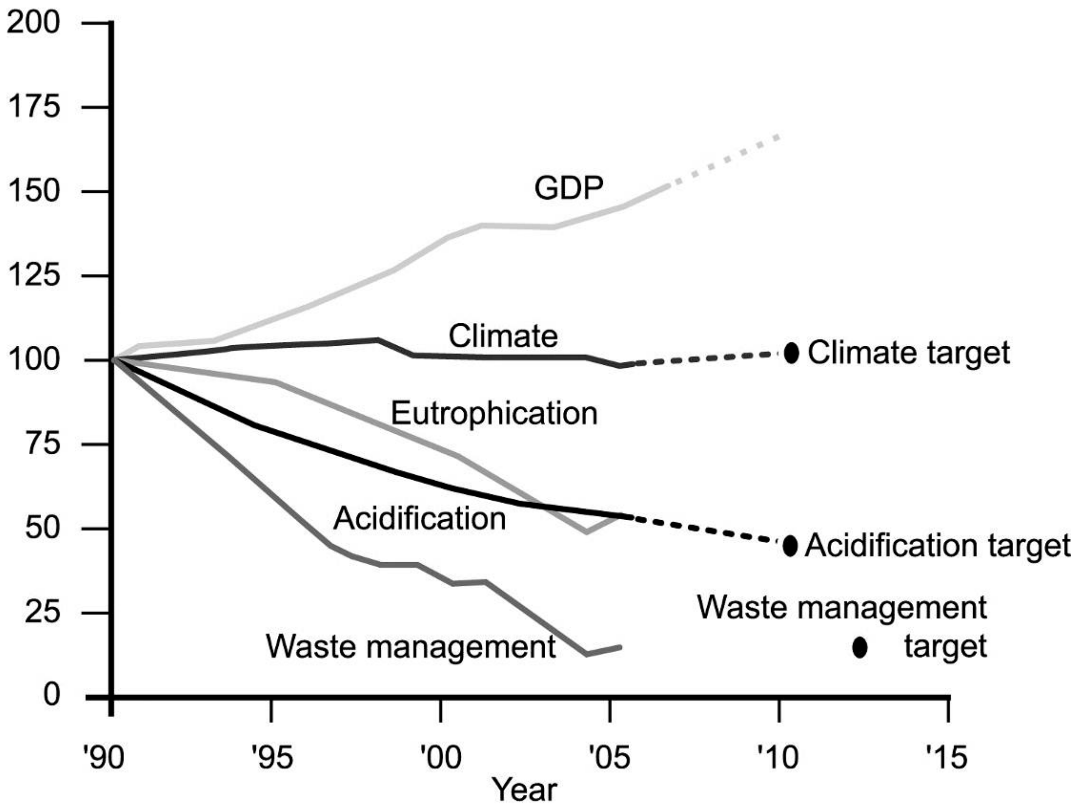


Figure 4.3: Achieving decoupling in the Netherlands

Source: Netherlands Environmental Assessment Agency (NEAA, 2007a)

The program, documented in detail in the 2000 publication *Sustainable Technology Development* by Paul Weaver *et al* (2000), sets targets of Factor 10 - 50 (depending on the issue) over 50 years from 1990 levels (i.e. by 2040). For example, fossil fuel based carbon dioxide emissions were targeted at Factor 25, oil was Factor 40, copper Factor 30, and acid deposition Factor 50. The Chairman of the program from 1993-1998, Professor Leo Jensen, reports that the Netherlands' GDP has grown by 220 percent between 1990 and 2006, and by 2006, greenhouse gas emissions reduced by 3 percent relative to the 1990 baseline (Econstat, 2008; NFIA, 2007), although final consumption of petroleum products also grew by nearly 18 percent from 1995 until 2006 (Eurostat, 2008).

These impressive results are in part due to the fact that across most sectors of the economy examples exist of companies that have cost effectively achieved significant reductions in environmental pressures and resource consumption, and even up to 80 percent. Working with research colleagues Professor Ernst von Weizsäcker, Dr Michael Smith, Dr Cheryl Desha, and Dr Peter Stasinopoulos during the development of the thesis a number of opportunities for significant greenhouse gas emissions reductions were identified across the economy, as presented in von Weizsäcker and Hargroves *et al* (2009), and summarised in Table 4.1.

Table 4.1: *Examples of opportunities to significantly reduce greenhouse gas emissions*

Sector	Best Practice Case Studies
Steel Industry	Leading US steel company, Nucor Steel, is around 70% more energy efficient than many steel companies around the world (Boyd and Gove, 2000), using state-of-the-art electric arc furnace systems, adopting leading practices such as net shape casting, and by implementing options such as energy monitoring, systems for energy recovery and distribution between processes. (Worrel et al, 2004)
Cement Industry	Ordinary Portland cement manufacture is responsible for between 6-8% of global greenhouse emissions and this is rising with demand. An Australian company, Zeobond Pty Ltd (Zeobond, 2008), is making geo-polymer cement which reduces energy usage and greenhouse gas emissions compared to Portland cement by over 80% (TNEP, 2009). Geo-polymers can be used for most major purposes for which Portland cement is currently used. (CSIRO, undated)
Paper and Pulp Industry	Catalyst Paper International has improved their energy efficiency by 20% across all operations since 1990, saving the company close to US$26 million between 1994 and 2004. At the same time, they've reduced their greenhouse gas emissions by nearly 70% through greater use of biomass and sourcing electricity from hydro power (Catalyst Paper Corporation, undated). The pulp and paper sector has the potential in both existing and new mills to become renewable electricity power generators through the use of Black

	Liquor Gasification-Combined Cycle (BLGCC) technologies. (Worrell, 2004)
Data Centres	Google has achieved 80% energy efficiency improvements in its data-centres through efficient data centre design, efficient power supplies, and efficient voltage regulator modules on motherboards (Google, 2009). Unnecessary components, such as graphics chips, are omitted. Fan energy is minimised by running fans only as fast as required. Finally, Google seeks to use components that operate efficiently across their whole operating range, a strategy that the company estimates could reduce data centre energy consumption by half. (Google, 2009).
Super-markets	Supermarket chains Tesco (UK) and Whole Foods (USA) are showing that there are numerous ways to significantly reduce electricity usage, through for instance reducing cooling and heating loads and utilising more efficient lighting (Fitcher *et al*, 2010). They are also experimenting with solar energy and wind micro-turbines (Fitcher *et al*, 2010). Whole Foods Market is set to power an entire store using solar panels and a combined cycle co-generation using fuel cells and heat recovery. (Whole Foods Market, 2008)
Restaurant	The restaurants – Bordeaux Quay, Bristol, UK (Bordeaux Quay, undated), Foodorama, Berlin, Germany (Sonnenberg, 2009), and The Acorn House, London, UK (Carvalho, 2007) – demonstrate that restaurants can significantly reduce their energy consumption through building design, energy efficient lighting and cooking equipment, purchasing their electricity from accredited renewable sources, buying organic fresh local food in season, composting and recycling all waste, and investing in carbon offsets.
Transport: Vehicle Efficiency	Whole system design approaches that integrate technical advances in light-weighting, hybrid electric engines, batteries, regenerative breaking and aerodynamics is enabling numerous automotive and

	transport vehicle companies to redesign cars (Lovins and Cramer, 2004), motorbikes, delivery vans (Environmental Leade, 2008b), trucks (Stodolsky, 2002; Bustnes, 2005; Cummins, 2006; Environmental Leader, 2009b; Alles, 2009;), trains (CSX, 2008), ships and aeroplanes (Daggett *et al*, 2003; Leifsson and Mason, 2005; King *et al,* 2008; Biella, 2008; Environmental Leader, 2008; Environmental Leader, 2009a) to be significantly (50-80%) more fuel efficient than standard internal combustion vehicles. Plug-in vehicle technologies are opening up the potential for all transportation vehicles to be run on batteries charged by renewable energy. (Kempton *et al*, 2001; Went, Newman, and James, 2008; Light Rail Now, 2008; Schwartzapfel, 2008; Kempton *et al*, 2009)
Transport: Efficiency from Modal shifts - Passenger Vehicles	Shifting transport modes can also lead to significant energy efficiency gains. One bus with 25 passengers reduces energy and greenhouse gas emissions per capita by approximately 86% per kilometre compared to 25 single occupant vehicles (Northern Territory Government, 2007). Trains are even more efficient. Typically, rail systems in European cities are 7 times more energy-efficient than car travel in US cities. (Newman and Kenworthy, 2007 and 2015)
Transport: Efficiency from Modal Shifts - Freight Vehicles	Shifting freight transport from trucks to rail can also lead to large efficiency gains of between 75 and 85% (Freight on Rail, 2009; Frey and Kuo, 2007). Several countries are moving to improve the efficiency of their transport sectors by making large investments in rail freight infrastructure, including improving the modal interfaces. For instance, China has invested US$292 billion to improve and extend its rail network from 78,000 km in 2007, to over 120,000km by 2020, much of which will be dedicated to freight. (Xinhua News Agency, 2008)

Source: von Weizsäcker and Hargroves *et al* (2009)

4.2 STRATEGIC CONSIDERATIONS TO ENHANCE THE FEASIBILITY OF ACHIEVING SIGNIFICANT GREENHOUSE GAS EMISSIONS REDUCTIONS

It is clear from the findings presented from the literature review in the previous chapters that a medium-long term approach is required to respond to the challenge of significantly reducing greenhouse gas emissions globally. And further that a range of options will be needed rather than a single solution. Over the last decade significant advances have been made towards understanding how to take a strategic approach to achieving significant medium to long term greenhouse gas reductions. The work of economists Stephen Pacala and Robert Socolow of Princeton's 'Carbon Mitigation Initiative' provide important context for strategies to reduce greenhouse gas emissions. Their work identified 15 existing sets of technologies that the researchers suggested could each reduce carbon dioxide emissions by some 3.6 billion tons each year, an estimated 126 Gt over a 50 year period (Pascala and Socolow, 2004).

The encouraging aspect of this work is that it presents a solid case to show that from as far back as at least 2004 there exists a range of realistic technological options for achieving significant reductions in greenhouse gas emissions. What is even more encouraging is that Pascala and Socolow readily acknowledge that their list of 15 technologies excludes many other potentially significant areas of greenhouse gas reductions. As Pascala reflects, *'For efficiency improvements we had only three examples and there were many more we could have added in.'* (The Climate Group, 2004).

Table 4.2 *Pascala and Socolow's suggested 15 existing technologies that could each prevent 3.6 billion tons a year worth of carbon dioxide per year*

Existing Technology	Action Required
Car efficiency	Doubling fuel efficiency of 2 billion cars from 30 to 60 mpg
Reducing car dependency	Decreasing the number of car miles travelled by half
Green	Using best-efficiency practices in all residential and commercial

buildings	buildings
Decarbonising energy supply	Replacing 1400 coal electric plants with natural gas-powered facilities
	Capturing and storing emissions from 800 coal electric plants
	Producing hydrogen from coal at six times today's rate and storing the captured CO_2
	Capturing and storing carbon dioxide from 180 coal-to-synfuels plants
	Adding double the current global nuclear capacity to replace coal-based electricity
	Increasing wind electricity capacity by 50 times relative to today [2004], for a total of 2 million large windmills worldwide
	Producing current coal-based electricity with twice today’s efficiency
	Installing 700 times the current capacity of solar electricity
	Using 40,000 square kilometres of solar panels (or 4 million windmills) to produce hydrogen for fuel cell cars
Reducing CO_2 emissions through agriculture	Increasing ethanol production 50 times by creating biomass plantations with area equal to 1/6th of world cropland
Conserving forests	Eliminating tropical deforestation and creating new plantations on non-forested land to quintuple current the plantation area
Conserving soils	Adopting conservation tillage in all agricultural soils worldwide

Source: Pascala and Socolow (2004)

Based on the findings presented in the previous chapters, the weaknesses of this work are that, a) it suggests an increase in nuclear energy, biofuel generation, and CO_2 capture and storage, each yet to be proven to be economically or socially sound or technically viable, b) it does not include technologies to reduce emissions of non-CO_2 greenhouse gases, which represent around 25 percent of overall greenhouse gas emissions (IPCC, 2007a), and c) it suggests that the focus be on halting growth in emissions at currently levels through to 2054 before seeking to reduce them, however as outlined previously this does not consider that particular stabilisation levels of greenhouse gas emissions will have corresponding average global temperature changes, and that current levels need to be reduced well before 2054, as outlined in Stern (2006).

The strength of the work is that it provides a strong counter to the argument that major new technologies need to be developed before significant reductions in greenhouse gas emissions can achieved. And apart from the suggested increase in nuclear energy, biofuel generation, and CO_2 capture and storage, the remaining options are based on an existing technologies and build on areas of the economy that have reached entry level maturity in the market. The realisation that by utilising existing technologies and processes we can achieve significant reductions in emissions is a key step forward for the engineering, business, and economics professions.

However, it also provides unprecedented challenges for industrial economies that have evolved over long periods of time, driven by the market, and have not been guided by an imperative to reduce environmental pressures.

This means that much of the policy and industrial strategy used to achieve development in the past will need to be critically re-assessed if it is to continue to deliver progress into the future.

Effectively the challenge now is not '*what*' to do or '*how*' to do it, but rather '*where*' it can be done and by '*when*' should it be done within the context of each nation's economy. Designing a strategy to transition a national economy in such a way as to continue the required overall economic growth and stability while delivering sustained emissions reductions is going to be the challenge of the 21st Century.

The complexity of the challenge to respond to climate change arises from the understanding that even if every company, operation, and person on the planet agreed to become climate neutral it would not be able to happen overnight. The world's economies have significant amounts of embedded infrastructure and institutional inertia, so the rate of change is somewhat constrained. According to UNEP's fourth global environmental outlook, '*Due to inertia in economic, social, cultural and institutional systems, transitions to more sustainable modes of production and consumption are slow and cumbersome. Typically, it takes 30–50 years or more before such changes are fully implemented, although the first improvements can be seen at a much earlier stage.*' (UNEP, 2007, p44)

It does not make financial sense to simply discard large amounts of existing industries and replace them with new ones overnight. Nor does it make sense to do nothing until such infrastructure is ready to be replaced. All sectors of the economy will be affected to differing degrees by the imperative to reduce greenhouse gas emissions, some requiring minor changes and others requiring significant overhauls, and even closure, as has been the case in each of the previous waves of innovation shown in Figure 1.1. This is further complicated by uncertainty around the government's response as this creates risk for business, with companies that move too fast or too slow being punished by a market that does not yet have a level playing field.

Building new supply chains, manufacturing plants, transport and freight options will all take time. Updating design standards and codes, protocols, and processes and creating associated checks and balances takes time. Reviewing government requirements, policies, and programs to identify their relationship to greenhouse gas emissions takes time. Aligning subsidies and taxation, building financing structures, investigating investment opportunities and re-designing procurement processes all take time. Reviewing requirements for accreditation of education programs and professional practice, again, takes time. Retraining parts of the workforce and updating education programs takes time; and influencing the community to change behaviours to align to reducing energy demand ahead of requirements to do so, will take time.

If the process takes too long we may fail the ecological imperative, if it is forced too soon we may fail the economic and social imperatives. The challenge to transition the economy to a low greenhouse gas emissions future will need to be met with sophisticated strategies that build on the short term opportunities from efficiency improvements, fuel switching, avoided deforestation, and personal behaviour changes, to provide a platform for future advances such as advances in renewable energy technologies, as shown in Figure 4.5 from the Stern (2006).

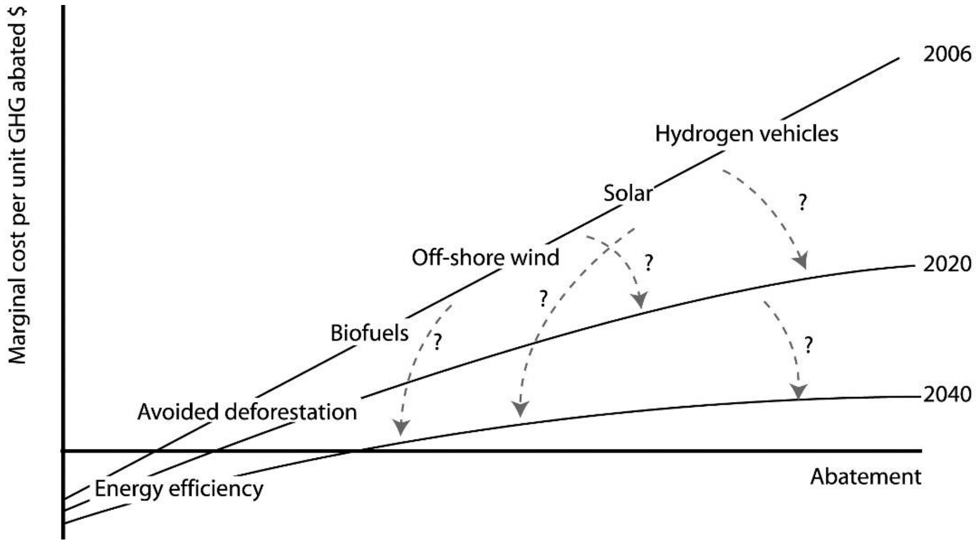


Figure 4.5: *Relative marginal costs of climate change abatement per unit GHG*

Source: Stern (2006)

An effective strategy will deliver both the short term emissions reductions cost effectively, and will also create conditions required to underpin ongoing sustained levels of reduction in emissions over time by lowering the cost of future options.

> *Historical experience shows that technological development does not stand still in the energy, or other sectors. There have been major advances in the efficiency of fossil-fuel use; similar progress can also be expected for low-carbon technologies as the state of knowledge progresses... The cost of technologies tends to fall over time, because of learning and economies of scale… Using a portfolio of technologies is cheaper because individual technologies are prone to increasing marginal costs of abatement, making it cheaper to switch to an alternative technology or measure to secure further savings. There is also a lot of uncertainty about which technologies will turn out to be cheapest so it is best to keep a range of technology options open. It is impossible to predict accurately which technologies will experience breakthroughs that cause costs to fall and which will not.*
>
> **Sir Nicholas Stern (2006)**

This complexity is a large component of why efforts in this area have been limited in the past, despite the warnings and scientific evidence of the threat that once environmental thresholds are exceeded it is very likely that the complexity may well overwhelm society's ability to then find solutions. Efforts to reduce greenhouse gas emissions will need to be developed at differing rates over time, and allow for economy-wide restructuring efforts. Firstly, emissions reductions need to be staged in such a way to best deliver a cost-effective transition. Secondly, the stock of infrastructure needs to be transitioned according to its lifespan as part of standard creation, maintenance and upgrading of such systems, both being complex processes.

Understanding this, economic studies by Jaccard and Montgomery (1996) of the US and Canadian economies in 1997 showed that, '*The key is adopting policies to encourage early development of energy-efficient and low-carbon technologies and to discourage long-lived investments in carbon-intensive energy facilities.'* (Jaccard and Montgomery, 1996, cited in Repetto and Austin, 1997). Work by Australian energy efficiency expert Professor Alan Pears, shown in Figure 4.6 highlights the reality that, for long-lasting assets, if economy-wide emissions reductions are to be achieved, the approach will need to include actions to improve existing plants, to affect the process of expansions and refurbishments, and to influence the design of new projects.

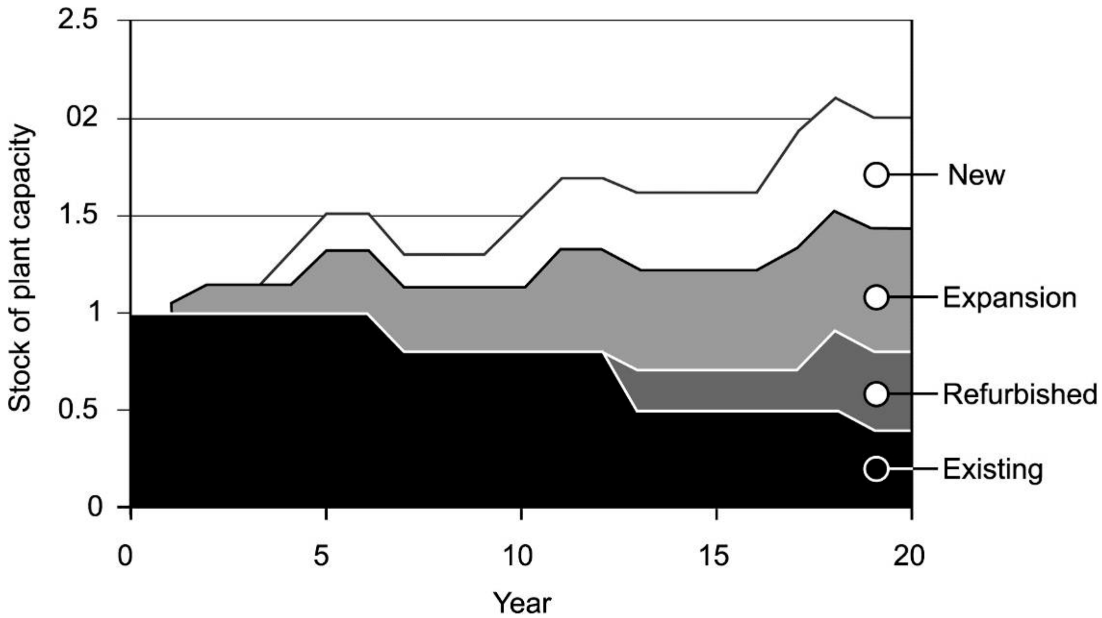


Figure 4.6: Simplified picture of stock of large industrial plant over time
Source: Pears (2004b) presented in Stasinopoulos *et al* (2009)

For equipment with a more rapid turnover, the performance of existing equipment may not be so important. However, it is surprising how long many items of equipment actually remain in use (often while their efficiency deteriorates), so there may be a case for strategies that encourage their retirement – as long as new alternatives are close to long-term optimum efficiency. As Stern points out, '*Costs would start to rise very rapidly if emissions had to be reduced sharply before the existing capital stock in emissions-producing industries would otherwise be replaced and at a speed that made structural adjustments in economies very abrupt and hence expensive. Abrupt changes to economies can themselves trigger wider impacts, such as social instability, that are not covered in economic models of the costs of mitigation ... Technological change eventually has to get annual emissions down to their long-run sustainable levels without having to accelerate sharply the retirement of the existing capital stock, if costs are to be contained.'* (Stern, 2006)

4.3 CASE STUDY OF REDUCING GREENHOUSE GAS EMISSIONS IN THE BUILDING SECTOR

This part draws on my contribution to the co-authored work 'von Weizsäcker, E., Hargroves, K., Smith, M., Desha, C. and Stasinopoulos, P. (2009) Factor 5: Transforming the Global Economy through 80% Increase in Resource Productivity, Earthscan, UK. The development of this part was informed by identification of key resources by the co-authors of the book, namely Dr Michael Smith, Dr Cheryl Desha and Dr Peter Stasinopoulos, for my consideration.

According to the OECD, the building sector is responsible for close to 40 percent of global greenhouse gas emissions (OECD, 2003b). Also, buildings are responsible for 12 percent of global water use (OECD, 2003b), and efforts to reduce this consumption can yield sizable energy savings through the reduced requirement to service a building with potable water. A key source of emissions from the building sector results from the use of electricity. As coal fired power stations provide a significant proportion of the world's electricity the reduced use of fossil fuel based electricity in buildings (from energy efficiency initiatives and a shift to renewable energy use) will result in reductions in greenhouse gas emissions (WBCSD, 2009).

Energy Efficiency in Residential Buildings

According to the International Energy Agency residential buildings consume 27.5 percent of the world's electricity, some 4.3 Million GWh (IEA, 2006), with this consumption covering a range of end-uses such as space heating and cooling, appliances and equipment, heating water, lighting, and refrigeration (See von Weizsäcker and Hargroves *et al* (2009) for details). The relative consumption in each of these areas varies from country to country as can be seen in Figure 4.7.

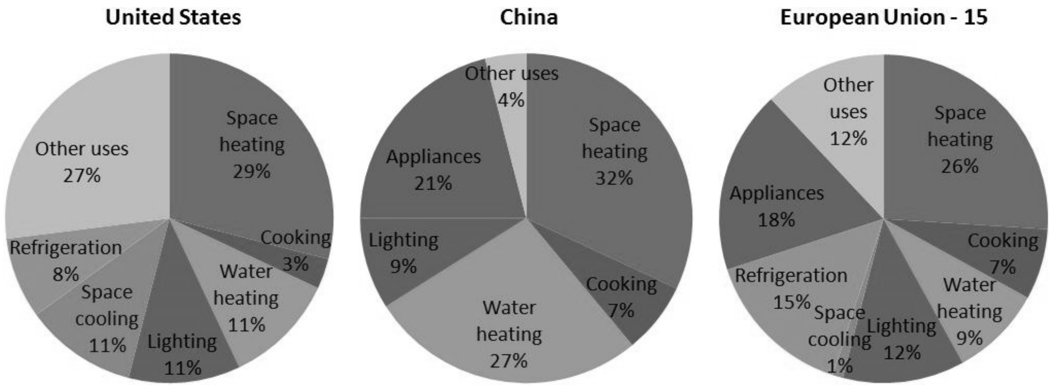


Figure 4.7: *Breakdown of residential sector energy use in the United States in 2005, in China in 2000, and in the EU-15 in 2004*

Source: Based on data from (a) EIA (2006), (b) Zhou (2007), and (c) IEA (2003) and Waide, Lebot, and Harrington (2004)

The city of Freiburg, Germany, is one of the leading examples of a City Council taking a progressive stance on reducing energy consumption through its energy efficient housing standard, which has resulted in reductions of up to 80 percent in energy use for space heating (Fraunhofer Institute, 2000). Enacted in 1992, the Council's energy efficient housing standard requires energy consumption for heating purposes in households to be limited to 65 kWh/m^2 for all construction under the Council's jurisdiction (including construction on land bought from the Council and in projects funded by the Council). This is approximately a 70 percent improvement on typical older European homes of 220 kWh/m2 per annum.

According to the Clinton Climate Initiative (2008), "*The entire Vauban and Rieselfeld districts have been constructed to this 65kWh/m2 standard, comprising a population of 18,000 people. Around 150 units have been constructed to 'passive house' (15kWh/m2) or 'plus energy' (houses producing energy surpluses) standards, savings around 2100 tonnes of* CO_2 *each year. Additional energy for passive houses is required for only a few weeks each year – a wood chip biomass combined heat and power plant provides this energy… Low-energy housing costs around 7% more to build than traditional housing, yet energy consumption falls by up to 80 percent… Construction costs for multi-unit buildings are lower. Costs associated with energy* *efficient construction are initially added directly to the purchase price, but the public has accepted these additional costs, in the anticipation of reduced running costs."*

As mentioned above, the energy consumption of residential buildings can be reduced in a number of areas, including:

- *Appliances and Equipment*: Household appliances are responsible for a major proportion of energy consumption in residential homes around the world, representing 21 percent in China in 2000 (Zhou, 2007), 25 percent in the EU-15 in 2004 (IEA, 2003), and 27 percent in the USA in 2005 (EIA, 2006, cited in IPCC, 2007a). The consumption of appliances can be reduced by more than 50 percent, by implementing best available technologies. According to the Lawrence Berkeley National Laboratory (2004), '*In the USA, the best horizontal-axis clothes-washing machines use less than half the energy of the best vertical-axis machines, while refrigerator/freezer units meeting the current US standard require about 25 percent of the energy used by refrigerator/freezers sold in the USA in the late 1970s (about 1,800 kWh/yr) and about 50 percent of energy used in the late 1980s*.'

  The IPCC further cites research that suggests that, despite the fact that the use of home appliances in developing countries represents a small amount of the overall demand, '*… the rapid increase in their saturation in many dynamically developing countries such as China, especially in urban areas, demonstrates the expected rise in importance of appliances in the developing world as economies grow*.' (IEA, 2004). For instance it is estimated that in 1985 only 7 percent of homes in China had refrigerators, and 17 percent of homes had TV's, but by 2005 these figures had risen to 75 percent and 86 percent respectively (East, 2006).

- *Heating Water*: Heating water is also responsible for a significant proportion of energy consumption in residential homes around the world, representing 9 percent in the EU-15 in 2004 (IEA, 2003), 11 percent in the USA in 2005 (IEA, 2006b, and 27 percent in China in 2000 (Zhou, 2007). Energy requirements for water heating can be reduced by at least 90 percent, through a range of cost effective options, including: reducing consumption of hot water, improving thermal properties of hot water systems, recovering lost heat, and selecting low energy consumption hot water systems, such as solar thermal or heat pumps. According to the IPCC (2007a), '*The integrated effect of all of these measures can frequently reach a 90 percent saving'*.

The most cost effective way to reduce the amount of energy used for domestic hot water is by first investing in water saving fixtures and appliances, such as water efficient shower heads and washing machines, to reduce the amount of hot water needed. Then secondly to identify a low mains energy consumption option for heating water. Electric storage systems are the highest mains energy consumers and are being phased out by government regulation in many countries. However, electric storage systems powered by a solar thermal system or a heat pump can significantly reduce this consumption.

– *Household Lighting*: Household lighting is responsible for a growing proportion of energy consumption in residential homes around the world, representing 9 percent in China in 2000 (Zhou, 2007), 11 percent in the USA in 2005 (IEA, 2006b), and 12 percent in the EU-15 in 2004 (IEA, 2003; Waide *et al*, 2004). The consumption of energy from lighting can be reduced by up to 90 percent, by implementing a range of cost effective options, including replacing incandescent light bulbs with low energy options, such as compact fluorescent lamps, halogen lamps with dimmer switches, and light emitting diodes, and reducing the need for artificial lighting through building design and day-lighting. According to the IPCC (2007a), '*Lighting energy use can be reduced by 75 to 90% (Factor 4-10) compared to conventional practice through (i) use of day-lighting with occupancy and daylight sensors to dim and switch off electric lighting; (ii) use of the most efficient lighting devices available; and (iii) use of such measures as ambient/task lighting. Advances in lamps have been accompanied by improvements in occupancy sensors and reductions in cost.'*

– *Domestic Refrigeration*: Household refrigerators are responsible for approximately 12 percent of energy consumption in residential homes in the developed world, representing 8 percent in the USA in 2005 (EIA, 2006b), and 15 percent in the EU-15 in 2004 (IEA, 2003, Waide *et al*, 2004). The consumption of energy from refrigerators has been significantly reduced since the 1970's and can be further reduced by up to 50 percent. According to Lester

Brown (Brown, 2008, p219), '*A refrigerator in Europe uses roughly half as much electricity as one in the United States, for example, but the most efficient refrigerators on the market today use only one fourth as much electricity as the average refrigerator in Europe - a huge opportunity for improvement.*' An effective refrigerator is in essence a well-insulated box with a cooling mechanism, with the technology rapidly improving over the last few decades. For example, in 1972 the average US model sold used 3.36 kWh/y and by 1987, when California bought efficiency standards, the average model used 1.87 kWh/y (von Weizsäcker, Lovins, and Lovins, 1997, pp34-35), and since 1983, Sun Frost have been making refrigerators that only used 0.19 kWh/y (Sun Frost, undated). This trend has been followed around the world. Energy efficiency improvements in Australia, as a result of energy labelling and mandatory energy performance standards, mean they now use roughly 70 percent less energy than the refrigerators of 1980. One might assume that after such a significant improvement there would be little potential left for further reductions in energy consumption. But at least another 50 percent improvement is possible through designing refrigerators with better insulation and door seals, more efficient compressors, fans and internal lighting (with the latter reducing heat generation in the unit).

Energy Efficiency in Commercial Buildings

In OECD countries like the USA, commercial buildings are responsible for 18 percent of the energy usage (US DOA, 2009). According to the International Energy Agency commercial buildings consume some 3.7 Million GWh of energy (IEA, 2006b), with this consumption covering a range of end-uses such as: heating, ventilation and air-conditioning (HVAC), indoor lighting, outdoor lighting, office equipment, servers and data centres. As with residential buildings the relative consumption in each of these areas varies from country to country as can be seen in Figure 4.8.

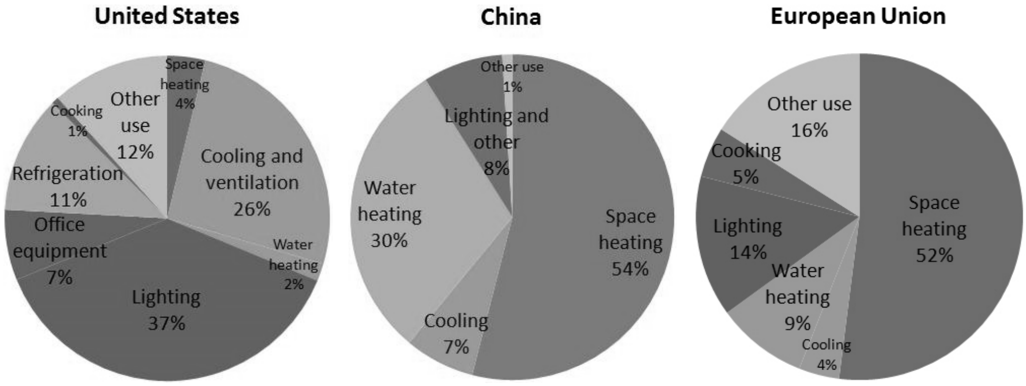


Figure 4.8: *Breakdown of commercial building sector energy use in the United States in 2005 (electricity), in China in 2000 (total energy), and in the EU-15 in 2004 (electricity)*

Source: Based on data from (a) EIA (2008), (b) Zhou *et al* (2008) p22, and (c) Janssen (2004) p37

In 2001, Engineers Australia (2001), the peak professional body for engineers in Australia, created a Sustainable Energy Building and Construction Taskforce that found that, '… *energy neutral commercial building stock should be the goal which industry and government should be now moving*.' The Taskforce found that, in 2001, energy efficiency savings of 60 percent could be achieved in retrofitted buildings and at least 70 percent in new buildings, based on experience from Australia and around the world. They highlighted that as far back as 1996, Pacific Gas and Electric undertook a project with the California State Automobile Association (CSAA) to determine the cost effective technical potential for energy efficient commercial/office building design. The project demonstrated overall energy savings (lighting, heating, cooling and office equipment) of 70 percent below the strict California Title 24 Code for energy efficiency in buildings.

Research by the US National Renewable Energy Laboratories (NREL) in 2007 - America's primary laboratory for renewable energy and energy efficiency research and development – concluded that a net zero energy (or net zero carbon) goal for office and commercial buildings is largely achievable, and highlighted that: '*Reducing consumption through energy efficiency is important in the net zero energy building context because it requires much less photovoltaic solar panels to reach net- zero energy... If [energy efficiency strategies] projected future technology and PV systems were applied to all buildings by 2025... new buildings in the commercial sector could, on average, consume 86% less than current stock.*' (Griffith, Long, Torcellini, and Judkoff, 2007, p8)

There are numerous examples of ‘green buildings’ around the world, including:

- Pearl River Tower, Guangdong, China: According to designers Skidmore, Owings, and Merrill (SOM) the 310 meter tall, 214,100 m^2 (2.3 million ft^2) tower will be the most energy efficient super tall tower ever built, and perhaps the world’s first ‘zero-energy’ skyscraper, consuming nearly 60 percent less energy than a traditional building of similar size, and sourcing its energy needs from renewable sources. (Frechette, and Gilchrist, 2009; Traum, 2007)

- Wal-Mart Super Store, Ontario, Canada: The first Canadian environmental demonstration store in Burlington, Ontario, features a first-of-its-kind application of geothermal technology in a large-scale Canadian retail operation and energy-conserving lighting innovations. (Green News, 2008) The new Burlington supercentre is expected to use an estimated 60 percent less energy than the company's typical supercentre store. According to David Cheesewright, Wal-Mart Canada's president and CEO, ‘*There's a tremendous opportunity to reduce our construction and operating costs and to pass those savings on to our customers, who are looking for lower prices now more than ever.’*

- Council House II Building, Melbourne, Australia: Council House II (CH2) is one the world’s leading green buildings (Smith and Hargroves *et al*, 2007), and is one of the earliest ‘Six Star’ buildings under the Green Building Council of Australia’s rating system, similar to a LEED Platinum rating (Fortmeyer, 2008). According to the City of Melbourne, the building cost AUD$51 million (approximately US$39 million), including AUD$11.3 million (22 percent), for sustainability features. Considering the AUD$1.45 million annual savings from such features, Council is expecting a pay-back period on the sustainability features of less than 10 years, and then ongoing savings (City of Melbourne, 2007). The building consumes 82 percent less energy than the first Council building, has reduced gas consumption by 87 percent, produces only 13 percent of the emissions, and reduces demand on the water mains supply by 72 percent. According to Council there has also been nearly 5 percent improvement in staff effectiveness as a result of the healthier building (clean fresh air and non-toxic finishes).

- China's Ministry of Science and Technology ‘Accord 21 Office Building’, Beijing, China: This 3,600m^2 (39,000 ft^2) building achieved LEED Gold certification in 2005, as the first LEED-certified project in China and one of the greenest building projects in the world. The building uses 70% less energy while producing over 15% of its energy from renewable energy sources such as solar panels and heat recovery. (NRDC, undated; Marquand, 2006)

- Pacific Controls Headquarters, Dubai, United Arab Emirates: This 11,150m^2 (120,000 ft^2) LEED-Platinum rated building at the Techno Park in Dubai was, in 2007, the first and only certified green building in the Middle East, and the 16th worldwide. Photovoltaic panels cover the roof of the building, meeting the daytime lighting needs, and shading the roof from heat gain into the building. The building also uses a solar-thermal system to provide 25% of the building design cooling load (i.e. fresh air cooling), where a solar collector farm of hot water panels produces hot water at 90^{o}C to run a 100 ton absorption chiller. (PRWeb, 2007)

- Sohrabji Godrej Green Business Centre (‘CII-Godrej GBC’), Hyderabad, India: This 1,900 m² (20,450 ft^2) building was the first outside the USA to achieve a LEED platinum rating from the United States Green Building Council, in 2003. The building uses 55% less energy than a conventional building, with 90% of the spaces having daylight access and views to the outside. (Confederation of Indian Industry, undated; United Nations ESCAP, 2008; Jafri, 2004; Srinivas, undated)

- Pusat Tenaga Malaysia’s (PTM) Net Zero Energy Office (ZEO) Building, Selangor, Malaysia: This 4,000 m^2 (43,000 ft^2) administration and research office building was completed in 2007, as the first zero-energy office building in South-East Asia. It does not use fossil fuel as an energy source, but has achieved ‘zero net energy’ through a combination of features including passive solar design and onsite renewable energy generation. (Yoong, 2008, pp65-67)

- Lawrence Berkley National Laboratory (LBNL): Today’s scientific facilities can be more than 100 times more energy-intensive than conventional buildings (Mills *et al*, 2007), and only 1-3% of these buildings are designed to be ‘green’ (Grant, 2007). The LBNL building is an US$85 million, six-story, 8,800 m^2 (94,500 ft^2) steel and glass building, completed in 2006, which achieved a LEED Gold Rating through extensive green and energy-efficient features and renewable power purchases. LBNL estimated the carbon dioxide emissions of this building to be 85% less than standard practice, which includes aggressive environmentally conscious California building codes.

Furthermore, from the rapidly expanding literature of green retrofitted building examples, the following notable commercial buildings of varying size and use demonstrate a variety of energy efficiency opportunities.

- <u>Renewable Energy House, Brussels, Belgium:</u> The Renewable Energy House is a 2,000 m^2 (21,500 ft^2) office building that was originally built in 1885 in Brussels, Belgium (Dymond, 2006; German Energy Agency, 2006, p10). The building now uses half of the energy of a typical building of its type, costs 70% less to run compared to before the retrofit, and demonstrates the application of many types of renewable energy technologies, including: an 80 kW boiler to meet most of the heating demand, 25 kW heat pumps to meet the rest of the heating demand, a 60 m^2 solar hot water system with 5,000 litre storage, a 37.5 kW thermally driven cooling system, rooftop and window solar panels, a highly efficient ventilation system with 85% heat recovery, highly efficient lighting, 15 cm mineral wool insulation, and double glazing on the windows.

- <u>Hudiksvall District Courthouse, Hudiksvall, Sweden:</u> Hudiksvall district courthouse is a 2,000 m^2 (21,500 ft^2) office building that was originally built in 1909 in Hudiksvall, Sweden (German Energy Agency, 2006, p7). The building's energy use has been reduced by 132 MWh per year through a combination of measures, including: reducing heating energy demand by 105 MWh per year or 30%, achieving 80% heat recovery and thus helping to reduce ventilation electricity demand by 13 MWh per year or 68%, and using a computer control system to manage heating and ventilation to manage power consumption and improving the insulation. The building's heating energy requirements, which were originally met by burning oil, are now met by district heating, which uses 99.7% renewable fuels.

– The Barton Group's Headquarters, New York, USA: The Barton Group's headquarters is a three-story, 1,500 m^2 (16,000 ft^2) brick building that was originally built in 1865 in Glens Falls, New York and retrofitted in 2007 (Del Percio, 2009). The building, which has achieved a LEED Platinum rating, is 49% more energy efficient than stipulated by the New York State building code, and sources all of its electricity from wind power. The building also has several resource efficient features, including: a geothermal system for internal temperature control, a green roof and greywater system, preferred parking for cyclists and hybrid vehicles, and office furniture with recycled content.

– Metrotower Office Complex, British Columbia: Based on the findings of a comprehensive energy audit in 2003 supported by BC Hydro, the Metrotower Office Complex, in Burnaby, British Columbia (Canada) undertook a CAD$1.1 million (US$750,000) lighting upgrade, replacing the existing double T12 fluorescent light tubes with single T8 tubes and a reflector. On average the upgrade reduced the energy use for each unit by almost half while delivering the equivalent light. According to the buildings manager, *'an estimated saving of 2.8 million kilowatt/hours of electrical energy was realized from the lighting retrofit. This translated to on-going annual savings of $150,000'* (Ivanhoe Cambridge, 2007). The building's energy conservation program also includes a number of complimentary activities such as smart controls for lighting and HVAC, chilled water closed-loop-systems, efficient motors and variable speed drives, low-energy reflective glass, and window blinds.

– Szencorp Building, 40 Albert Road, Australia: The 1,200 m^2 (13,000 ft^2) five-storey office building, built in 1987, became the first commercial 6 star *Green Star* (i.e. 'World Leadership Status') refurbishment in Australia, with a number of Australian 'firsts', including a *DryKor* air-conditioning unit which uses desiccant technology to dry and cool the office space simultaneously, and a ceramic fuel cell to provide heat and electricity. In the year following the refurbishment, the building achieved a 61% reduction in energy use, and an 82% water saving, compared to the industry average.[11] Following fine tuning in the

[11] Based on a survey of 117 existing Melbourne office buildings undertaken by Sustainability Victoria in 2000, the average base building office energy use is 600MJ/m2 - Sustainability Victoria (2008)

second year, this increased to 71% saving in energy and 90% savings in water use (Sustainability Victoria, 2008).

- Wal-Mart Building Retrofits – Upgrading 113 Stores in China: After opening its first energy-efficient location in Beijing in 2008, Wal-Mart is planning energy efficiency upgrades for all 113 of its Chinese stores within the next five years (China Daily, 2008). Compared to a typical store in 2005, the new Beijing store will consume 23% less electricity and 17 percent less water annually. Upgrades for other stores will include: LEDs for major lighting, motion sensors to control lighting during non-peak hours and in low traffic areas, sliding glass doors in refrigerators and coolers, and treatment and reuse of water running from the refrigeration system.

Approximately some 90 percent of a standard commercial building's greenhouse gas emissions are attributed to the energy needs to run the building over its lifetime it is important to focus efforts on reducing such demand (AGO, 1999). As mentioned above, the energy consumption of commercial buildings can be reduced in a number of areas, including;

- *Heating, Ventilation and Air-Conditioning (HVAC)*: HVAC is responsible for a significant proportion of energy consumption in commercial buildings around the world, representing 30 percent of electricity consumption in the USA in 2003 (EIA, 2008), 56 percent of electricity consumption in the EU in 2001 (Janssen, 2004, p37), and 61 percent of all sources of energy in China in 2000 (Zhou *et al*, 2008, p22). The energy requirement for HVAC can be significantly reduced using several features related to building orientation, the building envelope, and the building's form, taking advantage of opportunities for passive heating, cooling and ventilation, most of which are low-cost options if integrated in the earliest stages of design (Burke, 1996; AGO 2005b; Sustainability Victoria, 2006). According to a study by the Californian Energy Commission, '*By applying the integrated design principles … the energy consumption of buildings with small HVAC systems can be reduced by 25 to 35 percent without incurring significant increases in capital costs*' (State of California, 2005).

  The study reviewed the operation of 75 buildings and 215 roof top HVAC units in California and identified several issues with HVAC systems that increase energy consumption, including: economizers not operating properly (63 percent); improper refrigerant charge (46 percent); low airflow (39 percent); cycling fans during unoccupied periods (38 percent); fans running during unoccupied periods (30 percent); simultaneous heating and cooling (7 percent); and inadequate ventilation air (7 percent). (Architectural Energy Corporation, 2003, p2) According to the UK Carbon Trust (2006), '*Heating, ventilation and air conditioning can account for the majority of money spent by an organisation on energy. Making even small adjustments to systems can significantly improve the working environment and at the same time, save money'*.

– *Indoor Lighting*: Indoor Lighting is responsible for a significant proportion of energy consumption in commercial buildings around the world, representing up to 8 percent of all sources in China in 2000 (Zhou *et al*, 2008, p22), 14 percent of electricity consumption in the EU in 2001 (Janssen, 2004, p37), and 37 percent of electricity consumption in the USA in 2003 (EIA, 2008). Energy used for indoor lighting can be significantly reduced through the use of modern lights, effective methods to reduce lighting needs, and through effective lighting control. According to the IPCC (2007a), '*Lighting energy use can be reduced by 75 to 90% compared to conventional practice through (i) use of the most efficient lighting devices available; (ii) use of daylighting with occupancy and daylight sensors to dim and switch off electric lighting; and (iii) use of such measures as ambient/task lighting*'.

  The most cost-effective activity to reduce energy consumption in existing buildings is retrofitting them with modern energy efficient lamps, with payback periods in the order of 1-3 years (Sustainability Victoria, undated). There are also several technological control solutions, including: rewiring, key lock switches, time switched lights (push-button or time delay switches, lighting controllers), voltage reduction technology, and occupancy sensors (i.e. passive infrared, ultrasonic, microwave, photo). (AGO, 2005a)

– *Office Equipment*: Office Equipment is responsible for a significant proportion of energy consumption in commercial buildings around the world, representing 7 percent in the USA in 2003 (EIA, 2008, Table E3, data not identified for China and Europe). Estimates from the UK suggest office/client equipment is the fastest growing energy consumer in business, consuming about 15 percent of total electricity used in offices and expected to increase to 30 percent by 2020 (Carbon Trust, 2006, p3). Options to reduce energy demand in this area include consolidation of equipment (Kong, undated; Fuji Xerox Australia, 2008)), the select the appropriate equipment (Carbon Trust, 2006, p3), enhanced power management strategies (Carbon Trust, 2006, p3), and the use of low-energy client equipment, and management and monitoring processes to identify opportunities to reduce energy consumption, such as scheduling non-critical, high-energy activities out of peak periods. (Australian Computer Society, 2007)

4.4 CHAPTER SUMMARY AND CONTRIBUTION TO THESIS

The chapter concluded the findings of the literature review. The chapter began by presenting evidence that significant reductions in greenhouse gas emissions can be achieved, and clarified the symbiotic nature of energy demand reduction and renewable energy generation. The chapter highlighted a lack of capacity building in methods to achieve emissions reductions and presented a pragmatic inquiry into the nature of design to inform such outcomes. The chapter highlighted engineering examples of where a short term design focus led to advances that provided significant initial benefits but delivered sinister legacies, such as the development of Freon for refrigeration and the addition of tetra-ethyl lead to petroleum. The chapter then presented evidence that a number of countries have taken action to decouple greenhouse gas emissions and other environmental pressures from economic growth, and provides specific examples across a number of sectors.

The second part then explored a number of strategic considerations to enhance the feasibility of achieving significant greenhouse gas emissions reductions across economies, and concluded that a medium-long term approach is required to respond to the challenge of significantly reducing greenhouse gas emissions globally. The chapter then outlined a number of methodologies for structuring such an approach and discussed their relative strengths and weaknesses. The chapter then built on previously presented material related to the complexity of achieving economy-wide greenhouse gas emission reductions, such as embodied infrastructure and institutional inertia. The chapter then outlined considerations for the staging of actions to reduce greenhouse gas emissions aligned to the design life of energy intensive infrastructure.

The final part of the chapter then provided an example of how significant reductions can be achieved in the building sector, both residential and commercial, drawing on research I undertook and contributed to the book '*Factor 5: Transforming the Global Economy through 80% Increase in Resource Productivity*' (von Weizsäcker, E., Hargroves, K., et al, 2009).

This section of the literature review creates the premise that an approach to rethinking a range of industrial activities across the world's economies can lead to the profitable reduction of significant amounts of greenhouse gas emissions. This is a critical premise to base the response to the research question as it shows that it is feasible to transition to low greenhouse gas emissions.

DESIGNING STRUCTURAL CHANGES ACROSS ECONOMIES TO ACCELERATE THE REDUCTION OF GREENHOUSE GAS EMISSIONS

Chapter 5: Informing a Strategic Approach to Sustainability Transitions

Reports by the Sustainable Built Environment National Research Centre (SBEnrc) include parts of this chapter written by me. I wish to thank Prof. Peter Newman, Professor Frank Geels, and Dr Cheryl Desha for stimulating through discussion the creation of some of the arguments contained in this chapter, identifying resources for consideration to develop such arguments, and for providing valuable peer review.

5.1 UNDERSTANDING THE DYNAMICS OF 'WAVES OF INNOVATION'

The findings of the literature review presented in Chapters 2-4 suggest that the pace and scale of the challenge to respond to climate change calls for swift economy-wide changes that will affect all sectors, much like the previous shifts from burning wood and coal to electricity, from horse drawn carriages to automobiles, and from punch cards to computers – calling for significant innovation and commercialisation. As outlined in the book 'The Natural Advantage of Nations', (Hargroves and Smith, 2005) the development of the industrial revolution has been characterised as a series of 'waves of innovation', as shown stylistically in Figure 5.1. Much has been documented about these '*long-waves*', led by early work by Kondratieff (1926) and Schumpeter (1939), with the main characteristic of such waves being that they are based on a jump in technological innovation following a petering out of the previous innovations growth - typically associated with new opportunities to harness 'core inputs' or 'key factors' that offer new opportunities for economic growth such as wood, iron, coal, steel, oil, electronic chips, and solar photovoltaic panels.

Each of these waves involves an economy-wide technology transition that Geels (2002) describes as '*major technological transformations in the way societal functions are fulfilled*'. This element of widespread change as opposed to incremental change is described by Freeman and Perez (1998) as being '*the widespread diffusion of the new technology throughout the economic system is not just a matter of incremental improvements, nor just a question of the extension of existing capacity in a few industries. It involves a major upheaval in all sectors of the economy and changes in the skill profile and capital stock throughout the system*'. Hargroves and Smith (2005) suggest that the next wave of innovation will be in response to the imperative to reduce environmental pressures, especially the production of greenhouse gas emissions, as shown in Figure 5.1.

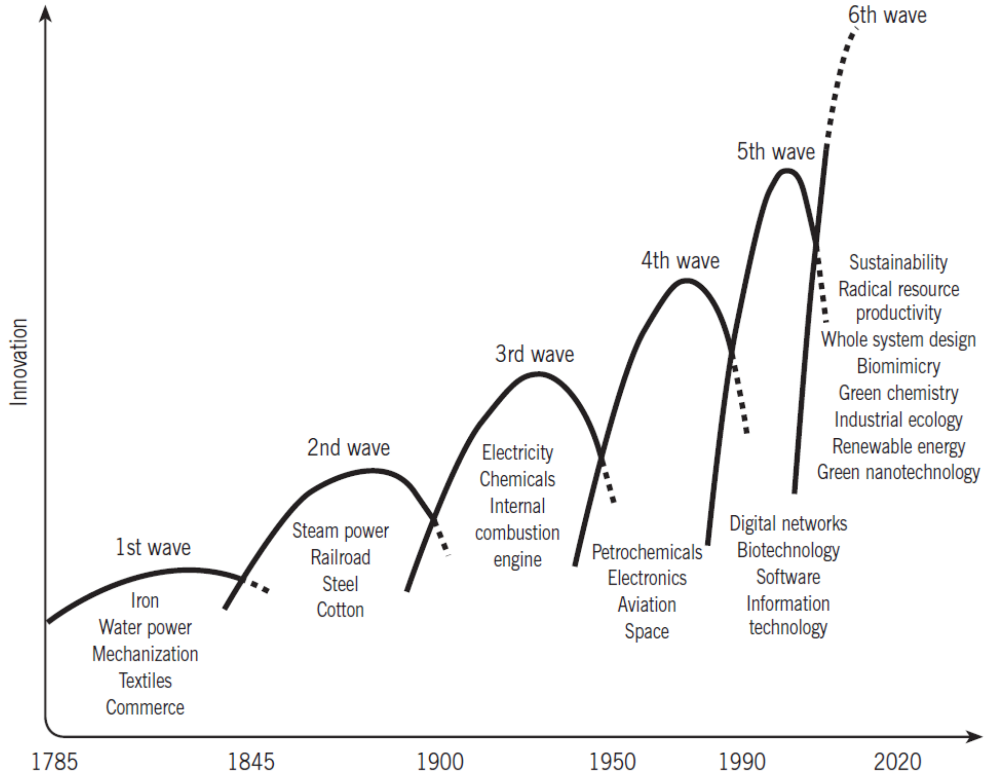


Figure 5.1: *A Stylised representation of the Waves of Innovation since the Industrial Revolution*

Source: Hargroves and Smith (2005)

According to Geels (2002) the process of developing a new wave involves the reconfiguration of a number of '*socio-technical regimes*', that Geels defines as sector/system specific transitions, e.g. shifts to new transport, energy, agro-food systems (Geels, 2014, pers. comm., 05 Jan 2014) that lead to a change in the overall '*techno-economic paradigm*' (which follows a new wave of innovation) as described by Freeman and Perez (1988). The techno-economic paradigm blends aspects of the previous waves with new innovations across a number of socio-technical regimes to create new opportunities for economic development. For example the 5th wave of innovation shown in Figure 5.1 created the information and communications techno-economic paradigm and it was built on fossil fuels, petrochemicals, electricity, etc. created in previous waves.

Much research has been done to seek to understand how past techno-economic paradigms have been replaced by new ones (Freeman and Perez, 1988), along with how technological and socio-technical regimes change (Nelson and Winter, 1982; Rip and Kemp, 1998; Geels, 2002, 2004, 2005, 2011) that can inform a transition to low greenhouse gas emissions. The core driver for such changes is the lure of profitable opportunities in the short term, and according to Freeman and Perez (1988), '*There is no possibility of a new paradigm displacing an old one until it has first clearly demonstrated … its comparative advantages at first in only one or a few sectors… and until the supply of the new key factor or factors already satisfies the three conditions of falling cost, rapidly increasing supply, and pervasive applications*.'

Hence it is suggested that there are two key factors that influence the likelihood of an autonomous change in techno-economic paradigm, namely:

1) The previous wave, or techno-economic paradigm, is providing diminishing returns with technologies saturating the market and reducing comparative advantages. Freeman and Perez (1998) suggest that despite new technologies being developed it is not until the components of the previous wave gives '*strong signals of diminishing returns and of approaching limits to their potential for further increasing productivity or for new profitable investment*', that the potential of the new technology can be fully realised, and

2) The new wave is offering technologies that present falling cost, rapidly increasing supply, and pervasive applications (Freeman and Perez, 1988), and hence the potential to create lucrative market opportunities for those that move early.

Many authors in the sustainable development field, myself included, assume that sustainable development will be the 6th wave of innovation. This is largely based on the understanding that sustainable development technologies are viable and have the potential to deliver strong economic returns as demonstrated by early strong market penetration of energy efficiency and renewable energy options including solar photo-voltaic and wind turbines, and lighting technologies such as compact florescent bulbs and light emitting diodes (von Weizsäcker, E. *et al* 1997; Lovins *et al* 1995; Hargroves and Smith 2005, etc.).

However considering the two suggested factors above related to conditions associated with an autonomous shift in techno-economic paradigm:

1) There doesn't seem to be evidence that the profitability of the fifth wave, that of information and communications technology based on fossil fuel energy, is diminishing to the point that will create the autonomous impetus to look for new technology options to continue profits, and

2) Despite outstanding advances in renewable energy, fossil fuel based technologies and energy are still relatively cheap, highly available, and widely applicable. Further there is significant embedded infrastructure and economic interests associated with fossil fuel energy. There are signs that this is rapidly changing with a significant increase in the pace of renewable energy generation, however it may not be enough to trigger an autonomous economy-wide shift in technologies in the short term, like the computer did in the previous wave.

Hence based on the factors that have led to autonomous changes in techno-economic paradigms in the past it seems unlikely that the same factors will be in place in time to bring about the '*sustainability*' wave and avoid dangerous climate change without significant intervention involving all parts of society. Geels (2011) suggests that this is partly due to the fact that '*Private actors have limited incentives to address sustainability transitions, because the goal is related to a collective good.'*

A further contributor to this may be that many of the new technologies associated with the 6th wave of innovation may not provide new products and services that will create demand, rather they provide the same or similar products and services with a lower greenhouse gas emissions intensity, which despite other secondary benefits related to health (CSE, 1999; Campbell-Lendrum and Corvalán, 2007), new investment opportunities and reduced environmental damages, may be something that is unlikely to drive significant market wide consumer demand. Geels (2011) suggests that "*most 'sustainable' solutions do not offer obvious user benefits … and often score lower on price/performance dimensions than established technologies*". This is particularly the case for residential energy as despite the opportunity for residents to purchase solar panels and capitalise on lower energy costs the upfront investment is a significant barrier that is not required to connect to standard fossil fuel based electricity services.

Further, a rapid transition to low greenhouse gas emissions may require the economically premature abandonment of infrastructure, technology, and resource reserves associated with fossil fuels, creating stranded assets, much that have investments that need to deliver returns, returns that will be protected. Geels (2011) suggests that this would '*require a strategic reorientation of incumbents who presently still defend existing systems and regimes*'. This is of course the case in each wave of innovation, for instance there were no bail out packages for manufacturers of VHS video tapes, or LP records, or analogue televisions, however in each case the transition was driven by greater interests in future potential profits and abandoning such technology was seen as necessary to keep up with market demand for goods and services.

It may be the case that the response to climate change is the first time a new techno-economic paradigm is being called for based on concerns of future economic and social impacts of current practices, rather than emerging from the enhanced profitability of new technology and process advances. Furthermore, not only is the type of innovation being specified to require low/no greenhouse gas emissions it is being called for as a matter of urgency, presenting a significant challenge, with Hekkert *et al* (2007) reflecting that '*Increasing the innovation speed at a national level is a highly complicated process, yet influencing the innovation direction is even harder*."

In previous waves the focus has been on the potential for creating short-medium term economic gains with the option available to externalise environmental and social impacts, such as greenhouse gas emissions (Dunchin and Lange, 1994). A key challenge of this new wave will be that it will need to deliver solutions to these previous externalities while also delivering continued economic growth, and in doing so avoid medium to long term impacts on the economy and society from such externalities. So using the waves analogy, rather than a new wave being created of sustainable development related technologies that enter the market and create expanding economic opportunities, what is called for is for a backwash wave to flow back over the remaining elements of the previous waves and wash away fossil fuel intensive technologies and processes and induce greater demand for alternatives.

This will be a significant challenge and without intervention to induce a shift in techno-economic paradigm it is likely that the market will ‘cherry-pick’ the most profitable sustainable development technologies and then turn to more lucrative technologies in areas such as on nano-technology, augmented reality, or genomics - which despite the potential for them to contribute to low greenhouse gas emissions outcomes will detract investment from finding and implementing low greenhouse gas emissions solutions.

Hence there are valid concerns about the viability of a sustainable development techno-economic paradigm being established using the same mechanisms and relying on the same drivers that were used to create the previous paradigms, hence new approaches will be needed. This presents a challenging situation in that there is an imperative for technology change based on medium to long term implications of current practices and the market mechanisms that have driven previous waves of innovation are designed around considering short term gains. When considering such a transition to sustainability Geels (2011) suggests that ‘*researchers need theoretical approaches that address, firstly, the multi-dimensional nature of sustainability transitions, and, secondly, the dynamics of structural change.*’

5.2 THE NEED TO INDUCE A SHIFT IN SOCIO-TECHNICAL REGIMES

Geels (2002, 2011) presents an ‘analytical and heuristic framework’ to understand the dynamics of technology transitions, the ‘Multi-Level Perspective’ (MLP) shown in Figure 5.2. The MLP provides a key perspective that acknowledges activities at three levels that affect the diffusion of new technologies across an economy, namely, as described by Geels (2011):

1) Socio-Technical Landscape: ‘*A range of contextual factors that influence technological development but that cannot be changed directly by actors*’,

2) Socio-Technical Regimes: *‘The locus of established practices and associated rules that stabilize existing systems’,* containing *‘Rule-sets that are built up around a dominant technology and grant it stability’,* and

3) Niche Innovations: ‘*The locus for radical innovations’, which ‘creates protected spaces in which actors search and learn in various ways about new technologies and their use’.*

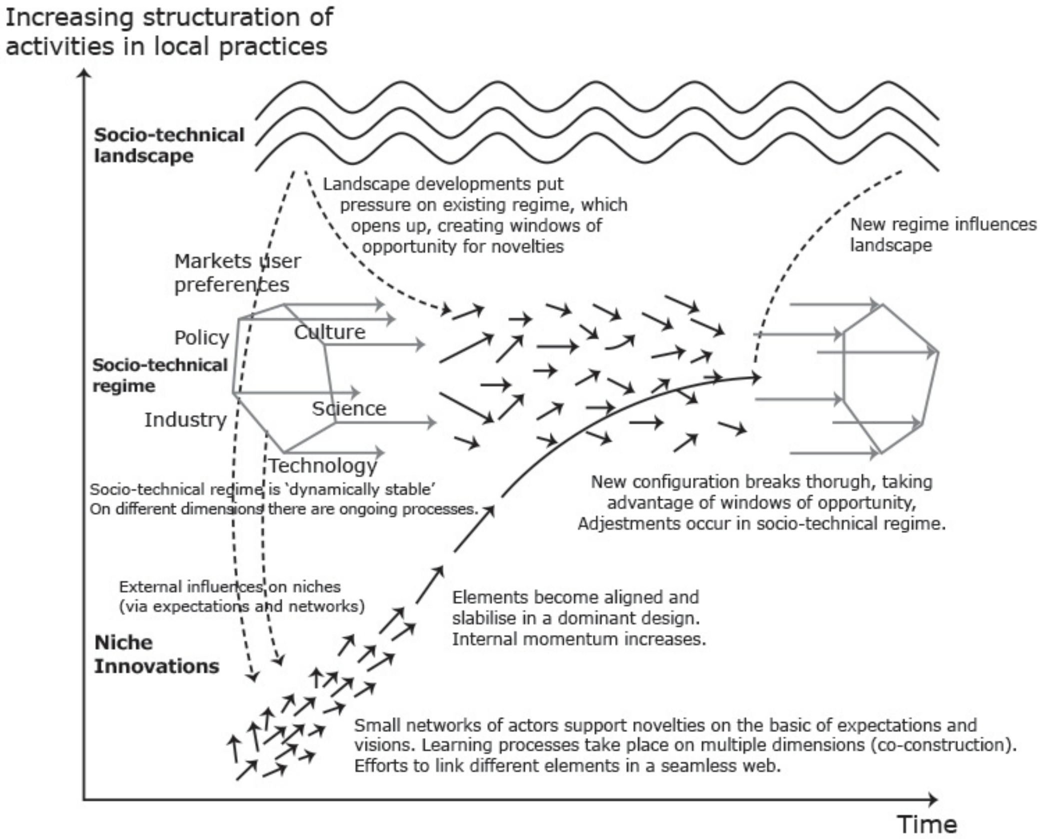


Figure 5.2: *A dynamic multi-level perspective on technology transitions*

Source: Geels (2011)

The model tracks the development of niche innovations and their diffusion into various socio-technical regimes that both influence, and are influenced by, the overarching socio-technical landscape. As outlined previously such niche innovations typically are successful when they offer significant opportunities for profit, such as electricity or computers, and provide the *'falling cost, rapidly increasing supply, and pervasive applications*' as stipulated by Freeman and Perez (1988). Considering the challenge of responding to environmental imperatives, Geels (2011) suggests that '… *the core analytical puzzle is to understand how environmental innovations emerge and how these can replace, transform or reconfigure existing systems.*'

I propose that as a society we need to not only assist environmental innovations to '*emerge*' as Geels suggests, but also act to '*induce*' such innovations on a faster timeframe that would happen if left to the market, as indicated in Figure 5.3. Hence I propose that in the case of low greenhouse gas emissions technologies the process of niche technologies being diffused across economies needs to be assisted with appropriate interventions, both by directly adjusting existing structures in the economy such as taxation and subsidies, along with creating support and capacity through in-direct measures such as industry led performance assessment and reporting systems, behaviour change, and renewal of education programs (as outlined in the following chapters). Figure 5.3 suggests an amendment to Geels (2011) multi-level perspective to include a greater focus on influencing socio-technical regimes to open lock-in mechanisms and induce the shift towards a sustainable development based techno-economic paradigm.

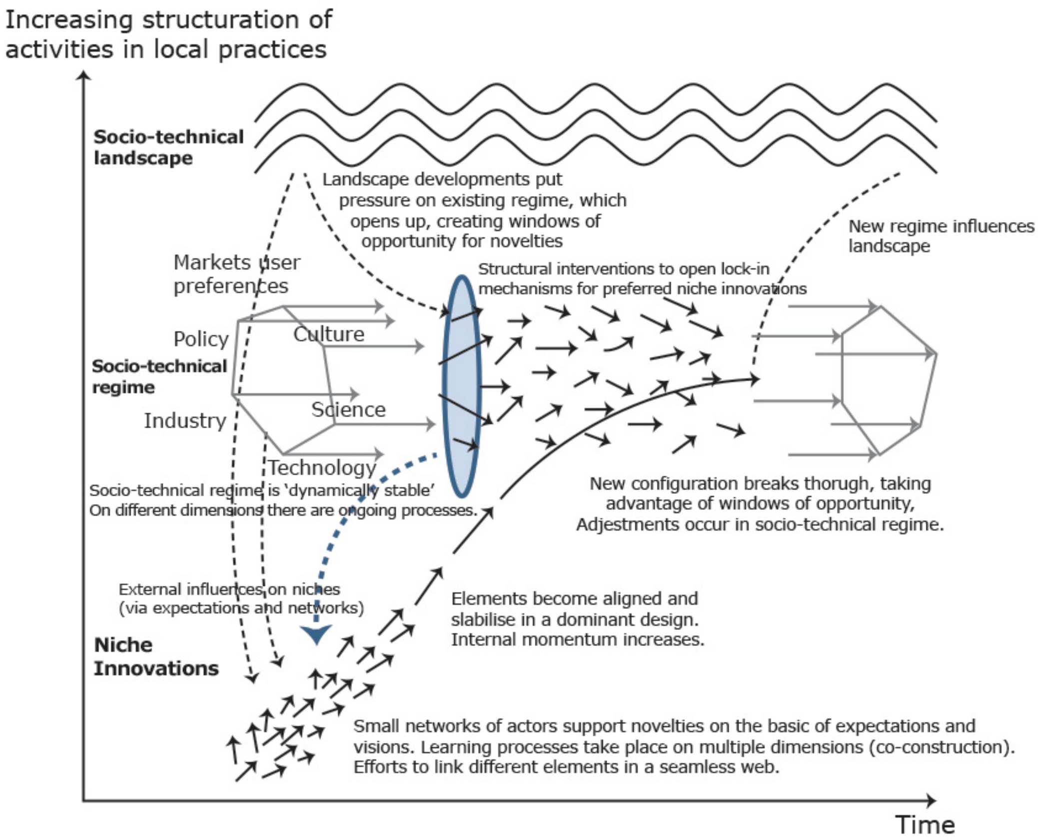


Figure5.3: *A modified multi-level perspective on technology transitions to include structural interventions to open lock-in mechanisms for preferred niche innovations*

Source: Based on Geels (2011)

From a multi-level perspective the success of new niche innovations is influenced by developments at both the socio-technical landscape level and the socio-technical regime level that can create "*a 'window of opportunity' for innovations to break out of* [technology] *niches*." (Geels 2002) Hence given the imperative for a low greenhouse gas emissions transition such windows need to be expanded and new ones created along with alignment and development of various supporting mechanisms to see preferred niche innovations quickly mainstreamed to achieve the reductions in greenhouse gas emissions.

Geels (2011) points out that various socio-technical regimes, simplified in Figure 5.4, '*interpenetrate and co-evolve with each other*', providing a dynamic change process that provides the potential for appropriate interventions to intentionally create windows for preferred innovations. Hence in order to respond to climate change the various socio-technical regimes need to be intentionally altered to create demand, and the associated structures, for low greenhouse gas emissions innovations.

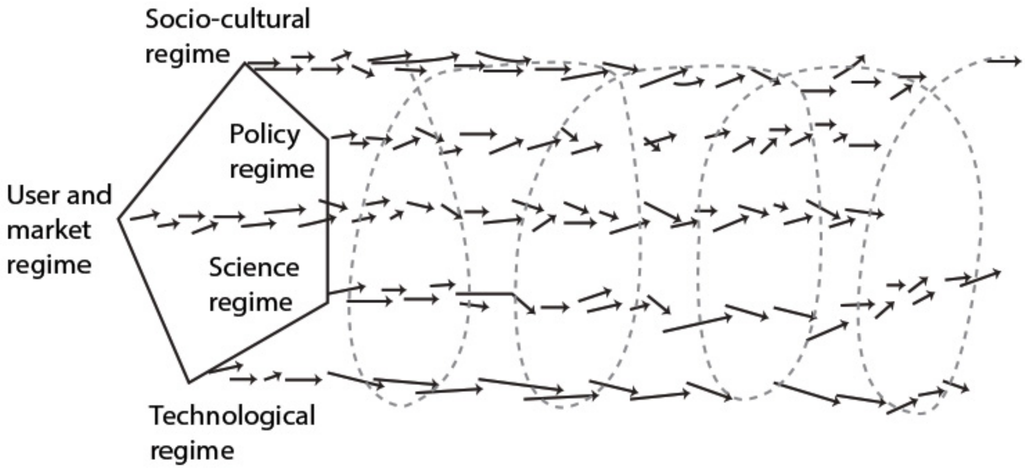


Figure 5.4: *Alignment of ongoing processes in a socio-technical regime*

Source: Geels (2011)

5.3 OVERCOMING LOCK-IN MECHANISMS HINDERING EFFORTS TO ACCELERATE THE REDUCTION OF GREENHOUSE GAS EMISSIONS

The key to altering socio-technical regimes comes from a focus on overcoming what Unruh (2000) referred to as '*lock-in mechanisms*', with Geels (2011) reflecting that, '*With regard to structural change the problem is that many existing (unsustainable) systems are stabilized through various lock-in mechanisms, such as scale economies, sunk investments in machines, infrastructures and competencies… Additionally, consumer lifestyles and preferences may have become adjusted to existing technical systems. These lock-in mechanisms create path dependence and make it difficult to dislodge existing systems'*.

Such lock-in mechanisms present a significant barrier to achieving low greenhouse gas emissions transitions and are in part responsible for the slow progress the world has made on reducing greenhouse gas emissions. In order to swiftly free up lock-in mechanisms efforts need to be made at the structural level of the economy, which will have far reaching implications, with Freeman and Perez (1988) pointing out that, "*Certain types of technical change have such widespread consequences for all sectors of the economy that their diffusion is accompanied by a major structural crisis of adjustment, in which social and institutional changes are necessary to bring about a better match between the new technology and the system of social management of the economy – or 'regime of regulation'. Once, however, such a good match is achieved a relatively stable pattern of long term investment behaviour can emerge for two to three decades*."

However there are very few examples of intentional processes that have successfully opened numerous 'lock-in mechanisms' across an economy to create avenues for preferred technologies or processes to be mainstreamed. Perhaps the closest example is that of war-time urgency, as we pointed out in Smith, Hargroves, and Desha (2010), with WW2 having a significant impact on the US economy involving a near complete retooling of many industries to the war effort in a very short period of time, '*In the period 1939–1945, unemployment in the USA fell from 14.6 percent to 1.9 percent, and GDP grew 55 percent.*' (Smith and Hargroves 2010). During this time a bipartisan national approach was implemented with 'war-time' urgency, and involved significant co-operation across the economy.

> *… the United States must build planes and tanks and guns and ships to the utmost limit of our national capacity. We have the ability and capacity to produce arms not only for our own forces, but also for the armies, navies, and air forces fighting on our side. Let no man say it cannot be done. It must be done - and we have undertaken to do it. I have just sent a letter of directive to the appropriate departments and agencies of our Government, ordering that immediate steps be taken: First, to increase our production rate of airplanes so rapidly that in this year, 1942, we shall produce 60,000 planes, 45,000 tanks; 20,000 anti-aircraft guns and 6,000,000 deadweight tons of merchant ships as compared with a 1941 completed production of 1,100,000.*
>
> President Franklin D. Roosevelt (1942) 9th State of the Union Address

By the end of WWII, the US had far exceeded these ambitious targets, for example, by producing a staggering 229,600 aircraft between 1942 and 1944 (Goodwin, 1994). Effectively the orders of the President and the imperative of the war galvanised a nation to take immediate action to refocus its industrial system towards a new goal - corset makers began producing grenade belts and webbing, and Merry-Go-Round makers produced gun mounts, and astonishingly, as Brown points out, '*from early 1942 through the end of 1944, nearly three years, there were essentially no cars produced in the United States*'.(Brown, 2008)

Although there is a great deal to learn from the period of industrial development, the challenge faced by climate change and environmental systems decline is that it is gradual and its early impacts are easily ignored, unlike the events of Sunday morning, December 7, 1941, which led to President Roosevelt (1942) stating that the rapid creation of, '*a multitude of implements of war will give the Japanese and the Nazis a little idea of just what they accomplished in the attack at Pearl Harbor'*. Hence as there has not yet been a unifying and immediately compelling threat to rapidly respond to by reducing environmental pressures, we need to seek ways to cultivate a sense of urgency on the matter before such a threat presents itself and at which point little may be able to be done to respond.

Other than periods of war time urgency lessons can be learned from the rapid peacetime industrialisation of many Asian economies, and in particular South Korea, Singapore, Taiwan, and Hong Kong. The rapid expansion of the so called 'Asian Tigers' demonstrates what can be achieved in terms of transforming economic production when a nation's government, private sector, and research and education institutions work together towards a clear vision to rapidly position themselves for new and emerging markets. In each case rapid industrialisation was underpinned by high personal savings rates, the encouragement of investment, and the prioritisation of skills and capacity building.

In his work *The Rise of the Korean Economy,* Byung Nak-Song (1997) lists, '*the most important components of the Korean model and necessary base for countries attempting to grow at high rates over a sustained period of time ... include a long-term national vision, communitarian capitalism, competent leaders, an ability to manage change and innovate, and cultural congruency*'. Clearly each of these characteristics in some form will be needed to also enable a rapid shift to sustainable development. However, unlike the progress of the Asian Tigers, which led in most cases to increasing levels of pressure on the environment, the creativity and ingenuity of a nation's governments, private sector, civil society, and research and education sectors needs to be focused on a clear vision to achieve economic growth while significantly reducing environmental pressures, in particular greenhouse gas emissions, if nations are to underpin their economies in the coming century.

Both the examples of war-time urgency and the Tiger Economies, also highlight the key role played by government in enabling rapid economy-wide transformations to occur, in both war and peace time. For instance the government's role in planning and co-ordination, investing in and directing R&D, providing incentives to drive new investment, influencing community behaviour, and supporting research and capacity building, was vitally important to enabling the rapid transitions of both the United States and the Asian Tigers. In more recent times the potential for governments to take a leadership role in driving economic development that both reduces environmental pressures and enhances economic growth was clearly shown to a greater of lesser extent in the response to the 2008 global economic crisis.

As can be seen in Figure 5.5, countries such as South Korea and China invested significant proportions of their total fiscal stimulus into what HSBC (2009) considered as 'Green Stimulus'. A stand out is that of South Korea, spending by far the highest at an estimated percentage of 81 percent of its stimulus package - some US$30 billion (or 2.3 percent of their annual GDP) - on green investment in order to create jobs.

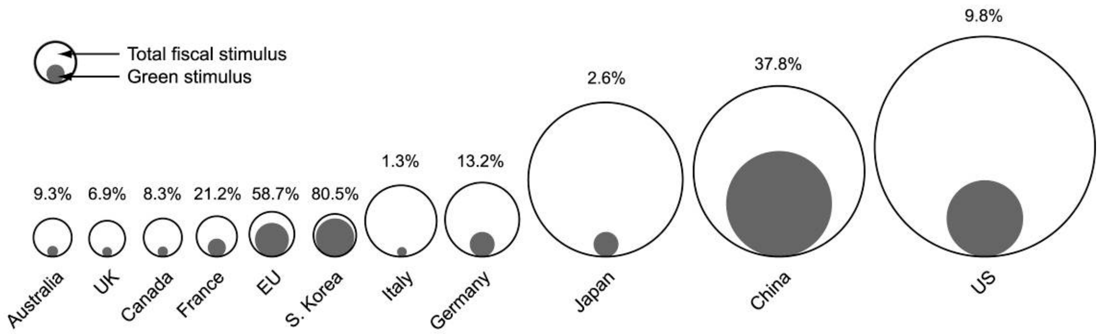


Figure 5.5: *Eco-friendly components of fiscal stimuli 2008/2009*

Source: Based on data from HSBC (Robins *et al*, 2009)

South Korea’s stimulus package is a valuable example of leadership, and includes payments for:

– *Housing*: US$6 billion for: the construction of 1 million green homes, energy efficiency upgrades for 1 million homes, energy conservation improvements in villages and schools, and the installation of LED lighting in public facilities.

– *Cars*: US$1.8 billion towards the development of fuel-efficient vehicles, such as electric and hybrid cars, by automakers Hyundai and Kia.

– *Trains and bikes*: US$7 billion for: the expansion of electrified tracks, the construction of new high-speed rail links, and the construction of more than 4000 km of bicycle paths.

– *Water*: US$11.1 billion for river restoration and water resource management.

– *Forestry*: US$1.7 billion for: forestry management, including tree planting to increase carbon sink capacity, and the construction of new facilities that use wood as biomass energy.

– *Recycling*: US$670 million for resource recycling, including the construction of electricity plants that run on the methane emissions generated from incinerating rubbish.

Hence, it is clear that government, working with business, universities and the community, can rapidly transform the focus of its entire economy, and that a key part of any agenda to significantly reduce greenhouse gas emissions will be the rapid innovation and development of low greenhouse gas emissions technologies and practices across all sectors of the economy. This will require the development of a range of complimentary measures through a portfolio approach, and will need full commitment from governments, the private sector, and civil society if it is to yield meaningful results. From reducing perverse subsidies that exacerbate environmental pressures, to providing incentives for low greenhouse gas emissions alternatives, there is much that governments can do to underpin business and industry to prepare for and capture the opportunity of the ‘next wave of innovation’, that of sustainable development.

For instance governments can:

- Provide rigorous information on the risks and opportunities related to various environmental pressures (*potentially through government scientific research organisations, such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, or through funding academic research*).

- Provide funding for related research and development to identify and commercialise innovative solutions to cost effectively reduce environmental pressures (*through national research bodies and grant-providing government departments*).

- Ensure that there is a level playing field for businesses (*as businesses will be willing to adapt and change to environmental policy as long as other businesses in their sector and market are also required to do so*).

- Provide business and industry with a clear regulatory environment to be able to plan and make investments with confidence (*such as the use of ecological taxes which provides certainty over the level of the taxation over long periods of time, in contrast to a carbon trading system which provides very little certainty of the cost and can lead to companies purchasing carbon futures on an open market)*.

- Identify resource intensive sectors that contribute to environmental pressures and undertake structural adjustment to transition to more efficient or newer operations *(which may for instance involve the investment of ecological taxation revenues)*.

- Review current government policy to identify policies that are blocking efforts to reduce environmental pressures (*such as subsidies for fossil fuel based energy generation*).

- Develop appropriate programs to target specific areas of action, for instance through encouraging and even requiring a level of improvement in resource productivity (*such as the Australian Energy Efficiency Opportunities program*).

- Provide a well-planned and transparent phasing in of policy changes or new ecological controls or taxes to allow adequate time for industry and business responses (*much like the long lead times on the European Union's electronic waste directives*).

- Assist particular industries to develop specific action plans for reducing their environmental pressures, particularly through industry sector groups (*such as the Australian Plastics and Chemicals Industry Association which produced a Sustainability Leadership Framework for Industry*).

- Control fraudulent claims of companies or products reducing environmental pressures, referred to as 'green-washing', and further add credibility to legitimate actions to do so (*such as through supporting labelling programs, setting requirements for performance, and dealing strong penalties for illegitimate claims*).

- Work with international efforts to achieve an international level playing field (*as differences in requirements to reduce environmental pressures in different countries can affect the more progressing countries' business position, whereas strict regulations such as in the EU can block countries that do not qualify with their strict environmental regulations*).

5.4 CHAPTER SUMMARY AND CONTRIBUTION TO THESIS

The chapter began by outlining the theoretical framework related to wave theory and provided context as to how it informs research into achieving significant economy-wide reductions in greenhouse gas emissions. The chapter linked 'wave theory' with 'sociotechnical systems theory' to provide insight into leverage points for supporting and accelerating the greater uptake of technologies, practices, and products that stand to deliver profitable greenhouse gas emissions reductions. The chapter presented the case that although there is promising current progress in 'green' technologies it is unlikely that a new wave of innovation in this area will be created autonomously and that action needs to be taken to induce such a wave – in particular the reconfiguration of a number relationships between society and technology.

The second part of the chapter focused on the potential to induce such a reconfiguration in an attempt to generate a new wave of innovation based on solutions that deliver reduced environmental pressures, and in particular reductions in greenhouse gas emissions. Based on the theoretical framework of the 'Multi-level

Perspective on Socio-Technical Transitions' the chapter presented the case that in order to respond to climate change the various socio-technical regimes need to be intentionally altered to create demand, and the associated structures, for low greenhouse gas emissions innovations.

The final part of the chapter presented the case for taking action to overcome lock-in mechanisms that are currently hindering efforts to accelerate the reduction of greenhouse gas emissions. The chapter then concluded that in order to overcome such lock-in mechanisms a structural change agenda is required rather than individual or *ad-hoc* efforts. The chapter then overviewed precedents for swift economy-wide structural changes, including the period of war-time urgency that led to the massive refocusing of US industry to support the war effort in response to the bombing of Pearl Harbour, and the rapid peacetime industrialisation of the 'Asian Tiger Economies'.

This section of the thesis creates the premise that in order to achieve significant reductions in greenhouse gas emissions globally a structural change approach is required, and that governments, the private sector, and civil society must collaborate. Hence in order to respond to the research question this premise calls for an investigation into the precedent for structural level change to achieve 'green' outcomes, as presented in Chapter 6.

Chapter 6: Designing an Economy-wide Transition to Low Greenhouse Gas Emissions

Reports by the Sustainable Built Environment National Research Centre (SBEnrc) include parts of this chapter written by me. I wish to thank Prof. Peter Newman, Professor Frank Geels, and Dr Cheryl Desha for stimulating through discussion the creation of some of the arguments contained in this chapter, identifying resources for consideration to develop such arguments, and for providing valuable peer review.

6.1 LESSONS FROM 'GREEN' ECONOMIC DEVELOPMENT STRATEGIES

Building on from the understanding that structural level changes are required to achieve significant reductions in greenhouse gas emissions the following part investigates the emerging area of strategy referred to as 'Green Growth'. This area of strategy although mainly focused on developing countries stands to inform efforts to induce shifts in socio-technical regimes to mainstream low greenhouse gas emissions technologies and processes. The following part outlines key lessons from green growth strategies that can inform such an agenda.

The 2013 report by the OECD (2013b) titled 'Putting Green Growth at the Heart of Development' asked the question: '*What type of growth can generate both wealth and well-being for all citizens of current and future generations, while at the same time respecting the environment?*' There is much investigation and debate internationally as to the answer to this question with the term '*Green Growth*' being created to encapsulate how global development can be achieved with strong environmental outcomes. At its heart green growth is focused on '*…encouraging economic activity to take place where it is of best advantage to society over the long-term.*' (2013b, Box 1.4) Advances towards this type of growth have been made with the OECD (2013b, p136) estimating that in 2011 the global trade in 'environmental goods' was in the order of US$880 billion in 2011.

The OECD (2011a) considers green growth to be an '*approach to economic growth [that] puts human well-being at the centre of development, while ensuring that* *natural assets continue to provide the resources and environmental services to support sustainable development*.' Much of the focus on green growth is targeted at developing countries as they are most vulnerable to environmental impacts and often rely heavily on natural resources, with little resilience to resource price shocks. The OECD (2013b) points out that '*the pursuit of green growth by developing countries is vital for their future and can lead to large economic and social benefits over time, including for the poorest of citizens*.' However much can be learned from this valuable growing field of understanding that can inform international approaches to low greenhouse gas emissions transitions. The OECD (2013b, Forward) cautions that '*Development that is not based on green growth may lead to prosperity, but only in the short term, and will soon be undermined by insecurity and vulnerability*'.

The green growth agenda relies heavily on the valuing of natural capital in economic decision making, especially important in developing countries where the wealth generated from natural capital can be as much as 25% of per capita wealth, compared to 2% in OECD countries (OECD, 2013, p23). The OECD (2013, p13) suggests that green growth '*integrates environmental considerations and the value of natural capital into economic decision making and development planning*'. However as this area of economics is in its early stages of development there can be diminishing returns on such a focus as identifying numerical values to be applied to ecosystem services is highly complex and in reality may be unachievable. This is not to say that the economics of natural resources and ecosystem services should not be considered, but rather to caution that it needs to be complimented by other considerations.

According to the OECD (2011a), "*Efficient resource use and management is a core goal of economic policy and many fiscal and regulatory interventions that are not normally associated with a 'green' agenda will be involved. And in every case, policy action requires looking across a very wide range of policies, not just traditionally 'green' policies.*" The OECD (2013, p18-19) suggests that green growth demands holistic strategies that include:

1. Equitable and efficient tax systems (including green taxes),
2. Phase out of environmentally harmful subsidies (including reconsideration of fossil fuel subsidies),

3. Free and open trade including environmental products and services (and note that eco-labelling may in fact create non-tariff trade barriers),

4. Policies that incentivize investment in green technologies and practices (including forest management and organic agriculture),

5. Industrial and other sector policies that promote innovation,

6. Risk assessment and management,

7. Labour market and skills policies that maximize the benefits for workers to help to ensure that adjustment costs are equitably shared, and

8. A host of flanking and complementary policies to explicitly address poverty reduction and social equity issues.

Each of these strategies will have economy-wide implications and given the imperative to respond to climate change in the coming decades such changes need to be fast tracked.

> "*The challenge is to waste no time in embarking on this transformative journey. An urgent goal will be to manage the difficult trade-offs between short-term demands and longer-term impact, and the need to make choices that will deliver a more stable and sustainable future while also securing immediate gains*."
>
> **Angel Gurría, OECD Secretary-General** (OECD, 2013)

Hence rather than piecemeal approaches a systemic economy-wide approach is needed with the OECD (2013, p25) pointing out that green growth '… *must support the structural transformation of the economy to achieve higher productivity and more value-added products'*. This calls for what could be referred to as 'green structural transformation' strategies, with a key part of such an agenda being strategies related to inducing and accelerating a transition towards greater uptake of low greenhouse gas emissions technologies and processes, as outlined above.

Achieving such a transition will require a number of aligned activities, such as a focus on knowledge and skills development (as presented in Chapter 9). According to the International Labor Organisation, '*Economies moving towards production* *based on sustainable use of natural assets can maximise job creation if they can anticipate structural changes and provide the support needed to shift workers to new occupancies'* (ILO, 2011). In Desha and Hargroves (2014) we refer to the opening decades of the 21st Century as '*an era of major transition*', and call for '*greater effort to be made to investigate, document, and support the design of curriculum renewal strategies aimed at sustainable development*'. This is based on the understanding that '*it is important in this process that industry is included to provide a quality assurance check on proposed priority graduate attributes'*.

Following a decade of research and collaboration with many of the world's leading environmental and sustainability educators in Desha and Hargroves (2014) we call for what we refer to as a 'dual-track approach' to knowledge and skills development that aligns to the stabilisation trajectories presented in Chapter 3. Such an approach involves a focus on both postgraduate education and professional development in areas to achieve the '*short term peaking of greenhouse gas emissions in the current decade'*, along with school and undergraduate education to support the required '*gradual tailing of emissions over the coming two to three decades'* to reach preferred stabilization levels. (Desha and Hargroves, 2014)

Given the compelling imperative to reduce greenhouse gas emissions the ideal response would be to make rapid shifts in policy and regulation to achieve a rapid reduction in fossil fuel use and a transition to low greenhouse gas emissions in order to reduce the likelihood of dangerous climate change. However despite this understanding such efforts are in the early stages internationally and are yet to grow to levels that will meaningfully impact global greenhouse gas emissions in the coming decade. Hence as the countries of the world consider their response to the challenge of climate change there is much investigation that needs to be carried out to inform such efforts in the future (when they are taken seriously), ensuring that associated benefits to businesses and organisations across all sectors are clear.

In light of this, and considering the recommendations to achieve green growth, the following questions are raised to inform a low greenhouse gas emissions transition:

- What structures affect the greenhouse gas emissions of an economy and are they aligned to lower greenhouse gas emissions?

- What trends stand to affect an economies ability to respond to climate changes and in particular those that will affect energy demand and utilisation?
- What low greenhouse gas emissions opportunities exist in particular sectors and sub-sectors of economies?
- What enabling factors exist that can support a low greenhouse gas emissions transition?

Based on a review of green growth strategies, findings of the IPCC, and the extensive research to support contributions to 5 international books[12] (comprising over a million words) in the area of achieving sustainable development it is clear that there are two key focus areas:

1) *Target fossil fuel intensive operations*: It will be critical that options for reducing greenhouse gas emissions in the most fossil fuel intensive areas of the economy are identified, with a well informed and robust economic case put forward. Such an investigation should pay particular attention to areas that provide the opportunity for actors across society to build momentum while acting to prepare to change the more complex and expensive areas of the economy. This may involve:

   - Identifying key areas of the economy that are contributing to greenhouse gas emissions and identify options to cost-effectively reduce emissions.
   - Investigating the economics of such options, such as through a marginal abatement cost curve investigation for particular economies.
   - Identifying multiple benefits through combinations of options, such as a focus on a shift to low greenhouse gas emissions cement that then delivers embodied energy savings to buildings.

2) *Enhance innovation that leads to reduced greenhouse gas emissions*: An equally important area will be to identify leading innovations that are delivering cost-effective or profitable reductions in greenhouse gas emissions and investigate

[12] Hargroves and Smith (2005), Stasinopoulos *et al* (2009), von Weizsäcker and Hargroves *et al* (2009), Smith, Hargroves and Desha (2010) and Desha and Hargroves (2014).

ways to enhance the uptake of such options (Halliday, Hart, and Ahuja, 1996; The Climate Group, 2005; von Weizsäcker, Hargroves, *et al* 2009). However, to achieve such a future this platform needs to be harnessed to address). This may involve:

- Identifying innovations in the economy that are leading to meaningful reductions in greenhouse gas emissions.
- Identifying common barriers to greater uptake across the economy and within particular sectors.
- Identify methods to reduce such barriers and foster innovation in a way that enhances sector and economy-wide capacity.

Hence there is now a greater level of clarity around actions that can be taken to significantly reduce greenhouse gas emissions across the world's economies. What is missing is a serious agenda to accelerate progress in this area that involves actors from across society that are dedicated to working in a manner that delivers economic growth while achieving preferred greenhouse gas stabilisation trajectories. It is not the purpose of this thesis to investigate ways of cultivating such an agenda. The purpose of the thesis is to prepare a response when such an agenda is set. There is a great deal of effort being undertaken to encourage and support governments around the world to set such an agenda. This research has been focused on providing guidance to those proposing such an agenda and to provide clarity on steps that can be taken once an agenda in this area is set.

6.2 INTRODUCING THE CONCEPT OF 'CARBON STRUCTURAL ADJUSTMENT'

Further to war-time urgency and the rise of the Tiger Economies, another example of economy wide changes in a short period of time is that of the result of conditional lending by the IMF and the World Bank, that creates 'Structural Adjustment Programs'. It is here that we find a strong precedent for informing economy-wide strategic interventions to transition society to low greenhouse gas emissions. Fundamentally the term '*Structural Adjustment*' can be interpreted as the process of making system wide changes to the very structure of an economy, typically through government policy, to improve its performance. Such changes are typically driven by an intention to improve the economic performance of the economy in a response to a need to reduce debt or position itself to repay development loans, often at the expense of environmental and social agenda's.

According to Alexander and Baden (2000)[13] structural adjustment is a '*process of market-oriented economic reform aimed at restoring a sustainable balance of payments, reducing inflation, and creating the conditions for sustainable growth in per capita income*'. Structural adjustment mechanisms are typically used by financial institutions when offering development loans in order to clear existing debt or to secure lower interest rates on such loans. In such cases the intention is to reduce the risk of the loan by requiring targeted and swift restructuring of the economy, typically involving:

- Changes to the level of taxation,
- Controls on inflation,
- Stabilising of investments,
- Devaluation of local currency,
- Privatisation of government assets and industries,
- Reduction of wages,
- Reducing government expenditure (typically on health, education, and social welfare) and subsides,
- Lifting trade restrictions and reducing local business protections, and
- De-regulation of industry (typically related to labour protection and environmental requirements) to reduce production costs.

According to the IMF (2006), structural adjustment is focused on '*changing the way in which an economy is organized in order to raise productive capacity*'. Hence according to such definitions the application of structural adjustment is effectively

[13] Nominated by the OECD as its definition of structural adjustment as per http://stats.oecd.org/glossary/detail.asp?ID=6817, accessed 03 August 2014.

undertaken to secure sustained productive capacity and income for a country. However this goal is often hindered over time by a number of social and environmental impacts that affect the economy, and hence it draws heavy criticism. Such impacts include an increase in the cost of living from a focus on wealth generation, an increase in unemployment from a focus on short term cost reduction by industry, a decrease in social welfare expenditure by government (including healthcare and education), a focus on the rapid liquidation of natural resources for profit, and the increased use of fertilizers and pesticides to boost agricultural exports that leads to significant environmental impacts.

According to Friends of the Earth, '*One major goal of structural adjustment programs is to generate foreign exchange through a positive trade balance. To meet the IMF's ambitious targets for currency reserves and trade balance, countries must quickly generate foreign exchange, often turning to their natural resource base. Countries often over-exploit their resources through unsustainable forestry, mining and agricultural practices that generate pollution and environmental destruction, and ultimately threaten future exchange earnings... Exports of natural resources have increased at astonishing rates in many countries under IMF adjustment programs, with no consideration of the environmental sustainability of this approach. Furthermore, the IMF's policies often promote price-sensitive raw resource exports, rather than finished products. Finished products would capture more added value, employ more people in different enterprises, help diversify the economy and disseminate more know-how*'. (Montanye and Welch, 1999)

Hence often structural adjustment measures include little to no consideration of the impact on the society or the environment, with such impacts considered to be either an avoidable cost or to be experienced on a much longer timeframe than the duration of the program. Hence in order for economies to achieve '*conditions for sustainable growth in per capita income*', advocated by the OECD, the scope of structural adjustment needs to be expanded to include mechanisms that lead to a significant reduction in environmental pressures, especially the reduction of greenhouse gas emissions. (Smith, Hargroves and Desha, 2010)

This chapter explores the notion that a structural adjustment type approach could be used to alter socio-technical regimes and induce low greenhouse gas emissions innovation and support their mainstreaming, as indicated in Figure 5.3. This amendment to Geels (2002) Multi-Level Perspective (shown in Figure 5.2) is intended to suggest that by focusing on intentional changes to socio-technical regimes, lock-in mechanisms can be opened to create avenues for preferred niche innovations. This means that the transition of the world's economies can be significantly accelerated through a focus on adjusting structural elements of economies.

The challenge lies in the fact that much of the application of structural adjustment mechanisms has been based on methods that have had success in the past, rather than in creating methods that will have success in a 'carbon constrained future'. This has led to a focus on resource profiteering and although this can provide wealth creation opportunities in the short term by increasing exports it undermines longer term economic development. Hence in the same way that fiscal structural adjustment was formulated as a solution to underdevelopment in third world economies in the 20th century, a new form of structural adjustment, *'carbon structural adjustment*', may need to be formulated as a solution to unsustainable development around the world in the 21st century.

> "Carbon Structural Adjustment = *A term to describe an agenda of swift adjustments to structures across economies to transition to low greenhouse gas emissions.*"

The influence of climate change on international development is becoming apparent with President Obama calling for '*an end of public financing for new coal plants overseas … unless they deploy carbon-capture technologies, or there's no other viable way for the poorest countries to generate electricity. And I urge other countries to join this effort*' (The White House, 2013). This was followed shortly after by the World Bank (2013) announcing that it would restrict investment in new coal fired power stations in developing countries to what it referred to as 'rare circumstances. According to the World Bank Group President Jim Young Kim, '*We need affordable energy to help end poverty and to build shared prosperity. We will also scale up efforts to improve energy efficiency and increase renewable energy—according to countries' needs and opportunities*'. (The World Bank, 2013)

Hence in order to '*raise productive capacity'* (IMF, 2006) of economies over the coming decades it is clear that efforts need to be focused at a structural adjustment level with the reduction of greenhouse gas emissions as a core operating principle. In their leading work on structural adjustment lessons for water management in Australia, CSIRO researchers Jim McColl and Mike Young (2005) state that, '*Structural adjustment refers to changes in the size and make-up of an economy in terms of the distribution of activity and resources among firms, industries and regions.'* It is within this definition that we find that structural adjustment may in-fact be the best suited framework for underpinning an economy-wide process to reduce greenhouse gas emissions.

Hence rather than focusing on increasing productive capacity to generate greater revenue through fiscal structural adjustment, an agenda of carbon structural adjustment would encourage economic development in a manner that reduced greenhouse gas emissions, this may involve a re-casting of mechanisms used in structural adjustment programs, such as:

- *Financial Mechanisms*: Rather than focusing taxation on employees and business income, a carbon structural adjustment approach would follow the recommendation presented in '*Natural Capitalism*' to shift the focus to resource taxation that places an additional price on the use of resources that resulted in undesired environmental and social impacts that will have a direct impact on economic growth. According to Hawken *et al* (2009), long time advocates of this approach, '*Shifting taxes towards resources creates powerful incentives to use fewer of them.'* Further, subsidies would be shifted from supporting fossil fuel based energy to supporting renewable and low greenhouse gas emissions alternatives.

- *Minimum Performance Standards*: Rather than the deregulation of industry sectors to allow greater wealth generation through reduced environmental charges and requirements, a carbon structural adjustment approach would include regulation and policy designed to drive industry to take innovative approaches to reducing greenhouse gas emissions, while capitalising on this innovation in the world market in the form of carbon trading or increased exports in technologies and expertise.

- *Research and Development*: Rather than resulting in cuts to government programs and spending on research and development activities, a carbon structural adjustment approach would encourage governments to investing in research and development of technologies and processes that were supported by industry to provide viable low greenhouse gas emissions outcomes.

- *Industry Development*: Rather than forcing business to look to options for short term profit, even when at the cost of medium to long term economic opportunities, a carbon structural adjustment approach would see governments providing assistance to industry and business to uptake low greenhouse gas emissions technologies and practices in collaboration with industry groups.

- *Curriculum Renewal*: Rather than reducing spending on education a carbon structural adjustment approach would support a comprehensive renewal of education programs to align then with the goal of achieving economic growth and a significant reduction in greenhouse gas emissions.

- *Skills Development*: Rather than a focus on exporting raw commodities, a carbon structural adjustment approach would focus on creating opportunities to enhance secondary and tertiary industries to harness such commodities and allow greater value adding and increased wealth generation through increased exports of low greenhouse gas emissions technologies and expertise.

- *Behaviour Change*: Rather than inflict the community with a higher cost of living, increased unemployment, and reducing social welfare, a carbon structural adjustment approach would focus on supporting communities to reduce fossil fuel demand in a way that delivers energy cost savings, reducing the economic burden from energy.

This new form of economic development would focus on bringing about a rapid reduction in greenhouse gas emissions in a manner that underpins and supports economic growth and increased societal well-being. A key focus of such an approach will be to encourage the greater development and uptake of low greenhouse gas emissions technologies and processes.

'Directed technological change should not be conceived as picking winners, but as making sure the market has enough winners to pick from to achieve cost-effective low-carbon outcomes. While directed-technological change is essential to meeting the challenge of deep decarbonization, there are many alternative technologies under development now and that may emerge in the future… Efforts aimed at building public support and acceptance for key technologies will also play an important role.'

Pathways to Deep Decarbonisation Project (SDSN and IDDRI, 2014)

In order for such an approach to be successful it will need to draw on lessons learned over the last two decades from efforts to progress the sustainable development and climate change response agenda's and merge this knowledge into an economy-wide structural change agenda. Considering the strategies advocated as part of green growth strategies, and the potential to re-orient structural adjustment program interventions, the following key structural areas are nominated for consideration as part of a 'carbon structural adjustment' agenda. This list does not represent all possible opportunities for carbon structural adjustment however it contains structural areas that are suggested as the key areas for initial focus. These structural areas have a direct impact on the greenhouse gas emissions of economies and changes to them can deliver significant reductions in emissions, while building understanding and institution learning outcomes.

1. *Standards and Codes,*
2. *Government Requirements (Local, State, Federal, and Statutory Agencies),*
3. *Taxation and Subsides,*
4. *Investment and Procurement Policies (government and private),*
5. *Professional Accreditation Requirements, and*
6. *Education Program Accreditation Requirements (Higher and Vocational).*

Reconsidering the approach shown in Figure 5.3, where strategic interventions are delivered to alter social-technical regimes to induce innovation and diffusion of low greenhouse gas emissions technologies and processes, these structural areas provide a basis for such interventions, as shown in Figure 6.1.

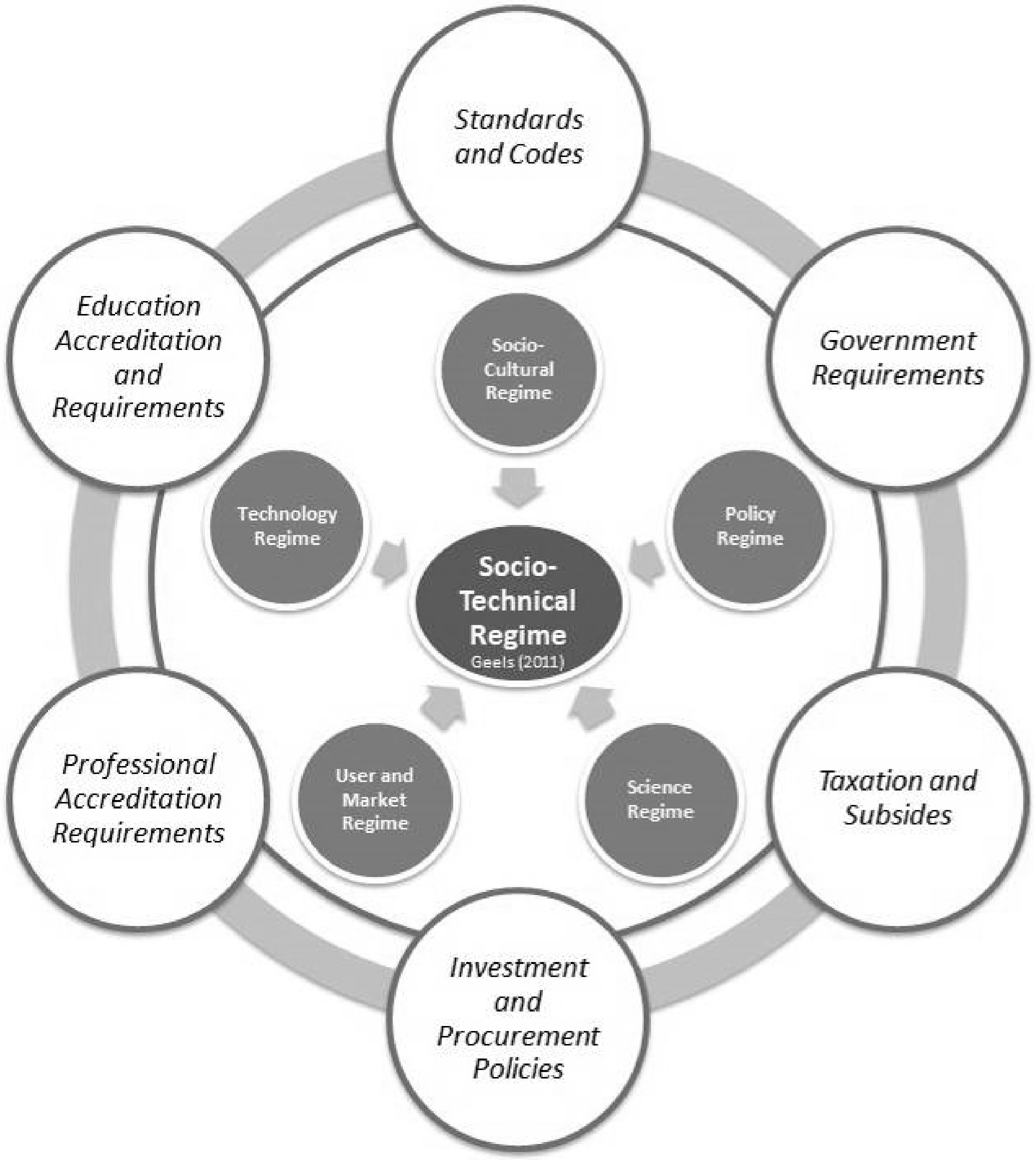


Figure 6.1: Proposed areas of structural intervention to open lock-in mechanisms in socio-technical regimes to induce innovation and diffusion of low greenhouse gas emissions technologies and processes

Source: Based on Geels (2011)

6.3 CREATING A CARBON STRUCTURAL ADJUSTMENT ROADMAP

There is much work being done to encourage a transition to sustainable development and it is assumed that this, combined with the mounting evidence of the impacts of not taking such action as outlined previously, will result in a serious call in the coming decade/s for economy-wide structural approaches. When such a call is made it will be important to undertake a strategic process to identify specific areas of the economy to adjust, establish the value in doing so, identify barriers and enablers, select tools and interventions, and develop a strategy specific for each economy and its sectors.

This part outlines a 'Carbon Structural Adjustment Roadmap' (CSA Roadmap)[14] that can be used to achieve these outcomes. As mentioned previously the purpose of this thesis, and in particular this roadmap, is not to persuade the implementation of items contained but rather to inform such activities at such a time when a focus on significantly reducing the greenhouse gas emissions is called for in on a meaningful scale. In order to inform the development of carbon structural adjustment strategies the following steps along the roadmap are recommended, with an overview related to each structural area provided in the following section:

1) *Identify Key Aspects of Areas to Adjust,*

2) *Identify Potential for Value Creation,*

3) *Identify Steps, Enablers, and Actors,*

4) *Identify Roadblocks, Challenges, and Delays,*

5) *Identify and Map Tools, and*

6) *Develop Strategic Approaches.*

The CSA Roadmap is created when each of the steps (or 'stops' on the roadmap) are undertaken for each of the 'structure areas' identified above, as represented in Figure 6.2.

[14] The CSA roadmap was developed by myself as part of an industry research project with the Sustainable Built Environment National Research Centre (SBEnrc) in Australia as a Senior Research Fellow with the Curtin University Sustainability Policy Institute, under the supervision of Professor Peter Newman and advised by Stephen McGrail, Swinburne University.

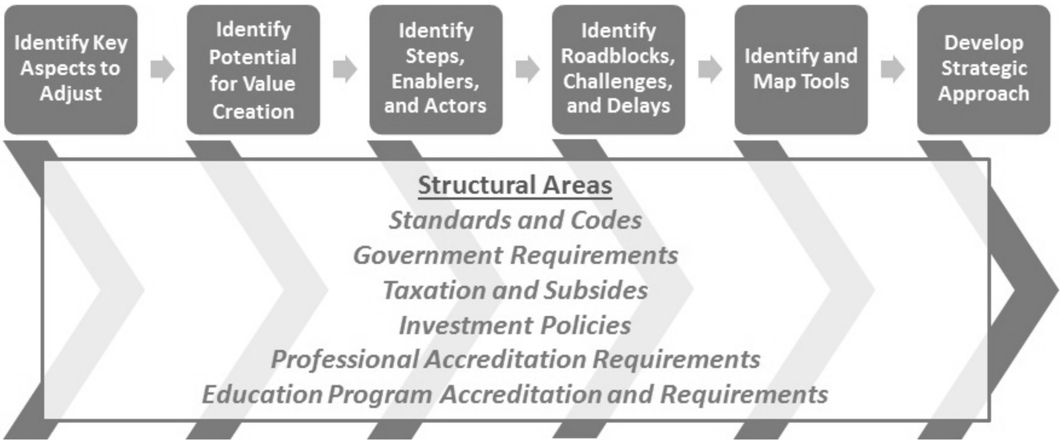


Figure 6.2: Schematic of Key Elements of a Carbon Structural Adjustment Roadmap

An important consideration in the undertaking of each of these steps is the understanding that they involve a range of actors from across society and that in order to maximise the potential for carbon structural adjustment to be successful a 'whole of society' approach is recommended, as presented in Figure 6.3. It is important to consider that the process of carbon structural adjustment must be led by government however organisations, businesses, institutions, and various groups across society must be actively involved and empowered to contribute to the overall process.

Figure 6.3: Whole of Society Approach to Sustainable Development

Source: Hargroves and Smith (2005)

The following provides an explanation of each of the 6-stops on the carbon structural adjustment roadmap that are intended to create a robust approach to the rapid reduction of greenhouse gas emissions. In order to illustrate each step, the example of 'Taxation and Subsides' is used, and in particular the Australian Fuel Tax Credit.

Stop 1: Identify Key Aspects of Structural Areas to Adjust

The first stop on the CSA Roadmap is to identify specific aspects of the structural area being considered, such as '*Standards and* C*odes'* that are deemed to 'need' adjustment in order to ensure greenhouse gas emissions reductions across the sector. It is recommended that this be undertaken with strong stakeholder engagement to identify key aspects of each structural area that needs to be considered for adjustment.

> *Taxation and Subsidies (Fuel Tax Credit): In Australia an estimated 10.8 billion dollars a year is provided in fossil fuel subsidies (Commonwealth of Australia, 2014), including coal and petroleum, with subsidies of over $110 billion estimated to be provided to the fossil fuel industry between 2005 and 2016 in Australia (OECD, 2013c). This is compared to a cost to tax payers of $21.6 billion estimated by the Minerals Council of Australia from the renewable energy target (Hepworth, 2014), roughly a fifth of the cost to tax payers of the fossil fuel industry subsidies. A large component of the fossil fuel related subsidies is the Fuel Tax Credit offered to the mining sector that subsidises the cost of diesel for mining companies and reduces the tax paid from 30 cents a litre to 6 cents a litres, reducing taxation revenues by an estimated $2.35 billion dollars each year (ATO, 2010).*

This stop would deliver the following outcomes:

1) The identification of specific aspects of the structural area being considered that stand to contribute to increasing the greenhouse gas emissions of the economy.

2) The provision of a clear and concise summary of the aspects, demonstrating the direct link to greenhouse gas emissions in particular sectors, and highlighting precedent and evidence for cost-effective emissions reductions.

3) The identification of any current or previous efforts to bring about change in this aspect of the structural area, both that have gained traction and that have not. This may include the identification of existing recommendations related to the adjustment of the areas or similar areas internationally.

Stop 2: Identify Potential for Value Creation

Once the specific aspects of the structural areas that require adjustment have been identified, the next stop on the CSA Roadmap involves identifying the potential value that can be created by the adjustment of these aspects. This is important as it identifies potential supporters for the adjustment and demonstrates the value to the economy, sector, and community for taking action to adjust the structural areas to reduce greenhouse gas emissions.

Value can be created in a number of direct and in-direct areas with the initial focus on both the economic value and the reductions in greenhouse gas emissions. Other areas of value may include job creation, increased trade in services and high value manufactured goods, generation of voter good will, along with direct savings to business through reduced energy use.

> *Taxation and Subsidies (Fuel tax Credit): According to the World Bank (2012), 'expenditures reduced by removing inefficient and environmentally-harmful subsidies … can be used to finance the adoption of less polluting and more efficient household energy sources as well as other critical priorities, such as health, education, or infrastructure development.' It is particularly important to encourage the use of saved subsides or received taxation to support the shift to lower greenhouse gas emissions from the sector. Should the fuel tax credit be waived the increase taxation revenue, in the order of $2.35 billion per year, could be invested to support greater energy efficiency and renewable energy generation across the sector, both of which will provide economic and greenhouse gas benefits to the Australian economy. Options may include providing subsidies to encourage the investment in energy efficient technology and products along with their use by consumers.*

This stop would deliver the following outcomes:

1) The identification and quantification, where appropriate, of the potential value that would be created through the adjustment of the aspects of the structural area being considered, both direct and in-direct.

2) The identification of evidence to support this value creation and precedent of such value being captured. This would include identification of value created for particular parties and stakeholders.

Stop 3: Identify Steps, Enablers, and Actors

Once the specific aspects of the structural areas that require adjustment have been identified, and the value of such adjustments demonstrated, the next stop on the CSA Roadmap involves identifying the main steps that are required to adjust the aspects. Consideration of the steps includes an investigation in to the existence of current enablers to such adjustment that will support the process. Further, as mentioned above it is important to take a whole of society approach to the process and at this stage the various actors that should be involved in each of the remaining steps should be identified. It may be the case that investigations have been undertaken to identify steps to adjust the selected aspects either locally, nationally, or internationally that can inform the identification of specific steps.

> *Taxation and Subsidies (Fuel Tax Credit): In order to achieve reform of the 'Fuel Tax Credit' the Australian Government would need to support such change and achieving this would involve a number of steps, such as demonstrating voter support. A survey of just over 1,000 Australians by ACF (2012) found that 77% of respondents believed that 'the fuel tax credits scheme should be scrapped for mining companies'.*

This stop would deliver the following outcomes:

1) The identification of specific steps to be undertaken to achieve the adjustment of the particular aspect of the structural area being considered (*Note: At this stage the steps are identified rather than the actions needed to achieve the steps, which is the focus of Stop 5.*)

2) The identification of existing enablers to support the adjustment of the aspect of the structural area, and

3) The nomination of actors and parties that should be involved in each step, such as business, industry groups, economic think-tanks, university researchers, government agencies etc. This may involve consideration of methods to engage and mobilise particular actors that may not be already engaged in the low greenhouse gas emissions agenda.

Stop 4: Identify Roadblocks, Challenges, and Delays

Once the steps required to adjust the aspects of the structural area being considered have been identified, the next step in the CSA Roadmap involves the identification of major roadblocks, challenges, and areas of potential delay that will be faced should the steps be implemented. Once identified investigation can be carried out on how to avoid, amend, or remove such barriers.

> *Taxation and Subsidies (Fuel tax Credit): It is anticipated that a major challenge in removing the 'Fuel Tax Credit' will be the response from the Mining Sector to having subsidies on the cost of fuel removed, and the influence on Government.*

This stop would deliver the following outcomes:

1) The identification of potential roadblocks, challenges and/or delays to the specific steps to adjust the structural area under consideration, which may include technological, institutional, or market barriers.

2) The identification of possible ways to avoid, amend, or remove the potential roadblocks, challenges or delays, with specific mention of parties involved.

3) The consideration of the strength of such barriers to carbon structural adjustment and the identification of leverage points to focus tools to reduce such barriers.

Stop 5: Identify and Map Tools

Once the potential for value creation has been established, and the existence of major roadblocks, challenges, and/or delays identified, the next step in the CSA Roadmap involves identifying and mapping tools that can either manage roadblocks, challenges, and delays, or enhance the value created by the adjustment.

> *Taxation and Subsidies (Fuel tax Credit): A tool for reducing roadblocks to adjustment of the 'Fuel Tax Credit' may be community consultation to gauge the views of voters, a campaign to ensure the community is aware of the subsidy and its impact on taxpayers, and the garnering of support for political candidates/parties that carry such reform as part of their agendas.*

Tools identified will be specific to the steps to be undertaken and will include a range of activities such as those identified by a review by Swinburne University of built environment roadmaps in Australia commissioned by the CRC for Low Carbon Living, including (McGrail (2014) A review of roadmaps for transitioning to a zero carbon built environment in Australia – A Report for the CRC for Low Carbon Living, Sustainable Cities Flagship, Swinburne Institute for Social Research, Swinburne University (McGrail, 2014):

- *"Policy Intervention: The iGrid roadmap and ClimateWorks plans both emphasise the need for actions to address institutional barriers to energy efficiency and decentralised energy.*

- *Capacity Building: COAG reports have a strong emphasis on building local supply chains, markets, and technical capacity.*

- *Coalition-Building: The ASBEC Zero Emissions Home Industry Roadmap has a strong focus on coalition building and collaboration … envisaged to be actioned through a new 'Net Zero Energy Alliance' which would include both private and public sectors actors.*

- *Technology Forcing: Innovation studies scholars define 'technology forcing' as the intentional use of standards, regulation and other government policies to better link technology and science to societal goals. Variants of this are included in the COAG roadmaps … [and] have also been more widely advocated by The Australian Academy of Technological Sciences and Engineering (McGrail, 2012).*

- *Demand-driven Commercialisation: While the Enabling Technology Futures survey notes the role of government (e.g. in creating a regulatory environment that ensures responsible use and development of such technologies), it most strongly emphasises 'the need for demand driven commercialisation strategies that focus on developing new products and services to address existing problems and challenges' (AIC, 2012)."*

This stop would deliver the following outcomes:

1) The identification of potential tools that may be used to implement the steps. It is anticipated that these tools will be suitable for implementation with involvement across the various actors involved in the process.

2) The mapping of such tools to specific roadblocks, challenges, and/or delays, as well as specific opportunities to enhance value creation.

3) The investigation of perceptions related to the identified tools held by stakeholders in the process as to their suitability and requirements for implementation.

Stop 6: Develop Strategic Approaches

Now that the process of following the CSA Roadmap has created a list of specific aspects of the structural area being considered that are recommended for investigation, an estimation of the potential value that can be created, identification of steps involved and the associated barriers, and a list of possible tools to both reduce the barriers and increase the value creation, the final stop in the CSA Roadmap is to develop strategic approaches. Such approaches will draw on enablers and engage with key actors and stakeholders to create whole of society based work plans to undertake each step and implement the associated tools. This may include consideration of options for cross-sectorial and international collaborations.

As it is not feasible for all aspects of each structural area to be adjusted at the start of the carbon structural adjustment process, this calls for a prioritisation process. In order to inform the identification of priority aspects to focus on it is recommended that two factors be considered, a) the likely 'Carbon Impact Factor', and b) the likely 'Willingness to Adjust'. The carbon impact factor would take into account the impact on the greenhouse gas emissions should the aspect identified at Stop 1 be adjusted as per the steps at Stop 3. The willingness to adjust would take into account the roadblocks, challenges, and delays identified at Stop 4 along with a range of other considerations including gauging political will, potential business and industry support, and community views.

Once these criteria have been estimated they can be plotted as shown in Figure 6.4 and three strategic approaches can be identified.

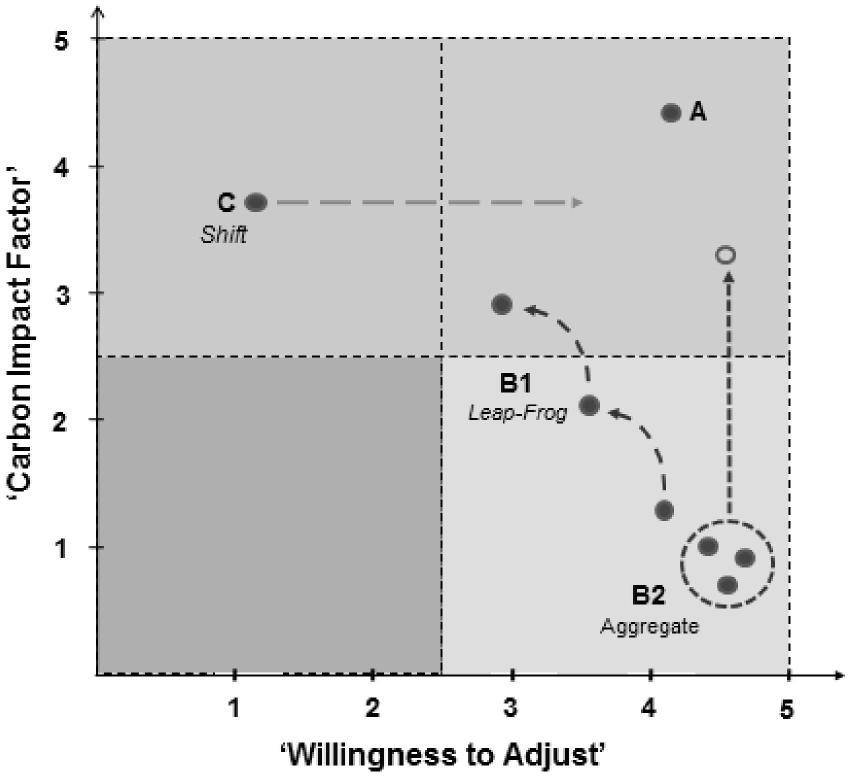


Figure 6.4: A method for the prioritisation of efforts based on the likely impact on greenhouse gas emissions and the likely willingness to adjust in the area of focus.

Source: Adapted by K. Hargroves from an adaptation by K. Hargroves and C. Desha of the CBSM Methodology (McKenzie-Mohr and Smith, 1999)

Based on Figure 6.4 the following three routes can be undertaken:

- *Route A:* A focus on progressing actions with high 'Carbon Impact Factor' and high 'Willingness to Adjust'.

- *Route B:* A focus on progressing parts with high 'Willingness to Adjust' and low 'Carbon Impact Factor' by either:

1. *'Leapfrogging', by starting with an aspect with a high willingness to adjust and low carbon impact factor to build momentum to then move on to aspects with slightly less willingness and slightly higher carbon impact, and so on… and/or*

2. *'Aggregating', by grouping aspects high willingness to adjust and lower carbon impact factor into a single multi-pronged program that delivers a combined high carbon impact factor.*

- *Route C:* A focus on increasing the low 'Willingness to Adjust' of aspects, including targeting specific barriers, starting with those with high 'Carbon Impact Factor'.

  Taxation and Subsidies (Fuel tax Credit): The carbon impact factor of the Fuel Tax Credit may be estimated based on the resulting increase in efficiency of transportation in the mining sector along with anticipated benefits from investing further in energy efficiency and renewable energy. The willingness to adjust may be informed by the political positions of the major parties and the policy statements of the current government.

The tools identified at Stop 5 can be used to progress activities along Route A and B with the willingness to adjust of each of the structural areas along Route C able to be influenced by various activities, namely:

1. *Standards and Codes:* The willingness to adjust standards and codes can be influenced by the development of voluntary programs that build industry support and create experience to road-test potential changes (Price and Yun, 2003). This may be influenced by demonstration projects for new technologies or practices.

2. *Government Requirements:* The willingness to adjust government regulations can be influenced by community behaviour change programs (such as the one outlined in Chapter 8) that can build voter support for action towards reducing greenhouse gas emissions.

3. *Taxation and Subsides:* The willingness to adjust taxation and subsides can be influenced by providing transparency on the payment of subsides and the impacts on the economy. Furthermore, understanding of the various options for adjusting

such structures can provide clarity on the feasibility of using them to encouraging activities that reduce greenhouse gas emissions.

4. *Investment and Procurement Policies:* The willingness to adjust investment and procurement policies can be influenced by industry associations (as outlined in Chapter 7) through the development of a voluntary industry led sustainability rating tools for infrastructure sustainability that can lead to the inclusion in request for tenders of the nomination of a minimum rating to be achieved by the project.

5. *Professional Accreditation Requirements:* The willingness to adjust professional accreditation requirements can be influenced by providing the industry or sector with evidence of the value of ratcheting requirements in-line with advances in technology or processes. Furthermore an indication of the interest in such professional attributes by major employers in the sector can influence the emphasis placed on particular areas.

6. *Education Program Accreditation and Requirements:* The willingness to adjust education programs can be influenced by programs to recognise and reward leadership in the coverage of low greenhouse gas emissions related topics in programs, such as the Australian Campuses Towards Sustainability, Green Gown Awards.

This stop would deliver the following outcomes:

1) The investigation of both the likely '*Carbon Impact Factor*' and likely '*Willingness to Adjust*' of aspects of the structural areas recommended for adjustment.

2) The development of strategies based on the strategic approaches outlined above to provide the basis of implementing the steps to adjustment in selected aspects of the structural area being considered. This would include the assignment of tasks to particular actors and parties and may involve inter-sectoral collaboration.

Each of the possible areas for carbon structural adjustment presented in Figure 6.2 warrant greater investigation in-line with the CSA Roadmap as presented above. Each area has a range of direct interventions that can bring about carbon structural adjustment that will be identified as part of the process to undertake the CSA Roadmap. However as leadership and commitment from government for such an approach has yet to be demonstrated it is important to create complimentary activities that increase the willingness to adjust across the economy.

It is the finding of the research that creating motivation for carbon structural adjustment by seeking to increase the willingness to adjust structural areas across economies will require a multi-pronged approach as outlined in the following section that both:

- Increases the general willingness in for structural changes to deliver reduced greenhouse gas emissions reductions, with the area of ‘community behaviour change programs’ selected for investigation, and
- Increases the willingness to change specific structural areas, with the following areas selected for investigation:
  - Informing curriculum renewal efforts to encourage greater inclusion of associated knowledge and skills in ‘Education Program Accreditation and Requirements’, and
  - The development of industry led performance tools to encourage greater inclusion of greenhouse gas emissions reduction activities in ‘Procurement and Investment Policies’.

It is anticipated that such activities will not only increase the willingness in society for carbon structural adjustment to take place but also to increase the capacity of various actors to do so.

6.4 CHAPTER SUMMARY AND CONTRIBUTION TO THESIS

The chapter began by investigating the emerging area of strategies to achieve ‘Green Growth’ for precedent and lessons to support the design of structural level changes in economies to achieve significant reductions in greenhouse gas emissions. The chapter provided an overview of the genesis of ‘Green Growth’ strategies (targeted at developing countires) and provided context as to its relevance to the research question of the thesis. The chapter outlined a number of strategic approaches advocated as part of a green growth agenda that are likely to be effective in reducing greenhouse gas emissions – each with economy-wide application and implications. The chapter then raised a number of questions from the literature on green growth that are relevant to reducing greenhouse gas emissions. The chapter then focused on the two areas of targeting fossil fuel intensive operations, and enhancing innovation to reduce greenhouse gas emissions, and identifies key elements of such agenda's.

The second part of the chapter then investigated the area of fiscal structural adjustment as an example of structural level change in economies before introducing the concept of 'Carbon Structural Adjustment'. The term 'Carbon Structural Adjustment' is defined as '*A term to describe an agenda of swift adjustments to structures across economies to transition to low greenhouse gas emissions*.' The part outlined the key mechanisms of a structural adjustment agenda and tailored them to meeting the goal of achieving significant reductions in greenhouse gas emissions while strengthening economies. The part then focused on identifying key areas for carbon structural adjustment in economies, namely: standards and codes, government requirements, taxation and subsides, investment and procurement policies, professional accreditation, and education program accreditation. The part outlined how a focus on structural changes in these six areas can be used to achieve shifts in socio-technical regimes to deliver low greenhouse gas emissions outcomes.

The chapter finished by presenting a roadmap for designing carbon structural adjustment interventions and outlined six key steps, namely: 1) identify key aspects of areas to adjust, 2) identify potential for value creation, 3) identify steps, enablers, and actors, 4) identify roadblocks, challenges, and delays, 5) identify and map tools, and 6) develop strategic approaches. Each of these steps were then applied to the area of taxation and subsides to provide clarity as to their application. The chapter then concluded by introducing the concept of 'Willingness to Adjust' to consider ways to increase the motivation for structural changes to be made to deliver greenhouse gas emissions reductions. The chapter then called for an investigation into three key areas that stand to increase the willingness to adjust, namely: voluntary community behaviour change programs, curriculum renewal of higher education programs, and industry led performance assessment and reporting systems.

The original contribution of this chapter is the realisation that in order to achieve a rapid reduction in greenhouse gas emissions across the economies of the world strategic approaches need to be undertaken with war-time urgency, modelled on the scope and pace of structural adjustment programs, and based on the actions *advocated in green growth strategies – leading to the creation of the term 'Carbon Structural Adjustment'. The chapter then presented a new strategic approach to inform efforts to design interventions to undertake structural changes across the economy to achieve significant reductions in greenhouse gas emissions. Further the chapter creates the new term 'Willingness to Adjust' and calls for an investigation into key leverage points for inducing shifts in socio-technical regimes.*

MOTIVATING ECONOMY-WIDE STRUCTURAL CHANGES TO ACHIEVE A TRANSITION TO LOW GREENHOUSE GAS EMISSIONS

Chapter 7: Voluntary Community Behaviour Change Programs

The content in the following chapter is based on the findings of a research project I co-led with Dr Cheryl Desha based at Griffith University that was funded by the Australian Government Solar Cities Program and the Townsville City Council (Ethics Approval Reference: ENV/31/09/HREC). I would like to thank Dr Cheryl Desha, Angie Reeve, and David Sparks for stimulating through discussion the creation of some of the arguments contained in this chapter, identifying resources for consideration to develop such arguments, and for providing valuable peer review. I also wish to thank the members of the Townsville City Council Integrated Sustainability Services Division for their advice in the development of the research, especially Greg Bruce, Mark Robinson, Dylan Furnell, and Andrew Hannay. I also thank Dr Doug McKenzie-Mohr for his peer review and mentoring of the research and Dr James McBroome, Griffith School of Environment, Griffith University, for his peer review of the community survey.

7.1 ENCOURAGING BEHAVIOURS RELATED TO THE REDUCTION OF GREENHOUSE GAS EMISSIONS

Following the development of a strategic approach to design interventions to adjust key structures of an economy to achieve a transition to low greenhouse gas emissions in the previous chapters, this chapter investigates a method to increase the general willingness to adjust such structures – namely through voluntary community behaviour change programs.

This chapter outlines an investigation into the effective design of voluntary behaviour change programs to increase willingness of the community to undertake preferred behaviours related to reducing greenhouse gas emissions, and posits that this may increase the willingness to support carbon structural adjustment related activities. The investigation is undertaken using the theoretical framework of 'Community Based Social Marketing' (CBSM) developed by Dr Doug McKenzie-Mohr to inform the development of voluntary behaviour changes programs, as outlined in Chapter 1. The methodology is well known in Australia with McKenzie-Mohr a regular collaborator with Australian local government, community organisations and businesses. McKenzie-Mohr reflected in 2010 that '*We're seeing programs being delivered in Australia now at the level of hundreds of thousands of households — TravelSmart has been delivered to over a million households. It's still not a societal-wide scale, but they're scaling at a much larger level than what we see in North America'*. (Roberts, 2010)

This chapter presents findings into the application of CBSM to encourage residents to undertake preferred behaviours related to reducing energy consumption, and the associated greenhouse gas emissions, in the City of Townsville, Australia.[15] It is anticipated that this research will identify key understandings of how to increase the likelihood of encouraging the community to undertake preferred behaviours related to reducing greenhouse gas emissions. It is anticipated that this stands to lead to an increase in the willingness to support carbon structural adjustment, and calls for further research in this area. For instance behaviour change programs based on community input that are designed to encourage residents to voluntarily switch electric storage hot water systems to low greenhouse gas emissions alternatives may build support for government requirements being adjusted to phase out or ban the use of such equipment.

Encouraging residents to focus on reducing energy demand in the home can deliver three main benefits: firstly the reduction of direct energy costs for the resident and hence energy bills; secondly a reduction in the consumption of fossil based electricity and an associated reduction in the generation of greenhouse gas emissions; and thirdly a greater willingness for the community to support efforts to adjust structural elements of the economy associated with the reduction of greenhouse gas emissions. Furthermore, such reductions can also provide a range of indirect community wide economic benefits, such as reducing costs to energy utilities to provide energy during peak times, reducing costs related to maintenance of the electricity grid, creating new industries for low energy consuming products, and reducing future anticipated liability against costs related to greenhouse gas emissions pollution abatement.

The chapter presents findings of and draws conclusion from research to apply CBSM as part of the Townsville City Council CitySolar Program - Townsville Residential Energy Demand Project (2007-2012).[16] In particular the research identifies key perceptions held by the community around specific behaviours related to reducing residential energy demand (fossil fuel based), along with preferences for the types of

[15] Townsville is a growing city in northern Queensland and according to the ABS, in 2006 Townsville had 53,225 occupied homes with 78% of these comes homes being separate houses, and 57% of them being fully owned or under purchase.
[16] See http://www.townsvillesolarcity.com.au/Overview(2007-2012)/Citysolar-CommunityCapacityBuildingProgram/BehaviourChangeProgram

interventions and programs that the Townsville City Council may offer. The key finding of the research is that efforts need to be based on the local perceptions of the barriers and benefits to reducing greenhouse gas emissions (whether they are real or perceived) rather than taking a simplified approach without community input.

According to the OECD (2011b), '*Addressing barriers to behavioural change will facilitate the emergence of new patterns of demand and increase the cost-effectiveness of policy signals aimed at producers. Special attention needs to be given to these barriers because habits and norms can lock households into patterns of consumption which are hard to alter*'. Changing behaviour in the community towards a preferred behaviour or set of behaviours is a complex and challenging goal that, broadly speaking, can be achieved in two main ways:

1) *Compliance with Regulations and Policy:* In this case the preferred change is required and enforced, with little effort on encouraging the behaviour change, such as through a process to adjust various government or industry structures as outline previously. This typically involves efforts to reduce the political risk of such changes and to assist affected industries, businesses, and members of the community. An example of this is the change to performance requirements that led to a phasing out of incandescent light bulbs in Australia (DEWR, 2007), Brazil, and the EU (The Associated Press, 2007). Another example is the UK government in 2008 setting requirements for homes built in the (UK Government, 2008), and

2) *Encouraging Voluntary Change:* In this case residents were encouraged to undertake behaviours that meet the preferred outcome of the program, which may or may not deliver direct personal benefit to the resident. An example of a program that may deliver personal benefit is on focused on encouraging a shift from electric storage hot water systems to lower mains energy consuming options (such as heat pumps, solar hot water, and instantaneous gas systems) that deliver bill reductions to residents, and reduce load on the grid, especially during peak periods, and results in reduced greenhouse gas emissions. An example of a program that may not deliver personal benefit is encouraging residents to reduce outdoor water consumption even though they may be on a bulk water plan and such reductions would not reduce water bills, but reduce the water utility costs.

In the absence of regulations and policy there are a number of ways that voluntary change can be encouraged such as (TCC, 2011a):

- Offering discounts and rewards to residents to reduce electricity consumption (*such as the Alice Springs Solar City program offering a mail out voucher system to provides 35-50% discount on the cost of undertaking particularly energy saving measures.)* (Alice Solar City, 2009)

- Offering Low interest loans to residents to purchase energy efficiency appliances (*such as Campbelltown (SA) providing residents with interest free loans for the purchase of solar hot water systems.)* (Campbelltown City Council, 2007)

- Offering direct payments to subsidies the purchase of energy efficient appliances and technologies (*Such as the 2009 Australian Government non-means tested package that included a rebate of up to $1,600 for ceiling insulation or solar hot water systems retrofits*.) (DEWHA, 2009)

- The development of demonstration sites to increase public awareness of various energy saving options (*such as the Magnetic Island Smart Lifestyle Centre, an information dissemination point for households on Magnetic Island, as part of the Townsville Solar City Project*.) (Isaac, 2009; Shmeco, 2009)

- The use of community pledges and commitments (*such as in Darbin, Victoria, where an online pledge website for residents to commit to reducing car usage attracted over 1300 participants since 2006 and saved an estimated $35,376.00 on fuel costs.*) (City of Darebin, 2009)

- The provision of technical assistance visits and audits (*such as in Penrith (NSW) where an Energy Home Rating Tool was piloted over a three-month period with estimated savings over a 10 year period of $350,000 in energy costs*.) (Penrith City Council, 2004)

- The requirement for mandatory disclosure of the energy performance of appliances and other products (*with 1993 study showing that 45 percent of buyers used information on the energy label to compare models of appliances*.) (National Climate Change Committee, 2002)

As part of the TCC project the community engagement included investigating the perceived value of various potential tools to be used in future community programs, with the results presented below.

However rather than rolling out blanket programs such as these across various communities the CBSM methodology asserts that behaviour change is most effectively achieved through initiatives delivered at the level of specific behaviours, informed by direct community engagement. The methodology provides a process to design programs that remove specific barriers (perceived and actual) to an activity while simultaneously enhancing the activity's benefits. The methodology is particularly applicable to cases where the behaviour being undertaken cannot be directly observed and investigated, such as those undertaken inside the home. For behaviours that can be directly observed, methodologies including 'Thematic Interpretation' can be used (Ham, 1992).

McKenzie-Mohr cautions behaviour change program developers to consider that:

1. *Despite the allure of generic information based campaigns, they often lead to little behaviour change in the community*. McKenzie-Mohr acknowledges that information based approaches are popular as program developers can quickly make assumptions about the audience and produce flyers, posters, or television advertisements that can receive large exposure in short periods of time. However as the specific perceptions of the community being targeted are often not considered, enabling such material to be targeted, such an approach is largely ineffective. McKenzie-Mohr cites a study conducted in the Netherlands that found that simply '*providing households with information about energy conservation did not reduce energy use*' (Midden *et al* 1983).

2. *Despite the availability of a direct benefit from a voluntary change this will not guarantee high take up in the community*. McKenzie-Mohr cites the example of US gas and electric utilities being mandated by federal law to offer energy audits to customers, and to provide a list of recommended contractors. The utilities offered to pay in full for the audit and offered interest-free loans to undertake any of the audit recommendations. In practice 6% of the households did the audit and if there was any waiting time involved, then 30% dropped off the list, and only

half of the remaining households (i.e. 2-3% of the original household population) acted on the audit results (McKenzie-Mohr, 2007, p12).

Hence social marketing programs need to provide more than generic information and facts and figures on returns on investment in order for residents to change behaviour. This understanding was reflected on by Keynes (1936), saying "… *a large proportion of our positive activities depend on spontaneous optimism rather than mathematical expectations, whether moral or hedonistic or economic. Most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as the result of animal spirits—a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities'*.

The CBSM methodology is informed by gaining an understanding such 'animal spirits' and basing programs on the perceptions of the community rather than the assumptions of those offering the program. CBSM is based on rigorous consideration and thorough implementation of a number of key elements prior to the piloting and rolling out of community wide behaviour change programs, including the identification of preferred behaviours, the investigation of associated barriers and benefits, and the selection of appropriate tools and strategies, as presented in Figure 7.1 (McKenzie-Mohr and Smith, 1999).

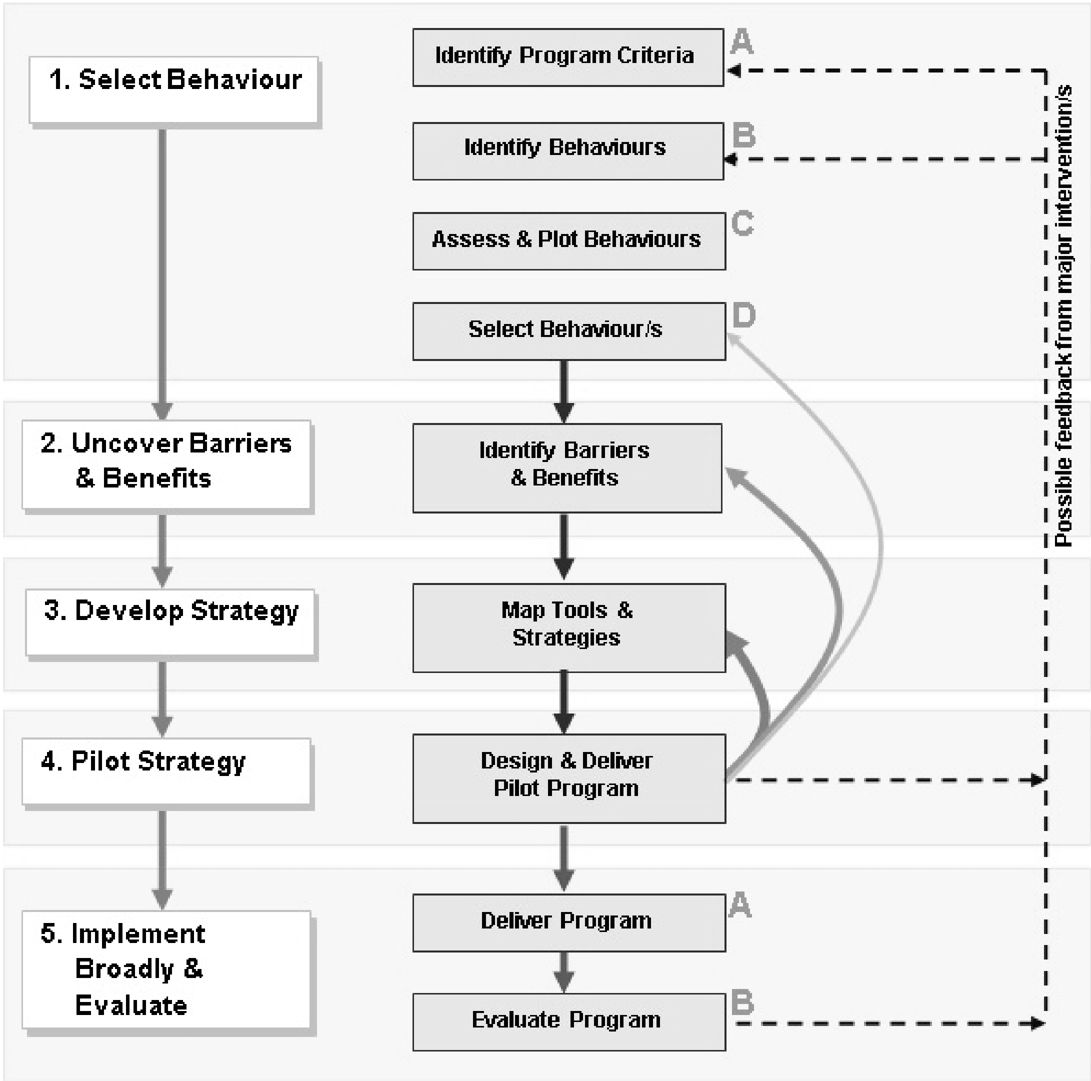


Figure 7.1: CBSM Method expanded, showing feedback loops

Source: Adapted from McKenzie-Mohr and Smith (1999) by K, Hargroves and C, Desha.

7.2 COMMUNITY INFORMED SELECTION OF TARGET BEHAVIOURS

Identification and Assessment of Potential Preferred Behaviours

This initial stage is often overlooked in the design of community behaviour change programs as it can involve lengthy investigations, leading to assumptions being made with little to no community engagement. The first step is the identification of potential behaviours that the community may adopt that align with the program goal, such as reducing residential energy demand as in the case of the TCC project. The second step is to investigate the 'potential impact' on the program goal and the 'perceived likelihood' of adoption by members of the community for each behaviour. The third step is to select specific behaviours to be investigated further. In the case of the TCC project the research team undertook an extensive literature review and expert panel peer-review process, to identify and investigate 240 behaviours that could lead to a reduction in home energy consumption (See List 7.1), including impact and probability rankings and evidence of similar program precedent elsewhere (TCC 2010a). As per the CBSM methodology the behaviours were assigned a rating, from 1 to 5, to suggest both the potential ‘impact’ and perceived ‘likelihood’. (McKenzie-Mohr and Smith, 1999)

The study also included the identification of existing government policies, incentives, or programs which might affect the behaviour or inform efforts to encourage it. The scope of the research task was designed by myself and Dr Cheryl Desha, and undertaken by Miss Angie Reeve, a research assistant that I supervised.

List 7.1: Categories of Residential Energy Demand Reduction Behaviours Identified Appropriate to Townsville, Australia (see Appendix A for a full listing including an indication of the [Impact:Likelihood] estimates out of 5). (TCC, 2010a)

- Reducing Electricity Consumption: Hot Water Systems (~28%)
- Reducing Electricity Consumption: Kitchen Appliances (Fridge 14%, Cooking 5%, Dishwasher 1%)
- Reducing Electricity Consumption: Entertainment Equipment (TV/VCR 3%)
- Reducing Electricity Consumption: Laundry Appliances and Bathroom (Clothes 2%)
- Reducing Electricity Consumption: Pools, Hot Tubs and Saunas
- Reducing Electricity Consumption: Heating & Cooling (Cool 14%, Heat 4%)
- Reducing Electricity Consumption: Lighting (8%)
- Complimenting Energy Efficiency Behaviours with Onsite Generation
- Options for House Construction and Retrofit
- Additional Behaviours related to housing construction

Selection of a Shortlist of Behaviours

The scores for the ‘impact’ and ‘likelihood’ were then plotted to create an ‘Impact-Likelihood Matrix’ for the project as per the CBSM methodology, as shown stylistically in Figure 7.2. As part of the research project myself and Dr Cheryl

Desha worked closely with Dr McKenzie Mohr to extend the 'Impact-Likelihood Matrix' to include three strategic approaches as shown in Figure 7.2, namely 'Shifting behaviours of high impact from low likelihood to a higher likelihood, 'Aggregating a number of behaviours with high likelihood to deliver an overall greater impact, and 'Leap-frogging a series of behaviours to start with one with high likelihood and low impact to build buy in to then move to one with slightly higher impact and slightly lower likelihood'.

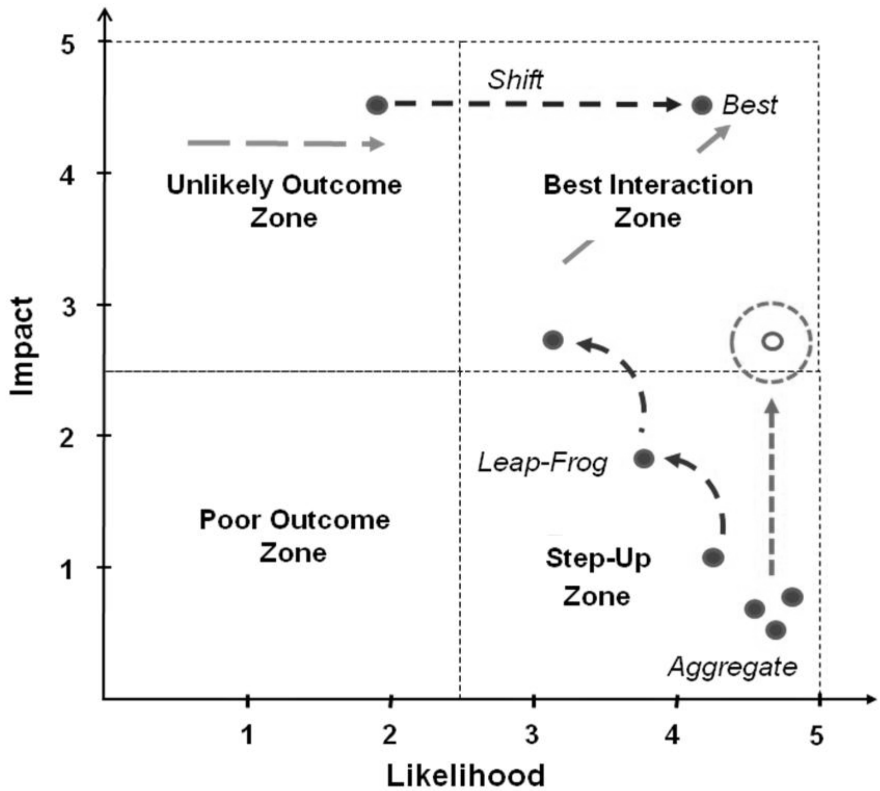


Figure 7.2: Stylistic representation of an 'Impact-Likelihood Plot'
Source: Adapted from McKenzie-Mohr and Smith (1999) by K. Hargroves and C. Desha.

The interpretation of the plot was then used to inform the selection of a short list of behaviours for further consider for potential inclusion in future community programs. The stylistic representation of such a plot shown in Figure 7.2 highlights a number of quadrants or 'interaction zones', where the following rationale can be applied:

- *Best Interaction Zone:* Behaviours plotted in this zone are considered to have the best viability for inclusion into behaviour change programs as they have both a high potential impact on the program goal and a high perceived likelihood of adoption by the community. However when such programs are being delivered by local governments they may not be the most attractive option as such options typically attract the attention of State and National governments, with associated programs able to be leveraged by local government rather than instigated.

- *Step-Up Zone:* Behaviours that are plotted in this zone are assumed to have a low viability for inclusion in a community program due to the low potential impact. However due to the high levels of likelihood they provide viable options for local government programs. In such programs there are two ways to increase the overall impact. The first is by identifying a series of behaviours that can be leap-frogged by residents by initially focusing on one with high likelihood to create buy-in and experience to then encourage a behaviour with higher impact but lower likelihood, etc. The second is to identify a cluster of behaviours with high likelihoods to aggregate together to increase the overall impact of the program. (Similar to the process recommended in the CSA Roadmap)

- *Unlikely Outcome Zone:* Despite the high potential impact, behaviours plotted in this zone are considered to have low viability for inclusion in a behaviour change program. However as Figure 7.2 suggests such behaviours can be moved from this zone into the 'Best Interaction Zone' by efforts to increase the likelihood. In the case of local government this may be the introduction of a State or Federal rebate or regulation that will increase the likelihood of adoption of the behaviour by the community.

- *Poor Outcome Zone:* Behaviours that are plotted within this zone are assumed to have a very low viability for inclusion in a behaviour change program. As with the 'Unlikely Outcome Zone' however such behaviours can be moved from this zone into the 'Step-Up Zone' by efforts to increase the likelihood.

In the case of the TCC project the Townsville City Council was presented with the findings of the investigation of the 240 behaviours which revealed that none of the identified behaviours fell into the '*Best Interaction Zone*', with virtually all lying in the '*Poor Outcome Zone*' or the '*Step-Up Zone*'. It was decided by TCC that a strategy of aggregation would be pursued to cluster a selection of behaviours in the '*Step-Up Zone*'. Following this the research team identified 33 behaviours which fell in the '*Step-Up Zone*' for consideration for selection in the aggregation, as is shown in Table 7.1.

Table 7.1: Shortlisted behaviours to reduce residential electricity consumption

No.	Description	Impact	Likelihood
2	Switching from an electric storage system to a gas storage or instant system	1.7	4
3	Switching from an electric storage system to a heat pump water heater	1.25	4
4	Switching from an electric storage system to a solar hot water heater	1.7	4
223	Painting the roof white, or a light colour	1.28	4
140	Opening windows and louvers during the night and shutting during the day	1.31	3
152	Shutting internal doors to rooms not being used when the air conditioner is being used	1.09	3
211	Planting conical trees to the south west and south east to provide shading during summer	1.5	3
136	Buying the most energy efficient air conditioner possible	0.6	4
220	Installing insulation in the ceiling as a retrofit	0.77	4
232	Installing insulation in the ceiling during construction	0.77	4
122	Buying the most energy efficient washing machine possible	0.76	3
139	Installing and using curtains to provide a thermal layer between the window and the room	0.66	4
224	Installing roof ventilation as a retrofit	0.37	4
145	Replacing old model air conditioners with a more efficient model	0.66	2

No.	Description	Impact	Likelihood
210	Installing eave vents	0.66	3
218	Positioning furniture to make use of natural breezes and heating / cooling	0.66	3
209	Insulating verandah roofs as a retrofit	0.37	3
216	Construct outdoor living areas (protected from the elements)	0.30	3
136	Buying the most energy efficient air conditioner possible	0.6	4
52	Turning off a second fridge where possible	0.6	1.5
78	Buying and installing gas cooktops and oven	0.5	3
228	Installing eaves	0.46	4
133	Reducing the use of pool pumps / filters during cooler months	0.45	4
144	Setting the thermostat to (no lower than) 25oC in summer	0.44	3
10	The installation of water efficient shower heads	0.38	2.5
159	Avoiding the installation of an air conditioner	2.18	2
196	Installing solar photovoltaic panels	1.63	1.5
215	Installing green walls	0.90	2
225	Planting deciduous vines to shade the northern aspects	0.65	2
227	Tinting windows as a retrofit	0.87	2
229	Tinting windows during construction	0.87	2
86	Purchasing an energy efficient television	0.6	1
43	Replacing existing fridge with a more efficient model	0.55	1
158	Restricting air conditioner usage	0.43	2

Source: TCC (2010b)

On consideration of the available time and resources, it was further determined that six behaviours would be selected from the pool of 33 behaviours for further analysis, as listed in Table 7.2.

Table 7.2: Six shortlisted options for decreasing electricity consumption within Townsville households

No.	Description	Impact (Average)	Likelihood (Average)
1	Switching from an electric storage system to a solar hot water heater	1.7	4
2	Switching from an electric storage system to a heat pump water heater	1.25	4
3	Planting conical trees to the south west and south east to provide shading during summer	1.5	3
4	In summer, opening windows and louvers during the night and shutting during the day (hot air purging)	1.31	3
5	Painting the roof white, or a reflective colour	1.28	4
6	Installing insulation in the ceiling as a retrofit	0.77	4

Source: TCC (2010b)

Identification of Barriers and Benefits for the Shortlisted Behaviours

The next step in the CBSM methodology is the consideration of barriers and benefits associated with each of the behaviours under consideration, with the results of a comprehensive literature review by the research team, led by myself, shown in Table 7.3. The scope of the research task was designed by myself and Dr Cheryl Desha, and undertaken by Miss Angie Reeve and Mr David Sparks, research assistants under my supervision. In considering the likelihood and impact of each behaviour it was understood that although some barriers and benefits may apply widely across the community, no two households will be the same in terms of how electricity is used given differences in the motivations and attitudes of the individuals within the household towards electricity conservation, the financial and physical ability of the household to implement changes to reduce their electricity usage, or the efficiency of the house infrastructure and appliances.

Table 7.3: List of key barriers and benefits maped to shortlisted behaviours

Key Benefits to Implementation	**1**	**2**	**3**	**4**	**5**	**6**
– Upfront costs	●	●	●		●	●
– Confusion surrounding rebates	●	●				●
– Ineligibility for rebates	●	●				●
– Time delay for approvals and inspections	●	●				
– Replacing still functional equipment	●	●				●
– Perception of inferior service	●	●				
– Ancillary costs and requirements	●	●				●
– No urgency for action	●	●	●		●	
– Aesthetic concerns	●		●		●	
– Does not provide environmental status symbol		●			●	●
– Noise concerns		●		●		
– Lack of knowledge		●	●			●
– Home-owner’s block of land is not appropriate		●	●	●		
– Time demands			●			●
– Load bearing capacity of the roof	●					
– Need for clear solar access	●					
– Maintenance requirements	●					
– Insufficient regulation to favour this system	●					
– Availability of the system		●				
– Space for installation of heat pump		●				
– Reduced effectiveness of other energy efficiency investments			●			
– Risk of damage to house			●			

Key Benefits to Implementation	1	2	3	4	5	6
– Reduced light inside the house			●			
– Security concerns				●		
– Requires ongoing action				●		
– Privacy concerns				●		
– Health concerns				●		
– Preference for ‘chilled’ air				●		
– Resistance to changing ingrained habits				●		
– Wide selection of options cause confusion						●
– Resident is not home-owner						●
– Time delay between taking action and receiving benefit			●			
Key Benefits to Implementation	**1**	**2**	**3**	**4**	**5**	**6**
– Reduced electricity costs	●	●	●	●	●	●
– Availability of rebates	●	●				●
– Visual display of ‘environmental status symbol’	●					
– Increase house value	●	●	●		●	●
– Existing legislation	●	●				
– Ideal climate	●					
– Increased comfort in the home			●		●	●
– Aesthetic appeal			●		●	
– Long life of system or infrastructure	●				●	
– Credit towards house energy efficiency rating					●	●
– Enhanced privacy			●			
– Fresh air and breezes				●		
– Enhanced views					●	
– Seal in roof asbestos					●	
– Personal satisfaction for mitigating climate change	●	●	●		●	●

Key Benefits to Implementation	1	2	3	4	5	6
– Enhance effectiveness of other energy efficiency investments					●	
– Reduce the neighbourhood heat island effect					●	
– Improved quality of rainwater					●	
– Reduced noise transfer						●

Source: TCC (2010b)

Selection of Target Behaviours

Based on the appreciation of the potential barrier and benefits of the 6 short listed options the TCC chose the following three for investigation through community engagement, as outlined in the following parts:

1. Painting the roof white,
2. Switching from an electric storage system to a lower mains electricity consuming system, and
3. Planting appropriate trees/shrubs to provide shading in summer.

7.3 IDENTIFICATION OF COMMUNITY PERCEPTIONS TO IDENTIFY LEVERAGE POINTS FOR BEHAVIOUR CHANGE

Up to this point the research to inform the development of future behaviour change programs by Townsville City Council was based on research, peer review, and the leadership of the TCC. This process led to the identification of 3 preferred behaviours that the TCC selected to encourage amongst residents in Townsville in order to reduce residential energy demand, and the associated greenhouse gas emissions. It is at this point that the CBSM methodology calls for direct community engagement to identify perceptions around the barriers and benefits associated with each of the selected behaviours. This was undertaken through a series of community focus groups and a community online survey that I co-designed, co-moderated, and analysed.

Process of Community Engagement

Community Focus Groups to Identify Perceptions of Barriers and Benefits

In order to investigate the barriers and benefits identified for the selected behaviours a process of qualitative research by focus group was undertaken as recommended by the CBSM methodology (McKenzie-Mohr and Smith, 1999). To ensure the focus groups followed the intention of the CBSM methodology Dr Cheryl Desha developed a specification that distilled more than 600 pages of text by focus group experts David Morgan and Richard Krueger (1998) referred by Dr Mackenzie-Mohr, and edited by myself (TCC, 2010c). The specification covered the design, delivery and analysis of focus groups to support a CBSM approach. This document was then used to inform the research team to work through the process of designing, moderating, and analysing the focus group sessions led by myself. The design specification begins with a brief background to focus groups as a qualitative research method, and potential roles for focus groups in the CBSM methodology. The specification then provided a step-by-step overview of the requirements for conducting focus groups, and to then interpret the data (including a checklist of tasks for each major stage: 1) Planning, 2) Recruitment, 3) Moderating, and 4) Analysis and Reporting). As with most methods, there are points in the process that may be iterative, or flexible as to when certain tasks are undertaken.

The main purpose of the focus groups was to allow direct interaction with the community within which the program will be delivered, and to investigate their perceptions and views related to the barriers and benefits of the selected behaviours, as presented in Table 7.3. A total of 12 focus groups were undertaken, 6 moderated by myself and 6 by Dr Desha, with 4 focus groups for each of the 3 behaviours that adhered to the conditions of the research ethics approval given by Griffith University (where I was a staff member while undertaking the this PhD part time at Curtin University).

The focus groups involved 75 community participants, grouped in the following configurations: ‘combined household income over $100,000 having already undertaken the behaviour’ (referred to High Income Complier), ‘combined household income over $100,000 not having undertaken the behaviour’ (High Income Non-Complier), ‘combined household income under $100,000 having already undertaken the behaviour' (Low Income Complier), and 'combined household income under $100,000 not having undertaken the behaviour' (Low Income Non-Complier).

For each of the groups the process was begun by allowing participants to list their perceived barriers and benefits, without being influenced by other participants or the moderator , and indicate the three most important. Once the 'Top-of-Mind' findings were recorded each participant announced their perceptions to the group, and a method was used to capture changes made to lists by participants as a result of hearing other participant's thoughts (through the use of a different coloured pen). The groups were then moderated to share experiences around the particular barriers and benefits, including a discussion around various options for the program to reduce the barriers and increase the benefits. These discussions were captured by an audio recorder (with approval and subject to the Griffith University Ethics Approval) and research assistant was present to capture notes around participant behaviour, including body language, emotional responses, and general demeanour throughout the process. The findings were then used as the basis of the development of a community survey as per the CBSM methodology, namely a list of potential benefits and barriers for each of the three behaviours as shown below in List 7.2, and was reviewed by Dr Doug McKenzie-Mohr.

List 7.2: Benefits of 'Painting the roof white' (TCC, 2010d)

- Cooler inside temperatures
- Reduced electricity consumption and cost
- Increases the energy rating of home
- Improves the lifespan of roof materials
- Personal satisfaction from environmentally inspired efforts
- Increases the property value

List 7.3: Barriers to 'Painting the roof white' (TCC, 2010d)

- Upfront costs
- Lack of information on suitable products

- Concerns about selecting trustworthy tradespersons
- Costs and time required to prepare roof for painting
- Cost of maintenance when painting unpainted roofs
- Hassle and inconvenience of organising the roof painting
- Cost of cleaning a white or light coloured roof
- Issues related to warranty/guarantee of roof
- Uncertainty over how to prioritise roof painting among other efficiency measures
- Uncertainty over the benefits
- Concerns around the way the new roof will look
- Paint and runoff causing environmental problems
- Asbestos related concerns

List 7.4: Potential Tools to Encourage and/or support 'Painting the roof white' (TCC, 2010d)

- Financial assistance to undertake white roof painting
- Access to information about white roof painting on a website
- A demonstration site to show performance of white roof painting
- Access to information on warranty/guarantee issues related to roof painting
- Access to information on council requirements related to changing to a white roof
- Access to information about white roof painting at paint stores
- Assistance to select and engage tradespersons
- A home visit to provide advice on white roof painting
- A council 'hot line' providing advice to homes around white roof painting
- A home visit to assess asbestos related risks to roof painting

List 7.5: Benefits of 'Switching hot water system' (TCC, 2010d)

- Ongoing electricity cost savings
- Availability of rebates and government financial assistance
- Reduced greenhouse gas emissions
- Reduces electricity consumption to increase effectiveness of solar panels
- Personal satisfaction for reducing environmental impact
- Reduced dependence on mains electricity
- Provides an environmental status symbol
- Increases the property value
- Townsville is an ideal climate for alternative systems

List 7.6: Barriers to 'Switching hot water system' (TCC, 2010d)

- Initial upfront costs
- Uncertainty about the length of payback period
- Existing hot water system is still working
- Concerns about the way the new system will look
- Confusion around rebates and eligibility
- Lack of knowledge of alternative system
- Unsuitability of site or building to alternate system
- Issues related to approvals from body corporate identities
- Concerns about the performance of new systems
- Concerns about selecting trustworthy tradespersons
- Uncertainty over how to prioritise alternative systems among other efficiency measures

List 7.7: Potential Tools to Encourage and/or support ‘Switching hot water system’ (TCC, 2010d)

- Access to information about alternative hot water systems on the market on a website
- Access to information about alternative hot water systems at retail stores
- A council 'hot line' providing advice to homeowners around alternative hot water systems
- Access to information on council requirements related to changing hot water systems
- Access to information on related rebates and eligibility related to changing electric storage hot water systems
- A home visit to provide advice on alternative hot water systems
- The provision of a recycling option for electric storage hot water systems
- Financial assistance to change to an alternative hot water system
- A demonstration site to show performance of various alternative hot water systems.

List 7.8: Benefits of ‘Shade Planting’ (TCC, 2010d)

- Provides shading to the home, making it cooler
- Provides a pleasant and shaded area to relax and play
- Encourages birds, butterflies and wildlife into the garden
- Increases the visual amenity and aesthetics
- Provides a privacy screen for the home
- Reduced energy cost
- Reduced carbon footprint of home
- A source of fruit and food in the garden
- Increases the property value

List 7.9: Barriers to ‘Shade Planting’ (TCC, 2010d)

- Cyclone/storm damage from limbs and branches
- Leaf litter in gutters, pools and yards
- Lack of knowledge on plant selection and maintenance
- Potential for root damage to house
- Time required to grow to provide shade
- Location of power lines and other services
- Falling limbs and branches
- Availability of space for mature plant
- Attract termites
- Cost of plants and soil preparation
- Additional vegetation matter for disposal
- Time required to plant and maintain
- Water requirements of plants

List 7.10: Potential Tools to Encourage and/or support 'Shade Planting' (TCC, 2010d)

- Access to information about suitable shade plant on a website
- Access to information about suitable shade plants at nurseries
- A home visit to identify the location of underground services that may be affected by shade planting
- Financial assistance to purchase plants for shade planting
- A demonstration site to show mature shade planting options
- A home visit to provide advice on shade planting
- Financial assistance in dealing with additional prunings related to shade planting
- A council 'hot line' providing advice to homes around shade planting

Community Survey of Perceptions of Barriers and Benefits

In order to gauge the level of agreement on the outcomes from the focus groups in the wider Townsville community a survey was used that was in-line with the 'Community Based Social Marketing' (CBSM) methodology. To ensure the community survey followed the intention of the CBSM methodology Dr Cheryl Desha developed a succinct summary of the key components of a community survey as part of the CBSM process by studying in detail the leading work on survey development and tailored it to the CBSM process requirements, edited by myself (TCC, 2010e). This resulting specification distilled more than 1480 pages of text by survey Arlene Fink (2003) as referred by Dr Mackenzie-Mohr, and edited by myself.

The survey was administered online with participants first asked to input their most influential benefits and barriers, without seeing any suggestions. Following this respondents where directed to a new page and asked to indicate their level of agreement of the strength of the perceived barriers and benefits from the focus groups, asked to indicate either that they agree strongly, agree, are unsure, disagree, or disagree strongly. The participants were then asked to provide an indication of the perceived value of a selection of program tools generated through discussion in the focus group and amended by the research team.

The survey was opened online from February to May 2010 and received responses from over 1200 Townsville residents, some 82% of whom were home owners. Participation was encouraged through the provision of five prizes of $1,000 worth of energy efficiency appliances by the Good Guys, and promoted widely by the TCC. Participants were invited to indicate if they had undertaken the behaviour (a 'complier') of if they had not (a 'non-complier') to identify differences in views between the two groups. As outlined previously the focus group participants were further divided into two specific income brackets, however as the differences in the findings were not deemed to be significant, and due the sensitive nature of making such a disclosure on a website, it was decided not to ask for this information in the survey.

The purpose of the survey was to:

– Explore the perceived level of agreement of the existence of the barriers and benefits identified in the focus groups.

– Identify any additional benefits and barriers, and

– Identify differences in the perception between compliers and non-compliers of the suggested barriers, benefits, or tools for each of the three behaviours.

As part of the research the findings of the survey were analysed as presented in the following parts (TCC, 2010f).

Key Findings of Community Engagement

White Roof Painting

Benefits of 'White Roofs'

When considering both the findings of the top-of-mind benefits, and the level of agreement on the benefits suggested by the focus groups, it was apparent that the most important benefit, for both compliers and non-compliers, was that it would cool the home, and then that this will lead to direct electricity savings. This suggests that communicating that painting the roof a white will cool the home is unlikely to influence behaviour as it is already well understood. Compliers generally agreed more strongly that a white roof would cool the home and result in electricity savings compared to non-compliers, suggesting that should a focus on communication of benefits be further explored the findings suggest that quantifying and communicating the potential to cool the home and reduce energy demand may influence non-compliers.

When further considering the findings of the level of agreement on the benefits suggested by the focus groups, it was apparent that there was strong agreement that a white roof would result in an increase in the energy rating of home, an improvement in the lifespan of roof materials, and an increase in the property value, despite the first benefit not listed as a top of mind, and the second two benefits being listed as top of mind my less than 2 percent of respondents. This suggests that such benefits are not generally thought of in association with white roofs, but when raised there is generally strong agreement. Interestingly between a quarter to a third of respondents (with a greater proportion of non-compliers) indicated that they had a neutral level of agreement, suggesting that a program that increases the understanding of the important of these benefits may influence behaviour.

In general, as Table 7.4 shows, there was a high level of agreement in both compliers and non-compliers of the benefits in cooling the home and reducing energy demand from a white roof, with generally stronger agreement from compliers, suggesting that a focus on communicating such benefits would be unlikely to influence behaviour. However should a focus on communication of benefits be further explored the findings suggest that a focus on quantifying and communicating the potential to improve the lifespan of roof materials, increase property value, and increase the energy rating of the home may influence behaviour change.

Table 7.4: Summary of level of agreement on leading benefits of painting the roof a white or reflective colour and likely influence of a program to promote such benefits to residents in Townsville (TCC, 2010f)

Key Benefits of 'White Roofs'	**Likely Influence**	**Top of Mind**	**Level of Agreement (Complier)**	**Level of Agreement (Non-Complier)**
1. Cool the home	*Low*	79%	94% (80% strongly)	89% (57% strongly)
2. Energy savings	*Low*	43%	87% (67% strongly)	86% (50% strongly)
3. Improving the lifespan of roof materials	*Low-Medium*	1.8%	71% (46% strongly)	52% (32% strongly)
4. Increase property value	*Low-Medium*	1.8%	56% (32% strongly)	47% (24% strongly)
5. Increasing the energy rating of home	*Low-Medium*	-	80% (56% strongly)	74% (38% strongly)

When reviewing the choice of language used in the focus groups to discuss the various benefits the following keywords were used by a participant and then adopted by other participants: '*satisfaction*', '*house value*', '*efficiency rating*', '*reducing suburb heat*', and '*seal asbestos*'.

Barriers to 'White roofs'

When considering the findings of both the top-of-mind barriers, and the level of agreement on the barriers suggested by the focus groups, it was apparent that the most influential barrier, for both compliers and non-compliers, to a white roof was the associated cost. When asked to then indicate the level of agreement non-compliers agreed more strongly that cost was a barrier, this may be due to non-compliers not having experienced the financial benefits associated with the behaviour that may reduce the overall cost. This suggests that a program to either reduce associated costs or communicate the overall cost savings available from white roofs may lead to behaviour change. The second most common top of mind barrier, with less than 15 percent, was concern that the roof colour may not match the house, and this was not nominated by the focus group participants.

When further considering the findings of the level of agreement on the barriers suggested by the focus groups, it was apparent that there was strong agreement that both a lack of information on suitable products, and concerns about finding trustworthy tradespersons, were influential barriers to white roofs. This suggests that these barriers are not generally thought of in association with white roofs, but when raised there is generally strong agreement. Hence a program that includes a focus on assisting in the selection of suitable projects and the identification of trustworthy tradespersons may influence behaviour.

As Table 7.5 shows, there was overwhelming agreement in both compliers and non-compliers that the associated cost was the most influential barrier, with non-compliers agreeing more strongly, suggesting that some non-compliers may be over-estimating the associated costs, and hence a focus on confirming the these costs will be unlikely to influence behaviour. Hence as the associated cost was the dominant barrier this suggests that there are two options for encouraging this behaviour, firstly to reduce the associated upfront costs, and secondly to communicate the cost savings over time.

Despite the generally equal level of agreement between compliers and non-compliers as to concerns about selecting trustworthy tradespersons, when considering the level of disagreement, compliers disagreed more than non-compliers that there were such concerns, suggesting that non-compliers may be overestimating the concern. Compliers disagreed much more that there was a lack of information on suitable products than non-compliers suggesting that non-compliers may not be aware of available information.

Table 7.5: Summary of level of agreement on leading barriers to white roof painting and likely influence of a program to reduce such barriers for residents in Townsville (TCC, 2010f)

Key Barriers to 'White Roofs'	**Likely Influence**	**Top of Mind**	**Level of Agreement (Complier)**	**Level of Agreement (Non-Complier)**
1. Cost	*High*	77%	83% (47% strongly)	91% (62% strongly)
2. Concerns about selecting trustworthy tradespersons	*Medium*	9%	68% (34% strongly)	72% (34% strongly)
3. Lack of information on suitable products	*Medium*	8%	67% (28% strongly)	81% (39% strongly)

When reviewing the choice of language used in the focus groups to discuss the various barriers the following keywords were used by a participant and then adopted by other participants: '*quality*', '*maintenance*', '*cost*', and '*conflicting information*'.

Perceived Value of Potential Program Tools

The focus groups allowed discussion regarding the range of potential tools that may be used as part of a community program to encourage white roofs. These findings then informed the identification of a set of potential categories of tools that were included in the community survey to gauge the level of perceived value to residents considering painting their roof white. It is apparent from the findings of the community survey that there was greatest perceived value to them supporting them to have a white roof were as follows (TCC, 2010f):

1. Financial assistance to undertake white roof painting (*with 51% of respondents strongly agreeing and 32% agreeing - with some 9% disagreeing that is of value*).
2. Access to information about white roof painting on a website (*with 41% of respondents strongly agreeing and 42% agreeing - with some 8% disagreeing that is of value*).
3. A demonstration site to show performance of white roof painting (*with 37% of respondents strongly agreeing and 37% agreeing - with some 12% disagreeing that is of value*).
4. Access to information on warranty/guarantee issues related to roof painting (*with 37% of respondents strongly agreeing and 42% agreeing - with some 9% disagreeing that is of value*).
5. Access to information on council requirements related to changing to a white roof (*with 37% of respondents strongly agreeing and 41% agreeing - with some 9% disagreeing that is of value*).

Both compliers and non-compliers perceived similar value in each of the above categories of tools. However, considering the level of disagreement, some 14 percent of compliers disagreed that providing financial assistance would be of value, compared with 7 percent for non-compliers. The two categories of potential tools that the community survey respondents felt would be of least value to them supporting them to undertake painting their roof white were (TCC, 2010f):

1. A council 'hot line' providing advice to homeowners around white roof painting (*with 27% of respondents strongly agreeing and 30% agreeing - with some 21% disagreeing that is of value*).

2. A home visit to assess asbestos related risks to roof painting (*with 23% of respondents strongly agreeing and 29% agreeing - with some 32% disagreeing that is of value*).

It is worth noting that the level of disagreement for these behaviours may result in political risk as residents actively disagree with the benefit of the tools and may oppose efforts to undertake them as part of a community funded program.

Switching Hot Water Systems

Benefits of Switching Hot Water Systems

When considering the findings of both the top-of-mind benefits, and the level of agreement on the benefits suggested by the focus groups, it was apparent that the most important benefit, for both compliers and non-compliers, of switching the hot water system was that it would reduce energy costs (with compliers more strongly agreeing) and reduce greenhouse gas emissions. This suggests that communicating that switching hot water systems will result in such reductions is unlikely to influence behaviour. However should a focus on communication of benefits be further explored the findings suggest that, as compliers more strongly agreed that switching the hot water system would result in cost savings compared to non-compliers, quantifying and communicating the potential for cost savings may influence behaviour change.

When further considering the findings of the level of agreement on the benefits suggested by the focus groups, it was apparent that compliers agreed more strongly that switching hot water systems would result in less reliance on grid for electricity during a blackout, and personal satisfaction for reducing environmental impact, despite being listed as top of mind by less than 5 percent of respondents. This suggests that such benefits are not generally thought of in association with switching hot water systems, but when raised there is generally strong agreement. Hence a program that includes a focus on communicating such benefits may influence behaviour.

As Table 7.6 shows, in general there was a very high level of agreement in both compliers and non-compliers (the average level of disagreement being only 7.5 percent) of the benefits of switching hot water systems, suggesting that a focus on communicating the benefits would be unlikely to influence behaviour. However if a focus on communication benefits was used in the program it may target non-compliers to communicate the potential cost savings as they agreed less strongly than compliers.

Interestingly, some 24 percent of compliers, and 34 percent of non-compliers, indicated that they were neutral about the level of agreement of the potential for switching hot water systems to increase property value. This may indicate that residents are unaware of the potential influence on property value from this behaviour, perhaps also indicating why it was not listed as a top if mind benefit. It is worth noting that the greatest level of disagreement from both compliers and non-compliers was that switching hot water systems would provide a status symbol, with some 25 percent disagreeing.

Table 7.6: Summary of level of agreement on leading benefits of switching hot water systems to an alternate system and likely influence of a program to promote such benefits to residents in Townsville (TCC, 2010f)

Key Benefit of Switching Hot Water Systems	**Likely Influence**	**Top of Mind**	**Level of Agreement (Complier)**	**Level of Agreement (Non-Complier)**
1. Cost saving	*Low*	83%	96% (81% strongly)	95% (67% strongly)
2. Reduced Greenhouse Gas Emissions	*Low*	60%	85% (54% strongly)	86% (51% strongly)
3. Less reliance on grid for electricity during blackout	*Low*	4.5%	82% (59% strongly)	84% (49% strongly)
4. Personal satisfaction for reducing environmental impact	*Low*	-	84% (56% strongly)	88% (49% strongly)

When reviewing the choice of language used in the focus groups to discuss the various barriers the following keywords were used by a participant and then adopted by other participants: ‘*improve value*’, ‘*green loans*’, ‘*visual display*’, and ‘*rebates*’.

Barriers to Switching Hot Water Systems

When considering the findings of both the top-of-mind barriers, and the level of agreement on the barriers suggested by the focus groups, it was clear that the most influential barrier to switching hot water systems, for both compliers and non-compliers, was the associated cost. When asked to then indicate the level of agreement non-compliers agreed slightly more strongly that cost was a barrier, however the difference to the level of agreement from compliers is not large enough to suggest that a program to communicate the overall cost savings available may influence behaviour. The second most common top of mind barrier, with less than 7 percent, was concerns over the reliability of an alternative hot water system, however this was not nominated by the focus group participants and was not investigated in the survey.

When further considering the findings of the level of agreement on the barriers suggested by the focus groups, it was apparent that non-compliers agreed more strongly that the fact that the existing hot water systems is working was an influential barrier, despite being listed as top of mind my less than 3 percent of respondents. This may suggest that the non-compliers may perceive that prematurely retiring the working system may result in a financial cost and a program to demonstrate the overall cost-benefit of the switch may influence behaviour.

As Table 7.7 shows, there was overwhelming agreement in both compliers and non-compliers that the associated cost was the most influential barrier to switching hot water systems, suggesting that there is little chance that non-compliers are over-estimating the associated costs, and hence a focus on confirming the these costs will be unlikely to influence behaviour. Hence as the associated cost was the dominant barrier this suggests that there are two options for encouraging this behaviour, firstly to reduce the associated upfront costs, and secondly to communicate the cost savings over time. Considering the first option as both compliers and non-compliers agreed strongly that 'confusion around rebates and eligibility' was an influential barrier this suggests that the process to apply for and assess eligibility of rebates is confusing – potentially addressed by the group offering the rebate. Considering the second option both compliers and non-compliers agreed strongly that 'uncertainty about the length of payback period' was an influential barrier, again suggesting that there is uncertainty – potentially addressed by providing accurate estimates of payback periods.

Table 7.7: Summary of level of agreement on leading barriers to switching a hot water system to a lower mains consuming system and likely influence of a program to reduce such barriers for residents in Townsville (TCC, 2010f)

Key Barriers to Switching Hot Water System	**Likely Influence**	**Top of Mind**	**Level of Agreement (Complier)**	**Level of Agreement (Non-Complier)**
1. Associated Cost	*High*	89%	92% (70% strongly)	94% (75% strongly)
2. Existing hot water system is still working	*Low-Medium*	2.7%	64% (33% strongly)	82% (42% strongly)
3. Uncertainty about the length of payback period	*Low-Medium*	1.8%	69% (34% strongly)	76% (36% strongly)
4. Confusion around rebates and eligibility	*Low-Medium*	1.8%	78% (31% strongly)	66% (30% strongly)

When reviewing the choice of language used in the focus groups to discuss the various barriers the following keywords were used by a participant and then adopted by other participants: '*enough information*', '*return on investment*', '*ugly*' and '*installation delay*'.

Perceived Value of Potential Program Tools

The focus groups allowed discussion regarding the range of potential tools that may be used as part of a community program to encourage a switch in hot water system.

These findings then informed the identification of a set of potential categories of tools that were included in the community survey to gauge the level of perceived value to residents considering switching hot water systems. It is apparent from the findings of the community survey that there was greatest perceived value to them supporting them to undertake a switching of hot water systems were (TCC, 2010f):

1. Financial assistance to change to an alternative hot water system (*with 67% of respondents strongly agreeing and 23% agreeing - with some 3% disagreeing that is of value*)

2. Access to information on related rebates and eligibility related to changing electric storage hot water systems (*with 50% of respondents strongly agreeing and 37% agreeing - with some 5% disagreeing that is of value*).

3. The provision of a recycling option for electric storage hot water systems (*with 44% of respondents strongly agreeing and 35% agreeing - with some 6% disagreeing that is of value*).

4. Access to information about alternative hot water systems on the market on a website (*with 41% of respondents strongly agreeing and 41% agreeing - with some 8% disagreeing that is of value*).

5. A demonstration site to show performance of various alternative hot water systems (*with 41% of respondents strongly agreeing and 35% agreeing - with some 9% disagreeing that is of value*).

Non-compliers perceived greater value in the provision of financial assistance, suggesting perhaps that cost savings from the behaviour are not perceived until the resident has undertaken the behaviour. Non-compliers also perceived greater value in the provision of a recycling option than compliers, suggesting perhaps that once the system has been replaced the concern for the environmental impact of the old system wanes. Compliers perceived a greater value in the provision of a demonstration site than non-compliers, suggesting that compliers may have realised the cost benefits and feel that if non-compliers can see the performance and validate the cost reductions that this may influence behaviour.

The two categories of potential tools that both compliers and non-compliers felt would be of least value to them supporting them to undertake shade planting were (TCC, 2010f):

1. Access to information about alternative hot water systems at retail stores (*with 27% of respondents strongly agreeing and 42% agreeing - with some 13% disagreeing that is of value*).

2. A council 'hot line' providing advice to homeowners around alternative hot water systems (*with 22% of respondents strongly agreeing and 34% agreeing - with some 21% disagreeing that is of value*).

It is worth noting that the level of disagreement for these behaviours may result in political risk as residents actively disagree with the benefit of the tools and may oppose efforts to undertake them as part of a community funded program.

Shade Planting

Benefits of Shade Planting

When considering the findings of both the top-of-mind benefits, and the level of agreement on the benefits suggested by the focus groups, it was apparent that the most important benefit of shade planting, for both compliers and non-compliers, was that it would cool the home, and then that this will lead to direct electricity savings. This suggests that communicating that shade planting will cool the home and lead to energy savings is unlikely to influence behaviour. Interestingly non-compliers generally agreed more strongly that shade planting would cool the home and result in electricity savings compared to compliers. It is also apparent that there is wide acceptance that shade planting will make gardens more pleasant to spend time in and will encourage birds, butterflies and other wildlife. Furthermore, the lowest level of agreement (still some 70% agreement) was that shade planting would increase the property value, with non-compliers agreeing more than compliers, with this benefit not nominated as a top of mind benefit.

As shown in Table 7.8, in general there was a very high level of agreement in both compliers and non-compliers (the average level of disagreement being only 3.2 percent), with greater agreement from non-compliers, of the benefits of shade planting, suggesting that a focus on communicating the benefits would be unlikely to influence behaviour. Interestingly, some 32 percent of compliers, and 21 percent of non-compliers, indicated that they were neutral about the level of agreement of the potential for shade planting to increase property value. This may indicate that residents are unaware of the potential influence on property value from this behaviour, perhaps also indicating why it was not listed as a top if mind benefit.

Table 7.8: Summary of level of agreement on leading benefits of shade planting and likely influence of a program to promote such benefits to residents in Townsville (TCC, 2010f)

Key Benefit of Shade Planting	**Likely Influence**	**Top of Mind**	**Level of Agreement (Complier)**	**Level of Agreement (Non-Complier)**
1. Cool the home	*Low*	60%	93% (68% strongly)	96% (80% strongly)
2. Energy savings	*Low*	24%	79% (42% strongly)	85% (64% strongly)
3. Making gardens more pleasant to spend time in	*Low*	17%	95% (63% strongly)	96% (82% strongly)
4. Encouraging birds and butterflies	*Low*	16%	92% (58% strongly)	96% (82% strongly)
5. Increasing property value	*Low*	-	60% (22% strongly)	75% (48% strongly)

When reviewing the choice of language used in the focus groups to discuss the various benefits the following keywords were used by a participant and then adopted by other participants: '*satisfaction*', '*well-being*', '*less noise*', '*aesthetics*', '*therapeutic*', '*privacy*', '*bills*', '*food and fruit*', and '*house value*'. During the focus group discussions there were many ‘joyful’ recollections of experiences with wildlife, and ‘pride’ in listing what species visited the garden and what native plants had been planted.

Barriers to Shade Planting

When considering the findings of the top-of-mind barriers it was apparent that the most influential barrier to shade planting was a lack of knowledge on appropriate plants and associated issues. When asked to then indicate the level of agreement compliers agreed more strongly, suggesting that non-compliers may have underestimated the issues related to gaining information on selecting, planting and maintaining shade plants. This suggests that the information available to non-compliers may not be sufficient to inform this behaviour. This suggests that a program to provide specific information to residents on shade planting may lead to behaviour change. Considering other influential barriers identified as top-of-mind, the information may be focused on topics such as: plant types and suitability to providing shade, space required for mature plantings, water consumption requirements, time to grow to maturity, risk of attracting termites, and level of leaf litter generated.

When considering the findings of the level of agreement on the barriers suggested by the focus groups, it was apparent that the risk of damage to the home, from cyclone/storm damage or root damage, were also influential barriers, despite being listed as top of mind by less than 10 percent of respondents. This suggests that such damage is not generally thought of in association with shade planting, but when raised there is generally strong agreement. Hence a program could respond to such concerns, addressing the potential for residents to abandon plans for shade planting after hearing of concerns related to property damage. This was the case with the potential for unwanted leaf litter, which received strong agreement despite being listed as top of mind by less than 5 percent of respondents.

As shown in Table 7.9, there was a clear difference between the most influential top of mind barriers and the barriers most agreed to from the list provided by the focus groups. The top of mind findings focused on a lack of knowledge on appropriate plants and associated issues, whereas respondents agreed most strongly with barriers related to property damage and leaf litter from the options provided from the focus groups. This suggests a dual focus for a program for this behaviour given that there are both barriers related to lack of knowledge and also related to property damage and leaf litter generation. When considering that the average level of disagreement from non-compliers was 24 percent this suggests that nearly a quarter of the non-compliers didn't see one or more of the barriers as influential, hence this also indicates that a program to encourage this behaviour would need to target more than one barrier to reach a greater proportion of non-compliers.

Table 7.9: Summary of level of agreement on leading barriers to shade planting and likely influence of a program to reduce such barriers for residents in Townsville (TCC, 2010f)

Key Barriers to Shade Planting	**Likely Influence**	**Top of Mind**	**Level of Agreement (Complier)**	**Level of Agreement (Non-Complier)**
1. Lack of knowledge on appropriate plants and associated issues	*High*	36%	75% (35% strongly)	60% (25% strongly)
2. Cyclone damage from limbs and branches	*Low-Medium*	8.1%	84% (43% strongly)	67% (27% strongly)
3. The potential for root damage to house	*Low-Medium*	4.5%	70% (30% strongly)	60% (26% strongly)
4. Unwanted leaf litter in gutters, pools and yards	*Low-Medium*	3.6%	78% (33% strongly)	66% (29% strongly)

When reviewing the choice of language used in the focus groups to discuss the various barriers the following keywords were used by a participant and then adopted by other participants: ‘*maintenance*’, ‘*affect solar panels*’, ‘*water*’, ‘*guttering*’, and ‘*screen for thieves*’.

Perceived Value of Potential Program Tools

The focus groups allowed discussion regarding the range of potential tools that may be used as part of a community program to encourage shade planting. These findings then informed the identification of a set of potential categories of tools that were included in the community survey to gauge the level of perceived value to residents considering shade planting. It is apparent from the findings of the community survey that there was greatest perceived value to them supporting them to undertake shade planting were (TCC, 2010f):

1. Access to information about suitable shade plant on a website (*with 48% of respondents strongly agreeing and 37% agreeing - with some 7% disagreeing that is of value*).

2. Access to information about suitable shade plants at nurseries (*with 42% of respondents strongly agreeing and 39% agreeing - with some 9% disagreeing that is of value*).

3. A home visit to identify the location of underground services that may be affected by shade planting (*with 40% of respondents strongly agreeing and 32% agreeing - with some 13% disagreeing that is of value*).

4. Financial assistance to purchase plants for shade planting (*with 40% of respondents strongly agreeing and 31% agreeing- with some 19% disagreeing that is of value*).

5. A demonstration site to show mature shade planting options (*with 35% of respondents strongly agreeing and 41% agreeing - with some 12% disagreeing that is of value*).

Compliers perceived greater value in receiving information at nurseries than non-compliers, suggesting perhaps that either the value of this tool is not perceived until the resident seeks to undertake the behaviour and goes to a nursery, or that non-compliers had received information at nurseries that was not useful to support this behaviour. Compliers also perceived greater value in financial assistance to purchase plants than non-compliers, which suggests that non-compliers may be underestimating the cost of shade planting. Interestingly despite strong agreement overall, some 19 percent of both compliers and non-compliers disagreed that financial assistance would be of value in encouraging shade planting.

The categories of potential tools that both compliers and non-compliers felt would be of least value to them supporting them to undertake shade planting were (TCC, 2010f):

1. A home visit to provide advice on shade planting (*with 31% of respondents strongly agreeing and 29% agreeing - with some 16% disagreeing that is of value*).

2. Financial assistance in dealing with additional prunings related to planting (*with 30% of respondents strongly agreeing and 38% agreeing - with some 19% disagreeing that is of value*).

3. A council 'hot line' providing advice to homeowners around shade planting (*with 28% of respondents strongly agreeing and 29% agreeing – with some 24% disagreeing that is of value*).

It is worth noting that the level of disagreement for these behaviours may result in political risk as residents actively disagree with the benefit of the tools and may oppose efforts to undertake them as part of a community funded program.

7.4 COMMUNITY PERFORMANCE TRIAL OF SELECTED BEHAVIOUR

Based on the findings from the community engagement presented above the behaviour of '*Painting the roof white*' was selected for further investigation. The next step was to verify the temperature reducing and energy saving effects of having the roof painted white ain Townsville conditions and the following part presents a brief summary of the process and outcomes. The community performance trial was designed by myself with support from Dr Desha and research assistants David Sparks and Angie Reeve, at QUT, and advised by Greg Bruce, Mark Robinson and Dylan Furnell from the Townsville City Council. (TCC, 2012a)

Prior to the development of the performance trial a series of meetings were facilitated by TCC with the research team and local painters and industry stakeholders to identify issues for consideration in the community performance trial, and to identify options for program components that would provide mutual benefits. From these sessions a bulk buy framework was selected and tailored to ensure that it addressed the concerns and considerations of participating painting companies, resulting in community participants being offered between 15 and 25% discount on the cost of the roof painting, depending on which company they opted to use. Participants in the trial were recruited at the 2011 Townsville Eco-Fiesta and Smart Lifestyle Expo. As part of the program the participants were required to:

1. Allow the collection of temperature data before and after the roof painting via a temperature recorder provided by TCC,

2. Provide permission for quarterly electricity consumption data to be provided to the research team by Ergon Energy, and

3. Undertake a post program participant survey by telephone.

The findings of the community performance trial were as follows:

- *Temperature Reduction*: The temperature inside the home is affected by several factors, including: downward heat flow through the roof; heat flow through the walls, windows, doors and other building surfaces and cavities; and use of air conditioners and other cooling mechanisms in the home. Hence, it is not possible to accurately predict what cooling effect a white roof will have on an individual home. It is only possible to demonstrate that white roofs reduce the heat transfer process into a dwelling, and will thus reduce the heating of internal spaces. The findings of the trial validated that in Townsville conditions a white roof was effective in reducing internal temperatures in all of the participating dwellings, as anticipated and shown in Table 7.10.

Table 7.10: Findings of Community Performance Trial related to Temperature change effects of a white roof in Townsville, Queensland, Australia. (TCC, 2012a)

Comparison of two similar days (average of houses; n=11)	Temperature Change
Maximum roof cavity temperature reduction	-9.5 to -17°C
Average daytime roof cavity temperature reduction (9am-9pm)	-6.4 to -15.3°C
Maximum internal temperature reduction	-1.2 to -2.5°C
Average daytime internal temperature reduction (9am-9pm)	-0.6 to -1.5°C

For example, Figure 7.3 shows that after the application of the white roof a participant house in the pilot lead to the roof cavity temperature reducing by some 17°C to close to ambient temperature.

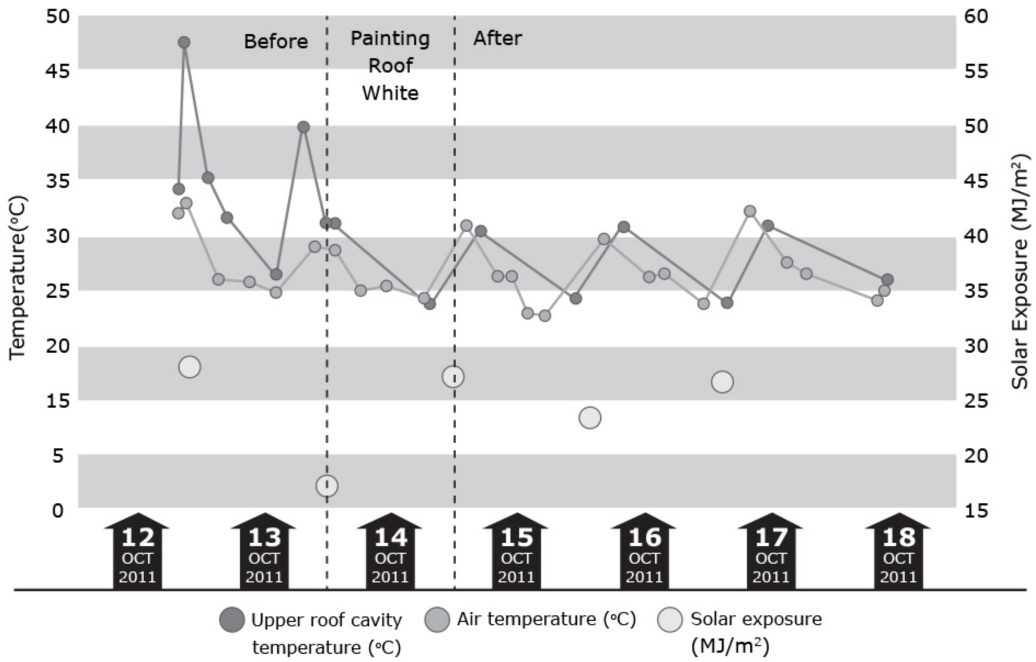


Figure 7.3: De-identified temperature readings before and after application of white coating on participant home

Source: Based on data from Townsville City Council (TCC 2012a)

Feedback from participants confirmed the improved conditions: '*It has exceeded my expectations. Estimate it has dropped the temperature of the house by 5°C. Difference is phenomenal*'; and *"It definitely works! When you walk in the door when you get home it no longer feels like walking into an oven – the wall of hot air has gone. It was worth the money."* (TCC 2012a)

- *Energy Consumption Reduction*: The performance trial included a focus on the impact a 'white roof' coating could have on household electricity consumption. A white roof will predominately reduce energy consumption in the home by the amount that the household reduces their use of air conditioners, or other mechanical cooling devices. It is noted that having lower temperatures inside the home will also reduce the cooling load, so that even if the household runs the air conditioner for the same amount of time, the air conditioner will have to work less to maintain the desired temperature. However, it is assumed that the greatest benefit would occur if the household also changed their air conditioner usage patterns due to their house being cooler as a result of the white roof. A number of participants reflected on the impact on their energy bill, saying: *'we don't use air-conditioning as much as we don't need it as much and it impacts our electricity bill'; and 'Already told several work colleagues – main interest is from the lower power bill*'.

  The majority of dwellings experienced a significant reduction in electricity consumption of approximately 20-60 per cent, with an <u>average reduction of just over 30%</u>. For example as the Figure 7.4 shows the corresponding change in electricity demand related to the change in temperature shown in Figure 7.3, a reduction in the order of 22-26%.

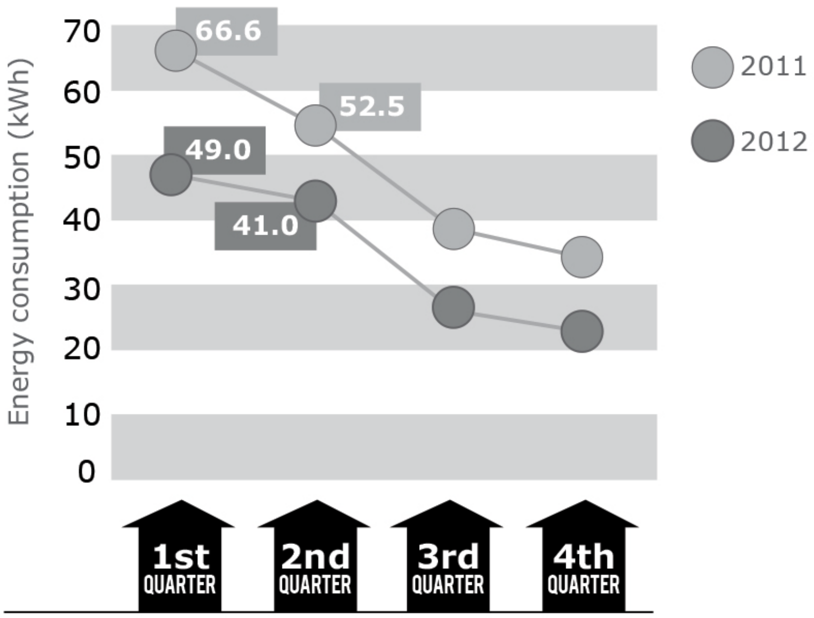


Figure 7.4: De-identified Average daily T11 electricity consumption before and after application of white coating on participant home Source: Based on data from Townsville City Council (TCC 2012a)

Figure 7.5 shows the change in summertime average daily energy demand across the 14 participants in the performance trial, and demonstrates that in each case energy savings were achieved.

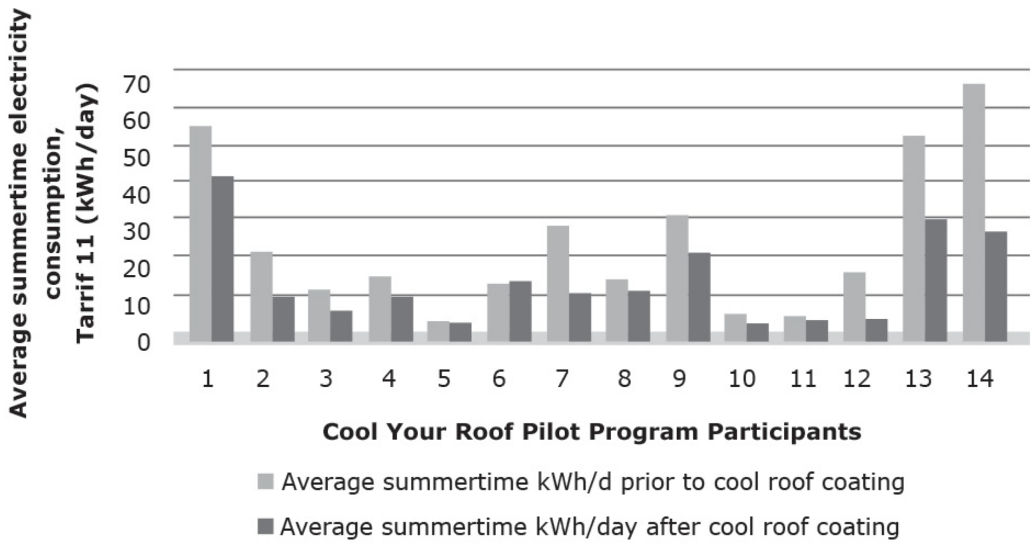


Figure 7.5: A summary of summertime quarterly energy bills of participants in the white roof performance trial

Source: Based on data from Townsville City Council (TCC 2012a)

It is important to note that as Tariff 11 is the general tariff for household electricity consumption other factors may also have contributed to the reduction in electricity use, including efficiency upgrades of other equipment and appliances (e.g. kitchen appliances, fridges, televisions) and more energy-efficient occupant behaviour that may have been encouraged by participation in the trial.

7.5 COMMUNITY PERCEPTION OF WHITE ROOF MESSAGING

Design of Community Consultation Process

Informed by the findings of the community focus groups, the community survey and the performance trial (as outlined previously) a series of 'Thematic Communications' were created by communication consultant, The Shannon Company, for Townsville City Council based on a brief developed by myself. The communications were intended to provoke the community to think about having a white roof and the associated benefits. The investigation into the effectiveness of the communications was designed in two main components, firstly a series of focus groups followed by community market testing. The focus groups involved members of the community that have not had their roof painted a white and explored their responses to the series of thematic communications. The second component involved the direct community market testing of the thematic communication messages as part of the '*Eco-Fiesta and Sustainable Lifestyle Expo*' in Townville over the 4th and 5th of June 2011. (TCC, 2011b)

The focus groups were designed, moderated, and analysed by myself, with support by Dr Desha and research assistants David Sparks, Omniya Baghdadi, and Angie Reeve, based on the focus group specification previously developed by Dr Desha as part of the project, and advised by Greg Bruce, Mark Robinson and Dylan Furnell from the Townsville City Council, along with staff of the Shannon Company. (TCC, 2012a) with the results included below. (TCC, 2010c) Following the focus groups the community market testing was undertaken as a two stage approach:

1) Community members were invited to enter a trade booth (set up with an entrance and separate exit), where the thematic communications messages were displayed one at a time, for approximately an hour each. Visitors were invited to enter the

booth, if they had not already done so of their own accord, and once they had reviewed the materials, were invited to participate in a brief exit survey that investigated their perceptions. (Participants were also invited to register interest for participation in the white roof performance trial).

2) On completion of the exit survey participants were asked to view all six of the thematic communication messages and identify the one they thought most encouraged them to have a white roof. A total of 94 participants voted on the six message boards.

Results of Community Market Survey

The following section provides a summary of the key findings from the community market survey and indicates how the thematic communications were amended following the investigation.

Message 1: "If your energy bills are going through the roof, that's the place to stop them."

Overall, responses to this message board were mixed. Some participants felt it was well targeted while others felt that it was 'wordy', 'cryptic' or 'unclear'. In general, participants did feel that it is relevant to the prevailing concern over rising electricity prices, however most sought a more explicit message and a quantification of the benefits (such as cost savings). As with most of the message boards, participants were sceptical of the claims, worrying about data being twisted and the misuse of statistics. Some suggested using an independent third party logo or endorsement to distinguish this from a marketing or sales pitch.

Exit survey respondents indicated that they understood the central concept being targeted in this message board and were slightly more likely to consider having their roof painted with a white roof product after viewing this message board. However, survey participants were about as likely to take some form of action as to take no action after viewing the message board. Participants who did intend to take some form of action after seeing this message board were as likely to seek more information as to engage a contractor.

Message 2: “Half of Townsville is saving 15% on their electricity, What about you?”

Participants generally responded favourably to this message board, approving of the factual nature and use of specific figures, even though the figure of 30% established as the average from the performance trial was halved for the purpose of the market testing. The colour scheme appealed, and some reported that they liked the simplicity of the arrows, which drew their attention. Participants generally were sceptical of the claims on this message board, doubting both the 15 per cent savings and that 50 per cent of Townsville households have painted their roof white already, and sought verification or evidence. One participant commented that the roof does not look like a Townsville roof, and this should be changed to ensure the poster resonates with residents, however other participants felt that it is a ‘*good local ad*’, that as people are already doing it, this is ‘*not a crazy idea*’.

Exit survey respondents indicated that they understood the central concept being targeted in this message board and were more likely to consider having their roof painted with a white roof product after viewing this message board. It prompted a higher proportion of survey participants to take some form of action after viewing it, compared with a number of the other message boards. The action most respondents were likely to take was to seek more information about white roofs.

Message 3: “Drops the temperature of your house – Lifts the value of your property”

Participants generally responded well to this message board, with comments such as that it ‘*makes sense*’, is ‘*factual*’, ‘*relevant*’, and that the simple message stays in their head. Participants generally liked the dual message of dropping temperatures and lifting house value, and some commented that this reduced their concerns over payback periods as there were other financial benefits from this behaviour. However, several participants noted that this benefit is only realised when selling the house, and hence wasn’t an incentive for them.

As for most message boards, several participants appeared to seek a more explicit message that quantified the benefits and gave more information. Also, participants noted that the message board looked commercial in nature, and suggested an independent third party endorsement. Exit survey respondents indicated that they understood the central concept being targeted in this message board and were slightly more likely to consider having their roof painted with a white roof product after viewing this message board. It prompted a high percentage of survey participants to take some form of action after viewing it. Particularly it prompted respondents to seek more information about white roofs.

Message 4: "Use your roof to cool your house... instead of your air-conditioner"

Participants generally did not respond well to this message board, with many feeling that the image of the mother and the baby does not relate to them, and most being unable to draw the link between reduced internal temperatures, reduced energy consumption, and happy families. Many reported feeling confused, and sought a more pragmatic, information-based message. Several participants interpreted the message board as saying that they would not need an air conditioner at all if they had a white roof, and were sceptical of this. One noted that the humidity in Townsville is such that air conditioners are needed to remove moisture, and others suggested that the temperatures are sufficiently high that a white roof would be unable to adequately cool the house.

Exit survey respondents had a mixed response to this message board. Respondents generally understood the central concept being targeted but some were sceptical of the image used and felt it confused the message or looked like an advertisement. The majority of respondents who viewed this message board were no more likely to have their roof painted with a white roof product after viewing this message. Survey participants were slightly less likely to take some form of action after viewing this message board.

Message 5: "Painting my roof now means I only use my air-conditioning half as often" Jane Citizen, Townsville

Participants were generally sceptical of the figures quoted in this message board, and sought verification and further quantification. ('*Jane citizen… appears to be a believable character, but still need something to back it up', 'figure pulled out of air. Half as often is hard to believe', 'references would lend credibility*'). Many participants did not resonate with the woman in this message board, with several participants commented that they felt this message board was targeting another demographic. However, others felt that she looked authoritative. Respondents responded favourably to the idea of using local residents and personalities with this message board concept (instead of a stock photo) and felt that real quotes would lend credibility. Participants appeared to seek a more explicit explanation of white roofs and the benefit, and did not appreciate the more subtle implications used in the message board.

Exit survey respondents indicated that they understood the central concept being targeted in this message board and were slightly more likely to consider having their roof painted white after viewing this message board. Respondents were slightly more likely to take some form of action after viewing this message board.

Message 6: "Changing the colour of your roof can change the quality of your life"

There were mixed responses to this message board, however in general participants did not appear to relate the image of baby to the concept of white roofs and enhanced quality of life. Participants made comments such as '*nothing to do with roofs at all'*, *'doesn't really reflect what it is advertising'*, *'what are they on about?'*, *'a bit over the top'*. Some seemed to find the baby cute and appealing, whilst others felt the baby was irrelevant. Younger participants without families in particular did not seem to connect with this message board. One participant appeared to be affronted by the suggestion that a white roof would improve the quality of the baby's life, as they interpreted an underlying suggestion that they would otherwise not be ensuring their baby is comfortable. They suggested that their baby would be comfortable, whether it was by using air conditioning or a white roof, hence this would not actually change the quality of their life. In general, participants appeared to understand the link between a white roof, cooler house, and improved quality of life however didn't feel that this would encourage them to paint their roof. The participants wanted practical information to allow them to weigh the costs and benefits for themselves.

Exit survey respondents indicated that they understood that the message board was communicating a message about white roofs and reduced indoor temperatures, but only one respondent made the 'sustainability' connection. Respondents were much less likely to consider having their roof painted with a white roof product after seeing this message board compared with other message boards. Respondents were also much less likely to take some form of action after viewing this message board.

Results of Favourite Message Vote

After the market testing and exit survey the participants were invited to view all six of the thematic communication messages and identify the one they thought most encouraged them to consider a white roof. A total of 94 participants voted on the six message boards. The findings suggested that the respondents between 20 – 50 years old preferred the '*Half of Townsville is saving 15% on their electricity, What about you?*' message board, whereas the 50 – 60 year olds preferred the '*Drops the temperature, lifts the value*' message board. Overall the findings as shown in Figure 7.6 suggest that the preferred message was '*Half of Townsville is saving 15% on their electricity, What about you?*' with just over 40 per cent of participants selecting this message board.

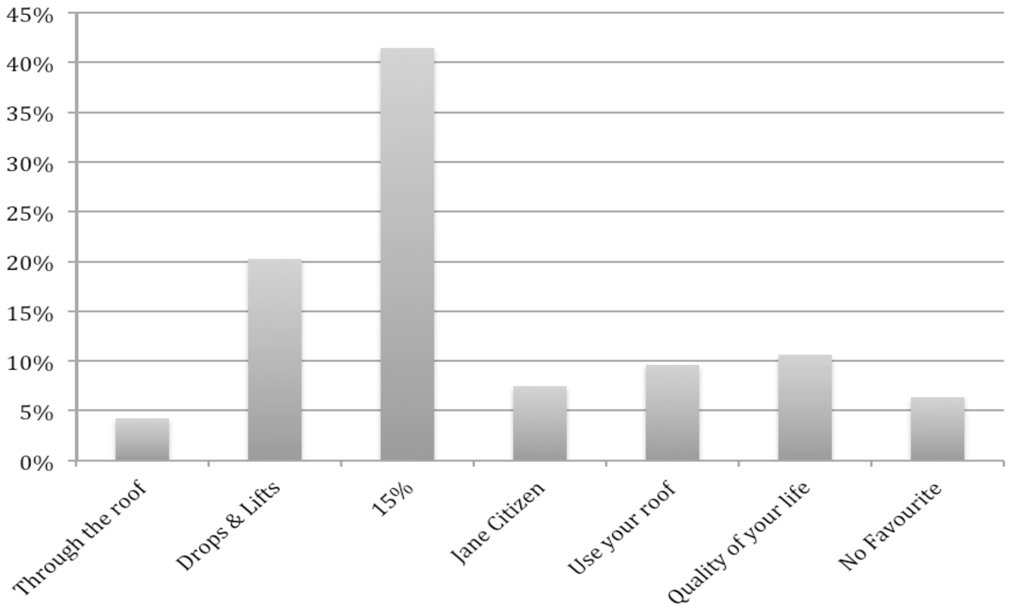
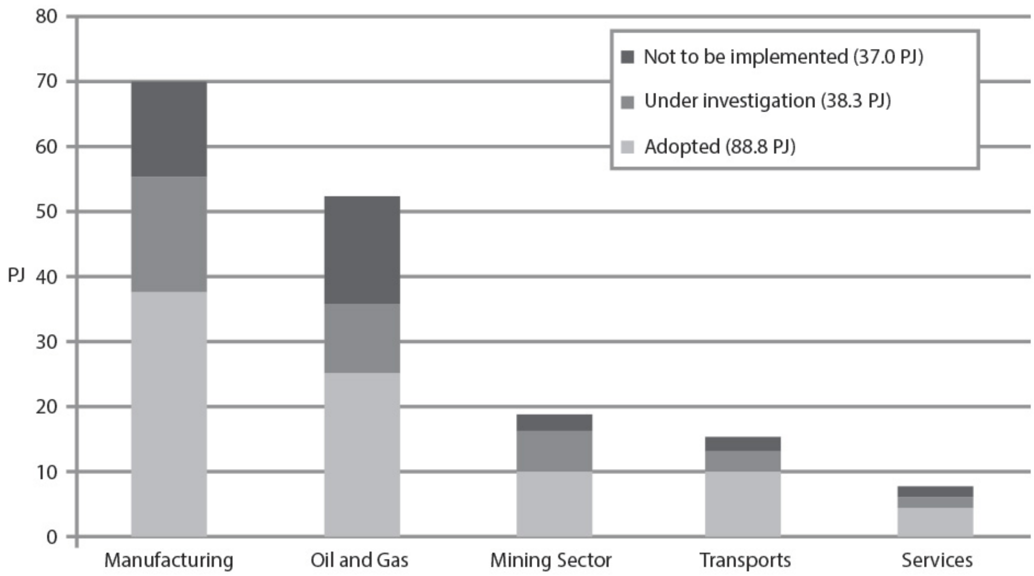


Figure 7.6: Results of Favourite Poster Vote

Source: Based on data from Townsville City Council (TCC 2012a)



The following is a summary of the responses of focus group and survey participants to the thematic communication message boards overall: (TCC, 2011b)

- Several of the thematic communication concepts had a positive impact on community members. In particular, the '15%' message board was positively received. However many respondents were sceptical of the effectiveness and energy saving potential of white roofs and sought verification.

- There was considerable scepticism and cynicism towards any figures given (such as the amount of energy that could be saved through using a white roof, the percentage of households who currently have a white roof, and the reduced amount of air conditioner usage). In general, participants displayed a lack of belief in the figures quoted, expressed a desire to see these verified or endorsed through an independent third party and/or wanted these to be better quantified. Discussions suggest that this scepticism is to a considerable extent the result of difficulties with previous government-led programs encouraging the installation of insulation, solar hot water heaters, and solar PV panels. There also appeared to be a common theme of mistrusting these figures where there is a perception that there may be a commercial interest (participants were wary of advertisements or being sold a product).

- Participants appeared to respond most favourably towards message boards that were more explicit and information based, as opposed to those that sought to evoke an emotional response to encourage white roof painting (such as to improve the quality of a child's life). Some participants understood the link between, for example, improved quality of life and a white roof, whilst others felt that these messages were not related to white roofs.

- Participants appeared most strongly motivated by messaging that promoted cost savings and increased house value. Participants responded well to the message board which suggested that a white roof could mitigate against rising power bills as they felt this was topical and would resonate with the community due to the current angst over electricity price increases.

- Images targeting certain demographics, such as older women and parents/carers of young children, appeared to polarise responses. Respondents frequently reported feeling disengaged or turned off by messaging intended for another demographic. Respondents furthermore appeared mildly cynical of 'heart-strings' messaging, such as using images of babies and mothers. This may have been overused in the marketing industry, causing participants to feel 'advertised to'. Results from the focus groups and exit survey suggest that the majority of viewers are generally much less likely to consider having their roof painted with a white roof product after viewing these types of posters.

In conclusion, the results of investigating the use of thematic communications to elicit responses from viewers indicate that participants sought a direct information based message that gave them key facts and figures, and/or explicit instructions, about white roofs rather than one which provoked an emotional response. This may be due to the community engagement processes, as: 1) most participants were already considering, or had decided, to paint their roof white or reflective, hence were at a stage where they were seeking information on how to go about this as opposed to encouragement to undertake the behaviour; and 2) focus groups and surveys tend to cause participants to overly analyse the message boards in order to make a contribution to the study.

7.6 AN EXAMPLE OF INFORMING CHANGES TO THE STRUCTURAL AREA OF 'STANDARDS AND CODES'

The primary goal of behaviour change programs is to encourage residents to undertake a preferred behaviour, as outlined above. A secondary outcome of such programs can be the increased willingness for the community to support changes to a number of structural areas related to such behaviours. In the case of the Townsville City Council program detailed in the previous parts the link between the community program and the willingness to adjust standards and codes related to roof colour was raised for further investigation (this investigation is being undertaken following the submission of the thesis and hence is not included).

However a research team led by myself and supported by research assistant David Sparks developed a report outlining the current level of '*components of government planning schemes and policies that require new urban developments to include minimum roof coating performance measures*' by national, state, and local government in Australia, in order to inform efforts to achieve structural change of development codes and standards to encourage white roofs. The 2012 investigation found that there were no policies or codes specifically related to white roofs in Australia. (TCC, 2012b)

When considering changes to standards and codes it is important to be specific about performance criteria of white roofs. A white roof decreases the flow of heat into a building in two ways, firstly by reflecting solar radiation that strikes the roof; and secondly by quickly re-radiating any heat that is absorbed. When considering changes to standards and codes related to the energy performance of roof coatings there are three metrics that can be used. As the performance of white roofs can diminish slightly with age and weather, internationally there has been a move towards specifying performance values measured three years after installation. (TCC, 2012b)

1. *Solar Reflectance*: Referring to the ability of the roof coating to reflect incoming solar radiation. High solar reflectance helps the roof to reflect solar energy, rather than absorb it, and this helps to reduce heat gain. Solar reflectance is rated on a scale from 0 to 1. A higher value indicates more reflectance (such as white roof coatings having a solar reflectance of around 80%, or 0.8) and a lower value

indicates that more of the incoming solar radiation is absorbed, heating the building (such as black roof coatings having a solar reflectance of around 5%, or 0.05).

2. *Thermal Emittance:* Referring to the ability of the roof to re-radiate absorbed solar energy. High thermal emittance helps the roofing material to cool down quicker after it gets hot. Thermal emittance is also rated on a scale from 0 to 1. A higher value indicates more emittance and is more desirable. A value of zero indicates that all absorbed heat is retained, rather than emitted. Light-coloured paints often have higher thermal emittance and generally perform better.

3. *Solar Reflectance Index (SRI):* Which incorporates both the solar reflectance and the thermal emittance into a single value and is rated on a scale from 0 to 100, with a higher value representing better energy performance, and less energy entering the building. It is noted that the use of the index is preferred in associated requirements as it provides slightly greater flexibility to achieve the performance requirement as a balance between the solar reflectance and the thermal emittance.

Hence dark colour roof coatings should be discouraged, except where the solar reflectance and thermal emittance of the product meets predefined performance limits similar to the abovementioned values. Uncoated metals often perform as poorly as dark materials due to their low thermal emittance and should also be discouraged. (TCC, 2012b) The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) have created standards that stipulate energy performance standards for non-residential and residential buildings. ASHRAE 90.1 recommends a Solar Reflectance Index (SRI) of 75 (ASHRAE, 2007b) and stipulates a minimum three year aged SRI of 64 (hence there is some flexibility as to the relative levels of the solar reflectance and the thermal emittance) (ASHRAE 2007a).

Putting such requirements in to practice the U.S. EPA requires that low-sloped roofing products have initial and three year aged solar reflectance not less than 0.65 and 0.50, respectively. Steep-sloped roofing products must have initial and three-year-aged solar reflectance not less than 0.25 and 0.15, respectively. In addition the Chicago Energy Conservation Code prescribes a three year aged solar reflectance value of 0.5 for low sloped roofs. (TCC, 2012b)

A further aspect important for consideration when designing changes to standards and codes related to the energy performance of roofs is to differentiate between solar reflectance and visible reflectance. The solar energy incident on a roof is comprised of ultraviolet, visible, and near-infrared wavelengths. Materials with high *solar reflectance* reflect well across all three types, particularly in the visible and near-infrared portions of the spectrum. Approximately half of the solar energy a roof receives is near-infrared, so it is important to reflect this energy. Where visual amenity or glare from roofs is a legitimate issue, some degree of flexibility may be introduced into provisions in order to facilitate the innovative use of high performance materials and skillful siting of buildings to mitigate adverse impacts on scenic amenity. This is preferable to imposing a blanket ban on all highly reflective building materials that can disregard high energy performance roof coatings and a performance-based policy may be appropriate.

7.7 CHAPTER SUMMARY AND CONTRIBUTION TO THESIS

The chapter begins by introducing the theoretical framework of 'Community Based Social Marketing' (CBSM) as the framework for considering the potential for voluntary community behaviour change programs to encourage the community to undertake preferred behaviours related to reducing greenhouse gas emissions as a way to increase general willingness to support carbon structural adjustment.

The chapter then outlines the central premise of the CBSM theoretical framework that behaviour change is most effectively achieved through initiatives delivered at the level of specific behaviours, informed by direct community engagement. The chapter then highlights two key considerations namely that:

1. Despite the allure of generic information based campaigns, they often lead to little behaviour change in the community, and

2. Despite the availability of a direct benefit from a voluntary change this will not guarantee high take up in the community.

The second part of the chapter then outlines the process that lead to the identification of specific community behaviours for further investigation. This process is based on the CBSM theoretical framework with amendments made by myself and research partner Dr Cheryl Desha (co-supervisor) in collaboration with the CBSM creator and staff from the Townsville City Council as outlined in the chapter. The chapter shows the findings of literature review (led by myself and undertake by research assistants) and expert consultation process to identify the potential impact and anticipated likelihood of 241 possible behaviours related to reducing greenhouse gas emissions related to fossil fuel consumption in the home. A strategy is then presented developed by myself and Dr Desha for the short-listing of behaviours for further investigation for inclusion in community behaviour change programs. The chapter then presents research findings related to the specific barriers and benefits of the short-listed behaviours (led by myself and undertaken by research assistants) that informed the selection of three target behaviours.

The third part of the chapter then presents findings from community engagement related to the perceptions of the level of strength of identified barriers for each of the three behaviours along with the level of interest in the associated benefits. The findings are based on a series of community focus groups (involving 75 residents of Townsville and co-moderated by myself) and a community survey (involving over 1200 residents of Townsville and co-designed and analysed by myself) that also investigated perceptions related to possible program tools.

The fourth part of the chapter presents the findings of a performance trial of the energy saving potential and temperature reduction effects of a white roof, before outlining a community consultation process to investigate the potential influence of six messages based on the findings presented previously in the chapter. This process enabled the Townville City Council to select messages for use in community programs. The final part of the chapter outlines a number of key considerations when designing changes to the structural areas of ‘Standards and Codes’, such as appropriate metrics and nomenclature to be used.

The contribution of this chapter to the thesis is that it demonstrates that a process of rigorous community engagement can identify key leverage points for encouraging behaviour change. In the absence of government leadership on reducing greenhouse gas emissions this is a critical understanding as it not only increases the likelihood of the community taking action to reduce their own greenhouse gas emissions but also stands to increases the general level of support for changes to structures associated with the behaviours (such as banning the installation of electric storage *hot water systems or increasing performance requirements for light bulbs leading to the phasing out of incandescent bulbs) from both the members of the community and those involved in the delivery of such programs, typically from government agencies and municipalities.*

Chapter 8: Curriculum Renewal of Higher Education Programs

The content in the following chapter is based on findings by from research projects based at Griffith University and the University of Adelaide, as noted throughout. I wish to thank Dr Cheryl Desha and Angie Reeve for stimulating through discussion the creation of some of the arguments contained in this chapter, identifying resources for consideration to develop such arguments, and for providing valuable peer review. I wish to thank Dr Doug Mackenzie-Mohr for his mentoring and peer-review.

8.1 A FOCUS ON ENGINEERING EDUCATION FOR ENERGY EFFICIENCY

This chapter outlines the findings of an investigation into encouraging curriculum renewal efforts in higher education to create willingness to adjust the specific structural area of education program accreditation to include greater coverage of low greenhouse gas emissions related knowledge and skills. Part of the findings are based on the application of 'Community Based Social Marketing' methodology, as outlined in Chapter 7 and presents the first such application to a professional community (Desha, Hargroves and Reeve, 2009). As outlined in Chapter 6, the updating of 'Education Program Accreditation and Requirements' is a key area of carbon structural adjustment - from primary school, through to university and vocation education, along with on the job training and professional development courses.

As previously highlighted by viewing the industrial revolution through the theoretical framework of the 'Wave of Innovation' there have been a number of significant advances in technology over the last 300 years that have delivered a step change in the way industry and society has operated. Each so called 'wave' has resulted in the renewal of education programs to include associated knowledge and skills, as shown in Figure 8.1. However with only the imperative of market demand driving such renewal it can typically be a lengthy process, as we pointed out in Desha and Hargroves (2012) by saying that, *'a typical process of undergraduate curriculum renewal … may take 3-4 accreditation cycles (of approximately 5-year intervals) hence 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.'*

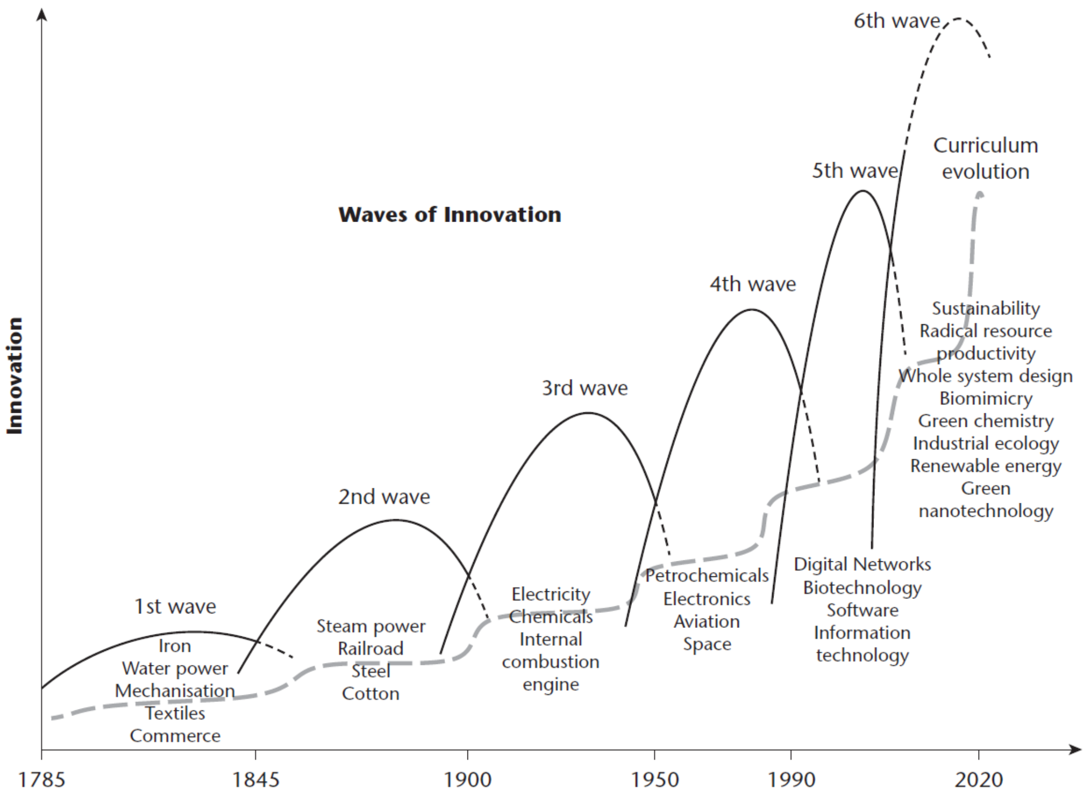


Figure 8.1: A schematic of curriculum renewal transitions resulting from significant waves of innovation since the Industrial revolution

Source: Adapted from Hargroves and Smith (2005) and presented in Desha and Hargroves (2011a)

Building on my undergraduate education as a civil engineer the following chapter presents the findings of an investigation into curriculum renewal in engineering education; however it is relevant to other built environment related higher education programs. To provide context for a focus on engineering education the following extract from the 2009 '*UNESCO Engineering: Issues and Challenges for*

Development' report by Desha and Hargroves (2009) provides a commentary on the journey of engineering education over this time.

> "*Engineering has gradually evolved to include environmental education in an engineer's training. At the time of the Industrial Revolution, an engineer's primary concern was the application of science fundamentals to engineering design (i.e. applied physics), for example with the mechanics of motion and combustion, as well as increasing the productivity of processes. This style of engineering acknowledged the 'environment', but only in as much as it provided energy, resources, and physical constraints, thus influencing design outcomes.*
>
> *Environmental education then evolved over the following 200 years, through what could be described as a number of 'generations' of engineering education, for example: The first generation of 'ad-hoc' environmental education in the mid to latter half of the twentieth century stemmed from the concern that some design outcomes could adversely affect the environment (for example with air and water pollution), following the release of seminal publications such as Silent Spring (Carson 1962), Limits to Growth (Meadows et al 1972), and Our Common Future (WCED 1987), and events such as the Bhopal chemical disaster in 1984, and the nuclear accident in Chernobyl in 1986. As engineering educators realized the need to address such issues within their courses or programmes, content was included within existing engineering degree programmes, often based on the interests and pursuits of individual academic staff.*
>
> *The second generation of 'Flagship' environmental education, from the 1980s to the end of the twentieth century, began to formalize such ad-hoc activities, as engineering departments began to react to increasing staff and community interest in the way engineering affects the environment. However, rather than integrating this set of knowledge and skills across engineering*

> *disciplines, the topic was isolated and allocated as a small component of the average engineering curriculum, and a specialist Environmental Engineering discipline and programme of study evolved to secure a place for most of the content and skills. It is conceivable that this placement of the topic in a separate discipline area was symptomatic of engineering education at the time, where full integration of any new content was difficult in a system that tended to accept and reward individual discipline efforts (in terms of administration, budgets and research funding) rather than integration. The third generation of 'Integrated' environmental education is currently underway with a growing number of leading engineering faculty members around the world beginning to understand that they must proactively integrate sustainability considerations into all engineering curriculum as appropriate, to address shifting regulatory, market, institutional, and graduate expectations.*" (Extract from Desha and Hargroves, 2009, in UNESCO, 2009)

This transition in engineering education to incorporate first environmental and more recently sustainable development related considerations represents progress of the discipline. However such efforts need to be accelerated as the education sector, and in particular engineering education, will need to provide society with graduates that can respond to significant threats such as climate change in a way that continues to strengthen economic development and social well-being. The typical timeframe of as long as 20-30 years to completely embed knowledge from a new wave of innovation into programs and produce graduates able to contribute to society will be too long (Desha and Hargroves, 2014).

For the first time in the history of higher education the timeframe to update the content of education programs needs to be accelerated across all institutions. There is little precedent for such acceleration and if a structural adjustment scale approach is considered a key mechanism will be the accreditation of higher education programs, as this is one of the few direct pressures on the content coverage of courses. Many professions have independent groups and institutions that provide assessment of course content to award accreditation, such as the Institution of Engineers Australia, and such requirements provide a structural lever for increasing the coverage of new knowledge and skills in higher education.

The topic of 'energy efficiency' was chosen as the area of focus for the thesis, along with much of my academic work over the last 15 years, as it is widely accepted to provide a significant opportunity for cost effective rapid reductions in greenhouse gas emissions,[17] such as:

- *Generating cost savings* by reducing the energy bills, extending the life of equipment by reducing operational loading, reducing operating times and levels of equipment and even allowing decommissioning of some unneeded equipment, and often reduces heat generated from equipment or lighting that adds load to the HVAC system.

- *Creating capital for investment* in the transition to the use of low/no carbon energy, often by investing in onsite renewable energy generation options that can harness waste heat from the existing system while providing security of supply for the operation of the building or plant.

- *Creating demand for new products and services* that will be needed around the world to assist industries and economies to reduce energy demand. This will translate into significant opportunities for Australian engineering firms that can innovate low/no carbon solutions ahead of international competition. (Desha, Hargroves, *et al*, 2009)

Increasing energy efficiency has gained significant attention over the last few decades, as governments and industries around the world have grappled with issues such as rapidly expanding needs for energy, the cost of supplying infrastructure to meet peak demand, the finite nature of fossil based energy reserves, and transition timeframes for expanding renewable energy supplies. This is of particular interest to engineering education as considering buildings, efficiency expert Joseph Romm explains that key to delivering improved energy efficiency of buildings is the understanding that the design phase is critical, pointing out that, '*Although up-front*

[17] MacNeill *et al*, 1991; Monbiot, 2006; Schaltegger and Synnestvedt, 2002; Schmidheiny, 1992; Halliday *et al*, 1996; von Weizsäcker *et al*, 1997; Lovins and Lovins, 1997; Hawken, Lovins, and Lovins, 1999; Engineers Australia, 2001; Schaltegger and Synnestvedt, 2002; Schmidheiny and Watts, 2002; McDonough and Braungart, 2002; Innovest Strategic Value Advisors, 2004; Jochem (*ed*), 2004; Hargroves and Smith , 2005; Stern, 2006; UK Treasury, 2006; von Weizsäcker and Hargroves, *et al*, 2009; The World Bank, 2013.

building and design costs may represent only a fraction of the building's life-cycle costs, when just 1 per cent of a project's up-front costs are spent, up to 70 per cent of its life-cycle costs may already be committed'. (Hawken, Lovins, and Lovins, 1999)

As pointed out in the book '*Whole System Design: An Integrated Approach to Sustainable Engineering*' (Stasinopoulos, Smith, Hargroves, and Desha, 2008) the cost of making changes increases significantly through the design and construction process, and as such it is important that early in the concept design phase opportunities for energy efficiency are identified and incorporated into the design rather than retrofitted at a later date, especially as buildings and civil infrastructure are designed with an operational life of some 50-100 years. (Stasinopoulos, *et al*, 2008)

A key part of a design approach to improve energy efficiency is to consider the potential for compounding energy efficiency savings. Energy efficiency expert Alan Pears uses the example of an electric motor driving a pump that circulates a liquid around an industrial site (Pears, 2004). If each element in the chain is improved in efficiency by 10 percent, the overall efficiency is not improved by 10 per cent but rather 47 per cent as the overall efficiency is the product of the component efficiencies: 0.9 x 0.9 x 0.9 x 0.9 x 0.9 x 0.9 = 0.53. Applying this systems approach can deliver significant energy demand savings, such as: (Stasinopoulos, *et al*, 2008)

- By focusing first on reducing both the mass of a passenger vehicle and the aerodynamic drag by 50% this can reduce rolling resistance by 65%; making a fuel cell propulsion system viable and cost effective, and delivering significantly better fuel consumption per kilometre.

- By using the right-sized energy efficient components to reduce generated heat, a computer server can be designed to have 60% less mass and use 84% less power than the equivalent server, which would reduce cooling load in a data centre by 63%.

A key outcome of a focus on energy efficiency is that it often also delivers multiple benefits across the system can be often overlooked. For example energy efficient cleaning systems may use less water and detergents, light-weighting vehicles to improve fuel efficiency may reduce material consumption, reducing cooling loads in a building through external shading may extend the operating life of air-conditioning equipment, reducing pumping loads in a system may lead to decommissioning of unneeded pumps, reducing residential energy demand during peak times can significantly reduce overall capacity requirements and defer infrastructure upgrades.

The selection of energy efficiency as the focus for this part of the thesis investigation was also in-line with government and industry focus in Australia during the period of the thesis. According to the Australian Government Department of Industry, '*Energy efficiency is widely recognised as the simplest and most cost-effective way to reduce Australia's greenhouse gas emissions and manage rising energy costs… Engineers play a key role in improving energy efficiency by designing and installing energy efficiency measures and technologies, particularly in companies that use large amounts of energy. Equipping engineers with sound energy efficiency knowledge and skills will enable them to better identify and implement significant energy efficiency opportunities.*' (Commonwealth of Australia, 2013a)

As mentioned in Chapter 3, in 2006 the Australian Government created the Energy Efficiency Opportunities (EEO) Act with the objective to '*improve the identification, evaluation, and public reporting of energy efficiency opportunities by large energy-using businesses, to increase the uptake of cost effective energy efficiency opportunities*' (Commonwealth of Australia, 2013c). The EEO Act was applicable to corporations that used over 0.5 petajoules of energy per year; this represented some 300 companies and just over half of Australia's total energy use. Participating companies were required to undertake an energy efficiency assessment and report to the government on the findings. Between 2006 and June 2011 participants in the program <u>identified the potential for annual energy savings of 164.2 PJ</u> through a focus on energy efficiency across each major sector, as shown in Figure 8.2. As part of the program <u>89 PJ of energy was saved</u>, the equivalent of 24 billion kWh's per year.

This energy saving is estimated to have resulted in an annual economic benefit of just over $800 million, with the majority of investments to achieve the energy savings having either a 1 year or 2 year return on investment (Commonwealth of Australia, 2013c). The significance of this program for engineering education is that it signals energy efficiency as an important graduate attribute with the largest energy using companies in the country having developed processes to undertaken energy efficiency. The participants in the program listed an aggregate of 38.3 PJ of energy saving opportunities (or some 10 billion KWh per year) as being 'under investigation', meaning that graduates can differentiate themselves by ensuring they are well versed in energy efficiency. This is being reflected in employer preferences with a 2012 survey led by myself and Dr Desha finding that in Australia, '*6 out of 10 of the largest engineering companies operating in Australia are providing in-house training on energy efficiency to supplement their formal training, and 4 out of 10 have included energy efficiency requirements in graduate recruitment*'. (Desha, Hargroves, and El Baghdadi, 2012)

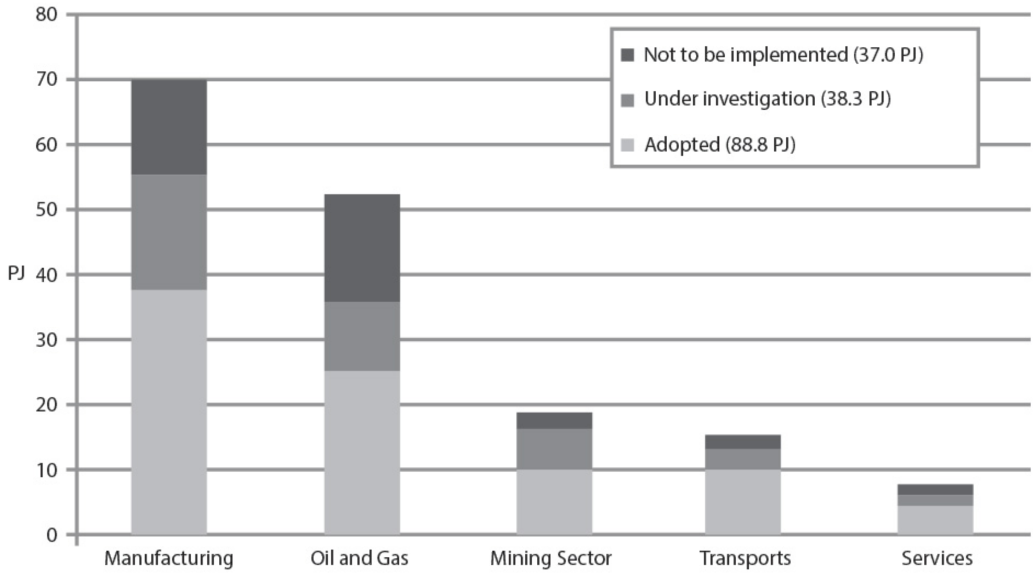


Figure 8.2: Summary of energy efficiency achievements in by participants in the Australian Government Energy Efficiency Opportunities (EEO) program (2006-11) (Commonwealth of Australia, 2013c)

8.2 A LONGITUDINAL STUDY OF ENGINEERING EDUCATION ON ENERGY EFFICIENCY

In order to identify a baseline level of inclusion of energy efficiency related knowledge and skills in engineering education programs in Australia, myself and Dr Desha led an investigation funded by the Australian 'National Framework for Energy Efficiency' (NFEE) in 2007 based at Griffith University. This baseline provides guidance on perceived coverage of specific areas of knowledge and skills related to energy efficiency to inform efforts to increase such coverage.

Responses were received from 82% of Australian universities teaching engineering education in every state and territory. The overall findings of the survey suggested that energy efficiency education was ‘*highly variable’* and largely ‘*ad hoc’,* and concluded that there is ‘*an urgent need to embed energy efficiency knowledge and skills into engineering curriculum, beyond once-off courses, special interest topics in later years, or highly specialised masters programs’.* (Desha and Hargroves *et al*, 2007) The findings also suggested that:

– ‘*Energy efficiency education was not embedded widely across engineering disciplines, and further the level of integration of topical energy efficiency issues into courses appeared to be very low.*

– *Energy efficiency education across most disciplines appeared to be based on the individual interests and research pursuits of the academic staff involved, rather than strategic integration across the department, faculty or university.*

– *Of those courses where lecturers said more could be done, lecturers were keen to receive assistance, particularly through accessing case studies on energy efficiency examples in engineering (i.e. worked real-life examples that show how the theory and knowledge is applied).*’ (Desha and Hargroves *et al*, 2007)

Considering the coverage of specific knowledge and skills related to energy efficiency the survey asked engineering educators to indicate if a both a set of nominated ‘topics’ and a set of nominated ‘concepts and principles’ were ‘mentioned’ or covered ‘in detail’ with the results shown in Table 8.1 and 8.2. The nomination of the options was based on comprehensive literature review undertaken by myself and co-authors (Hargroves and Smith, 2005; Stasinopoulos, Smith, Hargroves, and Desha, 2008; von Weizsäcker and Hargroves *et al*, 2009; Smith, Hargroves and Desha, 2010)

Table 8.1: Engineering educator's perception of the level of coverage of key energy efficiency topics in courses in Australia in 2007

Topic	In Detail	Mentioned	Total
Undertaking energy auditing and energy assessment	25%	25%	**50%**
The quantification of the economic benefits of energy efficiency	15%	31%	**46%**
Synergies between energy efficiency and other aspects of environmental performance	17%	29%	**46%**
The difference between 'Peak' and 'Base' energy load	17%	21%	**38%**
The link between energy and greenhouse gas emissions	15%	18%	**33%**
The identification of energy efficiency opportunities	8%	15%	**23%**
The ability to communicate the business case for energy efficiency	8%	8%	**16%**

Source: Desha and Hargroves *et al* (2007)

Table 8.2: Engineering educator's perception of the level of coverage of key energy efficiency concepts and principles in courses in Australia in 2007

Concept / Principle of Consideration	In Detail	Mentioned	Total
Efficiency, resource efficiency, and energy efficiency	40%	44%	**84%**
Energy efficiency & low carbon technologies (renewable)	29%	33%	**62%**
Energy generation, transmission and distribution losses	33%	27%	**60%**
Climate neutrality or emission mitigation	19%	35%	**54%**
Fundamentals of thermodynamics	27%	25%	**52%**
Energy efficiency & low carbon technologies (fuels)	25%	27%	**52%**
Sustainable energy supply - energy storage	17%	31%	**48%**
Heat transfer management (insulation and thermal capacity)	23%	21%	**44%**
Distributed generation of electricity	17%	27%	**44%**

(transmission losses)			
Life Cycle Analysis / Assessment	10%	33%	**43%**
Sustainable energy supply - standby energy	10%	25%	**35%**
Embedded energy of materials	6%	27%	**33%**
Performance at part and full load	10%	23%	**33%**
Incremental efficiency versus whole system design (for overall efficiency gains)	4%	27%	**31%**
Link between friction losses and energy consumption	9%	20%	**29%**
Resource productivity	4%	23%	**27%**
Product stewardship and responsibility	4%	17%	**21%**
Energy management of electronic components and systems	6%	15%	**21%**
Embedded water in energy generation	6%	13%	**19%**
Decoupling energy utility profits from kilowatt-hours sold	0%	17%	**17%**
Embedded energy of water distribution	8%	8%	**16%**

Source: Desha and Hargroves *et al* (2007) and Hargroves and Desha (2011)

The findings that a significant effort needs to be made to renew engineering education programs in the coming decade to increase the coverage of energy efficiency it is important to gain insight into the areas that engineering educators perceive as being important graduate attributes.

Informed by these findings, in 2009 the federal government commissioned research to identify energy efficiency assessment related capacity building gaps in industry to inform the governments ‘Energy Efficiency Opportunities’ (EEO) Program (GHD, 2010). The research included a series of surveys facilitated by GHD and prepared by Murdoch University, Griffith University (led by myself), Queensland University of Technology, and Sustainable Solutions Pty Ltd. The investigation surveyed over 100 companies who participated in the EEO program to investigate if they had the skills required to undertake an energy efficiency assessment, as per the EEO Assessment Framework. This framework requires companies to measure and analyse energy use using energy modelling techniques such as an energy mass balance, and find energy losses in a process, facility or activity area in order to identify, investigate, evaluate, make the business case for and report on energy use and energy efficiency opportunities in an energy using entity over time.

The findings of the research showed the greatest unmet demand for skills in understanding energy use was around the analysis of energy use data, namely:

– Identifying potential opportunities (*perceived by 83% of the engineering educators surveyed above as having ‘very high’ or ‘high’ importance, with the perceived level of coverage in detail of 22% of the associated courses in 2011*),

– Evaluating costs and benefits for inclusion into business cases (*perceived by 71% of the engineering educators surveyed above as having ‘very high’ or ‘high’ importance, with the perceived level of coverage in detail of 20% of the associated courses in 2011*), and more specifically,

– Technical calculations required to develop energy mass balances (*perceived by just over half, some 57%, of the engineering educators surveyed above as having ‘very high’ or ‘high’ importance, with the perceived level of coverage in detail of 17% of the associated courses in 2011*).

The 2009 survey also investigated whether the training sector was effectively delivering training related to energy efficiency assessments by asking respondents to indicate their perception of the level of competency in university of TAFE graduates employees as either:

1. Fully competent to undertake key tasks and follow up queries

2. Sufficiently competent to undertake key tasks with limited follow-up queries

3. Not competent – further training required

The of the 21 industry respondents 81% indicated that graduate employees were not competent in energy efficiency assessments, 19% indicated that graduate employees were sufficiently competent, and none indicated that graduate employees were fully competent. This suggests that there is a significant gap in education programs in the area of energy efficiency assessments, a key aspect of achieving a transition to low greenhouse gas emissions, with respondents identifying three areas that they regularly found skills gaps in university and TAFE graduates as (in priority order):

1. Energy efficiency and opportunity identification (47% indicating most common skills gap),

2. Engineering understanding and process analysis (15% most common),

3. Non-conventional financial analysis - whole of business cost benefits analysis (10% most common).

In response to such skills gaps respondents indicated that they were undertaking capacity building in both technical knowledge and managing energy efficiency assessment processes with a strong preference for informal on the job training and internal face to face workshops or training sessions. Using the 2007 and 2009 studies as a baseline the chapter presents the findings of an investigation of ways to encourage and support the greater inclusion of energy efficiency related material in engineering education programs.

Building on from the 2007 baseline study into the perceived coverage of energy efficiency in engineering education a second study was undertaken in 2011 to create a longitudinal assessment of the shift in perceived coverage, and included questions related to the perceived importance of the topics, concepts and principals. The study was commissioned by the Australian Government Department of Resources, Energy and Tourism (Hargroves and Desha, 2011). The intention of the 2011 survey received responses from 17 of 32 universities, with the findings compared to the findings of the 2007 survey in Tables 8.3 and 8.4. Both the 2007 and 2011 surveys provide valuable insight into the perceptions of engineering educators on the level of coverage of energy efficiency content, with Table 8.3 presenting a comparison of the findings related to key topics and Table 8.4 of associated concepts and principles.

Table 8.3: A longitudinal study of engineering educator’s perception of the level of coverage of key energy efficiency content in current courses

Topic of Consideration	In Detail		Mentioned		Total	
	2007	2011	2007	2011	**2007**	**2011**
The link between energy and greenhouse gas emissions	15%	34%	18%	37%	**33%**	**71%**
The identification of energy efficiency opportunities	8%	22%	15%	58%	**23%**	**80%**

The quantification of the economic benefits of energy efficiency	15%	20%	31%	54%	**46%**	**74%**
Synergies between energy efficiency and other aspects of environmental performance	17%	23%	29%	43%	**46%**	**66%**
Undertaking energy auditing and energy assessment	25%	14%	25%	51%	**50%**	**65%**
The ability to communicate the business case for energy efficiency	8%	14%	8%	40%	**16%**	**54%**
The difference between ‘Peak’ and ‘Base’ energy load	17%	14%	21%	40%	**38%**	**51%**

Source: Desha and Hargroves *et al* (2007) and Hargroves and Desha (2011)

Table 8.4: Respondents’ perception of the level of coverage of energy efficiency concepts and principles in their courses

Concept / Principle of Consideration	**In Detail**		**Mentioned**		**Total**	
	2007	2011	2007	2011	2007	2011
Efficiency, resource efficiency, and energy efficiency	40%	31%	44%	46%	**84%**	**77%**
Life Cycle Analysis / Assessment	10%	23%	33%	49%	**43%**	**72%**
Heat transfer management (insulation and thermal capacity)	23%	23%	21%	46%	**44%**	**69%**
Product stewardship and responsibility	4%	26%	17%	31%	**21%**	**57%**
Climate neutrality or emission mitigation	19%	18%	35%	47%	**54%**	**65%**
Fundamentals of thermodynamics	27%	23%	25%	34%	**52%**	**57%**
Energy generation, transmission and distribution losses	33%	23%	27%	34%	**60%**	**57%**
Energy efficiency & low carbon technologies (renewable)	29%	23%	33%	31%	**62%**	**54%**
Sustainable energy supply - energy storage	17%	15%	31%	44%	**48%**	**59%**
Distributed generation of electricity (transmission losses)	17%	11%	27%	43%	**44%**	**54%**
Incremental efficiency versus whole system design (for overall efficiency gains)	4%	18%	27%	27%	**31%**	**45%**
Energy efficiency & low carbon technologies (fuels)	25%	14%	27%	29%	**52%**	**43%**
Resource productivity	4%	11%	23%	33%	**27%**	**44%**
Link between friction losses and	9%	6%	20%	37%	**29%**	**43%**

energy consumption						
Embedded energy of materials	6%	14%	27%	20%	**33%**	**34%**
Embedded water in energy generation	6%	6%	13%	34%	**19%**	**40%**
Sustainable energy supply - standby energy	10%	6%	25%	31%	**35%**	**37%**
Embedded energy of water distribution	8%	3%	8%	34%	**16%**	**37%**
Performance at part and full load	10%	9%	23%	20%	**33%**	**29%**
Decoupling energy utility profits from kilowatt-hours sold	0%	6%	17%	23%	**17%**	**29%**
Energy management of electronic components and systems	6%	0%	15%	34%	**21%**	**34%**

Source: Desha and Hargroves *et al* (2007) and Hargroves and Desha (2011)

Considering the findings of the longitudinal study shown in Table 8.3 and 8.4, apart from a few topics there has been a consistent increase in the perceived level of coverage of each of the topics, concepts, and principles investigated. This suggests that in the 5 years between the surveys engineering educators have been undertaking efforts to renew curriculum to include such topics. These results may be attributed to the fact that, as described in Chapters 2-4, during this time responding to climate change and reducing greenhouse gas emissions has received significant profile – in particular the release of the Stern Review (2006) and the film '*An Inconvenient Truth*' (Gore, 2006), along with the topic playing a lead role in national political debate and election campaigning in Australia at the time.

The release of the film '*An Inconvenience Truth*' provided a laypersons summary that the community could understand and demystified much of the debate, with promotion efforts including the training of community climate change advocates around Australia. Such influences may be part of the reason why the results show strong increases in coverage of the key topics, shown in Table 8.3, such as the '*link between energy and greenhouse gas emissions*' increasing in perceived coverage from 15% to 34% in detail and 18% to 37% having been mentioned, representing a combined increase from 33% to 71% in just 5 years.

Considering the findings in Table 8.4 several concepts and principles appear to have gained more attention, including:

- Product stewardship and responsibility
  (4% up to 26% in detail and 17% up to 31% mentioned)

- Life Cycle Analysis / Assessment
  (10% up to 23% in detail and 33% up to 49% mentioned)

- Heat transfer management (insulation and thermal capacity)
  (23% in detail in both years and 21% to 46% mentioned)

- Incremental efficiency versus whole system design (for overall efficiency gains)
  (4% up to 18% in detail and 27% mentioned in both years)

- Embedded energy of materials
  (6% up to 14% in detail and 27% down to 20% mentioned)

- Resource productivity
  (4% up to 11% in detail and 23% up to 33% mentioned)

- Decoupling energy utility profits from kilowatt-hours sold
  (0% up to 6% in detail and 17% up to 23% mentioned)

And a few concepts/ principles appear to have lost some ground, for example:

- Efficiency, resource efficiency, and energy efficiency
  (40% down to 31% in detail and 44% down to 34% mentioned)
- Energy efficiency and low carbon technologies (fuels)
  (25% down to 14% in detail and 27% up to 29% mentioned)

Overall, since 2007 the survey findings suggest that there has been an increase in the perceived level of coverage of the key topics, concepts, and principles related to energy efficiency. However the average perception that an area was covered in-detail in courses was just 16%, with the average perception that an area was mentioned in courses some 38%. This suggests that some 60% of engineering education programs in Australia do not cover key topics, concepts or principles related to energy efficiency. This presents a significant skills gap related to the countries response to climate change, and presents an urgent challenge for carbon structural adjustment. Hence as part of an agenda of carbon structural adjustment it is very likely, considering the findings from the surveys in Australia, that engineering education programs around the world will need to make significant changes to programs to prepare graduates to assist society to respond to climate change.

Having identified areas of low perceived coverage in engineering programs the 2011 survey then asked participants to indicate the level of perceived importance of each of the lists (shown in Table 8.5 and 8.6) to compare to the perceived level of coverage. These findings allow for the identification of topics that have a high perceived importance (which is very important to gain buy-in from academics teaching courses) and low current coverage in order to highlight the scale of the challenge and prioritise curriculum renewal efforts.

Table 8.5: Respondents' perception of the importance of key EE topics (ordered based on results for 'very high')

Key Topics	**Very High**	**High**	**Med**	**Low**	**Very Low**
The link between energy and greenhouse gas emissions	43%	31%	17%	6%	3%
The identification of energy efficiency opportunities	37%	46%	11%	6%	0%
Synergies between energy efficiency and other aspects of environmental performance	36%	28%	22%	8%	6%
The ability to communicate the energy efficiency business case	31%	40%	23%	6%	0%
The quantification of the economic benefits of energy efficiency	31%	29%	40%	0%	0%
Undertaking energy auditing and energy assessment	20%	40%	29%	11%	0%
The difference between 'Peak' and 'Base' energy load	11%	31%	46%	9%	3%

Source: Hargroves and Desha (2011)

Table 8.6: Respondents' perception of the importance of EE concepts and principles

Concepts and Principles	**Very High**	**High**	**Med**	**Low**	**Very Low**
Efficiency, resource efficiency, and energy efficiency	44%	50%	6%	0%	0%

Life Cycle Analysis / Assessment	37%	40%	20%	3%	0%
Heat transfer management (particularly insulation and thermal capacity)	35%	38%	21%	6%	0%
Energy efficiency & low carbon technologies (renewable energy)	37%	37%	14%	9%	3%
Energy efficiency & low carbon technologies (fuels)	27%	44%	21%	6%	3%
Energy generation, transmission and distribution losses	26%	46%	20%	0%	9%
Sustainable energy supply - energy storage	17%	54%	23%	3%	3%
Incremental efficiency versus whole system design (for overall efficiency gains)	31%	34%	20%	9%	6%
Energy recovery	11%	63%	17%	6%	3%
Embedded energy of materials	17%	46%	31%	3%	3%
Distributed generation of electricity (reducing transmission losses)	15%	53%	21%	6%	6%
Energy Mass Balances	20%	34%	37%	9%	0%
Fundamentals of Thermodynamics	22%	39%	22%	11%	6%
Climate neutrality or emission mitigation	17%	49%	17%	9%	9%
Energy security	23%	34%	26%	11%	6%
Embedded energy of water distribution	17%	37%	34%	11%	0%
Sustainable energy supply - standby energy	11%	46%	31%	11%	0%
Product stewardship and responsibility	26%	34%	14%	20%	6%
Embedded water in energy generation	18%	38%	29%	9%	6%
Resource productivity	17%	29%	40%	11%	3%
Energy rating	11%	43%	29%	11%	6%
Link between friction losses and energy consumption	11%	34%	40%	11%	3%
Energy management of electronic components and systems	11%	29%	43%	11%	6%
Decoupling energy utility profits from kilowatt-hours sold	17%	31%	20%	17%	14%
Performance at part and full load	3%	40%	37%	11%	9%

Source: Hargroves and Desha (2011)

When comparing the areas that were perceived to have the greatest importance with their perceived level of coverage in current programs a number of key findings emerged. In particular the following list shows the key topics ranked by perceived importance (from highest to lowest) and indicates the percentage of respondents that indicated that the area was not covered at all in programs/courses:

- The link between energy and greenhouse gas emissions (74% of respondents indicated it was of either high or very high importance, and 29% indicated it was <u>not mentioned at all</u> in programs),
- The identification of energy efficiency opportunities (83% important and 19% not mentioned),
- Synergies between energy efficiency and other aspects of environmental performance (64% important and 34% not mentioned),
- The ability to communicate the energy efficiency business case (71% important and 46% not mentioned),
- The quantification of the economic benefits of energy efficiency (60% importance and 26% not mentioned),
- Undertaking energy auditing and energy assessment (60% important and 34% not mentioned), and
- The difference between ‘Peak’ and ‘Base’ energy load (42% important and 49% not mentioned).

Secondly considering the concepts and principles related to energy efficiency. The following list shows the seven concepts and principles that ranked the highest in perceived importance (from highest to lowest) and indicates the percentage of respondents that indicated that the area was not covered at all in programs/courses:

- Efficiency, resource efficiency, and energy efficiency (94% of respondents indicated it was of either high or very high importance, and 23% indicated it was not mentioned at all in programs),
- Life Cycle Analysis / Assessment (77% important and 29%),

- Heat transfer management (particularly insulation and thermal capacity) (73% important and 31% not mentioned),
- Energy efficiency & low carbon technologies (renewable energy) (74% important and 46% not mentioned),
- Energy efficiency & low carbon technologies (fuels) (71% important and 57% not mentioned),
- Sustainable energy supply - energy storage (72% important and 41% not mentioned), and
- Energy generation, transmission and distribution losses (71% important and 43% not mentioned).

Further to the concepts and principles considered of high importance that were perceived to not be covered in courses, a number of them were considered to have low coverage in programs/courses. Further to the highly important topics above this list provides a key indication of the size of the gap in current curriculum to support carbon structural adjustment.

- Energy security (*34% high and 23% very high importance, but only 6% covered in detail*),
- Embedded energy of water distribution, (*38% high and 17% very high importance, and 3% covered in detail*),
- Energy recovery (*63% high and 12% very high importance, and 12% covered in detail*),
- Energy efficiency & low carbon technologies (fuels) (*44% high and 27% very high importance, and 14% covered in detail*),
- Embedded energy of materials (*46% high and 17% very high importance, and 14% covered in detail*),
- Sustainable energy supply - standby energy (*46% high and 12% very high importance, and 18% covered in detail*),

- Embedded water in energy generation (*38% high and 17% very high importance, and 6% covered in detail*),

- Incremental efficiency versus whole system design (*for overall efficiency gains) (34% high and 31% very high importance, and 18% covered in detail*),

- Energy management of electronic components and systems (*29% high and 11% very high importance, and not covered in detail by any respondents programs/courses*), and

- Energy efficiency & low carbon technologies (renewable energy) (*37% high and 37% very high importance, and 23% covered in detail*).

The findings suggest that even though the key topics, concepts, and principles investigated in the surveys have been identified by lecturers as being important there is a clear gap in the coverage of such content in the majority of programs/courses. This presents a significant challenge for carbon structural adjustment, as for instance the ability to undertake energy assessments is a core part of a company's ability to cost-effectively reduce its greenhouse gas emissions, however the survey results show that despite a very high level of agreement on its importance (40% high and 20% very high), '*undertaking energy auditing and energy assessment*' ranked very low in coverage in 2011, with only 14% covering the topic in detail.

8.3 IDENTIFICATION AND INTERROGATION OF OPTIONS TO INCREASE THE COVERAGE OF ENERGY EFFICIENCY

The findings above suggest that there is a significant need to increase content related to energy efficiency in engineering programs. This is a likely proxy for other climate change related content in engineering programs, and is also a likely proxy for the coverage of such content in education programs in other professions. When considering ways to increase the coverage of preferred content, such as changes to 'Education Program Accreditation and Requirements' it will be crucial to consider options to assist educators to do so and prepare to meet more stringent requirements. Building on the previous findings presented, in 2009 a research team led by myself and co-supervisor Dr Cheryl Desha was commissioned by the National Framework for Energy Efficiency (NFEE) to investigate options to increase energy efficiency content for both undergraduate and postgraduate engineers (Desha, Hargroves, and Reeve, 2009).

When searching for an appropriate model to base an investigation on the availability of such tools in engineering education the methodology of '*Community Based Social Marketing*' (CBSM) was identified and selected (McKenzie-Mohr, 2007). This methodology, outlined in Chapter 8, was designed to support the development of community behaviour change programs, however it also provided a unique basis for investigating the potential to support engineering educators to adopt behaviours that would lead to an increased coverage of energy efficiency. This is the first application of the CBSM methodology to a specialised community of engineering educators and the process was mentored by the methodology's creator, Dr Doug McKenzie-Mohr.

The following part outlines the key findings of research on identifying ways to support engineering educators, and inform other higher education educators, in order to increase the willingness to support changes to education program accreditation requirements. As outlined above, the project methodology involved a multi-stage process, including a literature review, survey, and the application of the relevant parts of the CBSM methodology, namely:

1. "Identification of a list of 19 <u>desired behaviours</u> (i.e. 'actions', or 'options') that lecturers could undertake to increase the extent of energy efficiency in the curriculum,

2. Identification of the <u>impact and likelihood of each of the 19 options</u>, based on a literature review and national survey of engineering educators teaching courses involving energy related content,

3. <u>Short-listing the 19 options</u> to consider 10 in more detail, through phone and email consultation, with a cohort of 23 engineering educators from across Australia,

4. Investigation of the <u>barriers and benefits to the 10 shortlisted options</u> relevant to the current Australian higher education context." (Desha, Hargroves, and Reeve, 2009)

The first step in applying the CBSM methodology was the identification of a range of feasible 'behaviours' that engineering educators could be encouraged and supported to undertake, referred to as 'options' for the purpose of the study. The initial list of such options was drawn from the 2007 survey outlined above (Desha and Hargroves *et al*, 2007) and was amended through a comprehensive literature review and interviews with engineering educators (undertaken by Dr Desha and Angela Reeve and reviewed by myself). The final list was peer reviewed through phone interviews by Dr Desha with 13 energy educators across the country, and finally through review by Dr Doug Mackenzie-Mohr, to create the following 19 options as the base of the investigation:

1. Include a case study on energy efficiency,
2. Include a guest lecturer to teach a sub-topic,
3. Offer supervised research topics on energy efficiency themes,
4. Offer industry placements in energy efficiency (Work Integrated learning),
5. Offer energy efficiency as a problem-based learning topic,
6. Include assessment that aligns with the energy efficiency theme within the course (e.g. exam questions and assignments),
7. Include tutorials that align with the energy efficiency theme in the course (e.g. presentations/ discussions/ problem solving),
8. Show a DVD of a related documentary,
9. Overhaul the course to embed energy efficiency,
10. Include one workshop on energy efficiency in the course (i.e. laboratory-style experiments),
11. Include a field trip related to energy efficiency,
12. Add energy efficiency readings to the required reading list,
13. Show a DVD of a keynote lecture on energy efficiency,

14. Develop a new course on energy efficiency,

15. Include a topic-specific lecture set (i.e. a sub-topic) within the course,

16. Include elective modules on energy efficiency within the course,

17. Offer a ‘major’ stream in the engineering degree on energy efficiency,

18. Include several workshops on energy efficiency in the course (i.e. including laboratory-style experiments), and

19. Develop a new degree program on energy efficiency (e.g. B Energy Eng).

The second step in applying the CBSM methodology was to undertake an investigation on two key aspects of each option (with each aspect assigned a score of between 1 and 5, with 1 being low and 5 being high), namely:

1. The perceived probability that engineering educators would undertake the option, and

2. The perceived impact on the level of coverage of energy efficiency in the program should the option be undertaken.

To create the initial scores for each variable the research team undertook a detailed literature review and conducted 13 phone interviews with engineering educators from 6 of the 7 Australian States and Territories, led by Dr Desha and Miss Reeve and reviewed by myself. The phone interview invited comment on the list of 19 options as shown above and then requested both quantitative data to indicate the perceived potential impact and probability for each of the options; along with qualitative data regarding their rationale for the score, and perspective on the framing of options. Following this a review of the suggested scores was undertaken by a further 10 engineering educators through participation in a survey.

The third step in the process was to create a short list for further investigation and in order to reduce the number of options the ones with a likelihood average of 2.5 or less, or an impact of 3.0 or less, were removed to produce the final list of 10 options as shown in Table 8.7.

Table 8.7: 10 Shortlisted Options to Increase the Coverage of Energy Efficiency in Engineering Education (with average perceived likelihood and impact)

Option	Description	Likelihood	Impact
1	Include a case study on energy efficiency	4.1	3.2
2	Offer supervised research topics on energy efficiency themes	4.0	3.2
3	Include a guest lecturer to teach a sub-topic	4.0	3.6
4	Include tutorials that align with the energy efficiency theme in the course (e.g. presentations/ discussions/ problem solving)	3.7	3.3
5	Offer energy efficiency as a problem-based learning topic	3.7	3.7
6	Include assessment that aligns with the energy efficiency theme within the course (e.g. exam questions and assignments)	3.7	3.4
7	Overhaul the course to embed energy efficiency	3.4	3.7
8	Include a field trip related to energy efficiency	3.1	3.5
9	Include one workshop on energy efficiency in the course (i.e. laboratory-style experiments)	3.1	3.5
10	Develop a new course on energy efficiency	2.9	4.1

Source: Desha, Hargroves, and Reeve (2009)

The fourth step in applying the CBSM methodology was the consideration of the barriers and benefits associated with the short-listed options shown in Table 8.7. Engineering educators are faced with a range of barriers to curriculum change such as the following identified in the 2007 survey outlined above: (Desha and Hargroves *et al* 2007)

1) *The potential for course content overload,*

2) *Having insufficient time to prepare new materials, and*

3) *Some lecturers do not appear to be aware of content that is beyond 'introductory'.*

In 2009 this research was extended to identify a number of specific barriers related to each of the 10 short-listed options presented previously in this chapter (Desha, Hargroves and Reeve, 2009). Specifically, the research focused on barriers at the level of the lecturer responsible for curriculum coordination in a given engineering department, as shown in Table 8.8.

Table 8.8: Short list of key barriers and benefits associated with 10 key options to increase the coverage of energy to energy efficiency education

Key Barriers and Benefits	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Common Barriers										
– Lack of available data/ information	●	●		●	●	●	●		●	●
– Lack of time for preparation	●	●		●	●	●		●		●
– An overcrowded curriculum	●		●	●		●			●	●
– Prohibitive cost	●		●	●	●	●		●	●	●
– Lack of knowledge	●	●	●	●	●		●		●	●
– Lack of value attached	●		●			●				

Source: Edited from Desha, Hargroves, and Reeve (2009)

Other barriers identified in the research included lack of industry contacts (where it is difficult for lecturers to gain insight into the industry application of energy efficiency due to a lack of contact), resistance to top-down directive where lectures resist the call to extend their field of knowledge into new areas (Robinson and Sutterer, 2003; Boyle, 2004; Peet, Mulder, and Bijma, 2004; El-Zein *et al*, 2008), lecturer apathy where lecturers are not incentivised to update courses and this leads to lack of interest to make such changes (Peet, Mulder, and Bijma, 2004), and administrative coordination issues related to curriculum change. (Desha, Hargroves, and Reeve, 2009)

As Table 8.8 demonstrates there are a number of barriers to greater uptake of sustainable development related content in undergraduate programs that can be reduced through various activities, such as those outlined below:

1. *Lack of available data/ information*: It is clear from the literature that there is a lack of data and information available to support lecturers to renew curriculum to increase the coverage of energy efficiency, or even sustainability (Boyle, 2004),

creating a significant barrier (Peet, Mulder, and Bijma, 2004). Understanding this imperative I and my research colleagues have developed a range of open access peer reviewed energy efficiency materials suitable for education and capacity building programs that are included on various websites including the Australian Government 'Energy Efficiency Exchange', National Climate Change Adaptation Research Facility, stating that '*This is a great resource for teachers, educators and those wishing to know more about climate change adaptation actions for planners and engineers*' (NCARF, 2013), Environmental College of the Institution of Engineers Australia, TAFE NSW, and the European Environment Agency. The team has also developed course modules with supporting case studies for an introductory level course on sustainability for engineers, including a teacher's guide (Desha, Palousis, Hargroves, and Smith, 2005).

When developing such materials it is important to understand the preferences of the lectures for a range of factors that will affect its development, as shown in Table 8.9.

Table 8.9: Survey respondent's perception of the important of suggested considerations when selecting energy efficiency education resources

	Not Important	Important	Very Important
Clear aims and objectives	2.9%	37.1%	60.0%
Succinct learning points	5.7%	42.9%	51.4%
Appropriate depth of coverage	2.9%	47.1%	50.0%
Easily used/adapted to curricula	5.7%	45.7%	48.6%
Incorporates a systems focus	14.3%	37.1%	48.6%
Reputable author or organisation	11.4%	42.9%	45.7%
Engaging and relevant to current context	0.0%	54.3%	45.7%
Contains structured exercises related to learning objectives	5.7%	57.1%	37.1%
Wide application across engineering disciplines	19.4%	52.8%	27.8%

Clear structure that allows flexibility	2.9%	71.4%	25.7%
Provides key words	45.7%	40.0%	14.3%
Considers of different learning styles	17.1%	71.4%	11.4%

Source: Hargroves and Desha (2011)

2. *Lack of time for preparation*: Options for creating time for lecturers include the buying out of lecturing time, meaning that other staff are then used to teach parts of the course load to allow the lecturer to renew curriculum. Other options include aligning the topic to a research grant, conference presentation or academic paper, allowing the academic staff member to effectively deliver two outcomes from one investment of time. This will be a key barrier to overcome if engineering schools are to effectively review and enhance the coverage of energy efficiency in their offerings. Any changes to curriculum can be disruptive to staff and it will be important that the changes undertaken related to energy efficiency are well informed as to reduce redundancies and duplication.

Preparation time can be reduced through a range of efforts such as the development of a committee/group focused on supporting the increased coverage of energy efficiency in programs. This group may focus on the identification of appropriate materials and support to assist lecturers to renew courses (Holmberg *et al*, 2008). The literature warns against overly top-down approaches to encouraging curriculum renewal, and cites experience in which a collaborative approach involving lecturers can be an effective way to assist in reducing time for academic staff to renew courses (Peet, Mulder, and Bijma, 2004).

3. *An overcrowded curriculum*: It is of course expected that an engineering education program has a full set of curriculum, as it would be difficult to deliver an award course if it was incomplete. The issue is that as the needs of society for graduates change such programs need to also change, it would be abnormal for a program say in 2010 to be the same as the one offered in say 1910, which was also full. Hence this is a key barrier to overcome as in the coming two decades the needs of society are going to change more rapidly and on a larger scale than at any other time in history. A further complication is that existing energy intensive infrastructure and processes have been invested in and have operational lives that are tied to the

financial arrangements associate with their construction and operation. Hence during the transition away from such energy intensive options graduates will need to get some of the old along with the new as they will be called upon to work in existing energy intensive operations until such time as they are updated or replaced.

A common way to overcome this barrier is the development of post-graduate courses specialising in energy management. This provides income to the department from enrolments from post graduate students and allows academic staff to create new materials that will flow back down in to undergraduate programs.

4. *Prohibitive cost*: The cost associated with staff investing additional time into renewing courses typically comes from the employment of support staff to undertake teaching and marking roles to create the time required. This barrier may be significantly reduced through changes to staff workload allocations that adjust their workload proportions (i.e. teaching, research, service) to allow time to focus on renewing course/s. Further not only does the lecturer need time to create new materials there is capacity building requirements for tutors and support staff assisting with the delivery of the course. Responding to such challenges is complicated when a particular course is offered through a number of departments as this may result in conflict over how such changes should be funded, and by whom.

5. *Lack of value attached*: This may be attributed to the current low levels of requirement to cover energy efficiency in programs from accreditation bodies who are struggling to identify appropriate levels of coverage to require. Accreditation bodies will play a critical role in shaping engineering programs in Australia and around the world with such requirements often the single most influential driver for course renewal and change (Desha, Palousis, Hargroves, and Smith, 2005). Further a lack of clear direction from government on the issue of reducing greenhouse gas emissions has resulted in uncertainty in business and industry around the demand for energy efficiency services, leading to a reduced demand for graduates.

8.4 AN EXAMPLE OF INFORMING CHANGES TO THE STRUCTURAL AREA OF 'EDUCATION PROGRAM ACCREDITATION AND REQUIREMENTS'

When considering a structural approach to changing the knowledge and skill requirements in higher education an important structure is that of the accreditation of courses by an external body, especially for engineering programs and other regulated professional disciplines such as business. The assessment to secure the ongoing accreditation typically takes place on a 3-5 year rotation with a set of required graduate attributes articulated by the accrediting agency or body.

In 2007 the Royal Academy of Engineering said 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*' (RAE, 2007). The International Engineering Alliance's Washington Accord, a non-mandatory agreement sets out common performance guidelines, states that graduates of engineering programs should, '*understand the impact of engineering solutions in a societal context and demonstrate knowledge of, and need for, sustainable development*' (IEA, 2009).

Engineers Australia is responsible for the accreditation of engineering undergraduate programs in Australia and it has two important documents that state the fundamental role of engineering in addressing sustainable development issues: 1) the Code of Ethics; and 2) the Sustainability Charter. These include for example the *Code of Ethics* document which states on page 1, *'As engineering practitioners, we use our knowledge and skills for the benefit of the community to create engineering solutions for a sustainable future. In doing so, we strive to serve the community ahead of other personal or sectional interests'.* This is supported by the institution's *Sustainability Charter*, which states, '*Engineers Australia believes that achieving sustainable development requires a fundamental change in the way that resources are used and in the way that social decisions are made. Accordingly, change will require time and a transitional process towards an aspirational outcome. This means that the process for achieving sustainable development becomes as important as the outcomes themselves. Regular reporting of progress towards sustainability outcomes is vital and should be conducted openly and transparently'.* (Engineers Australia, 2008)

However, according to Byrne, Desha, Fitzpatrick, and Hargroves (2010) '*The pace at which accreditation guidelines incorporate various declarations, initiatives, communiqués, charters and policies, appear to be often beset with a significant time lag*'. This is further complicated by the level of complexity in responding to climate change making it difficult for accreditation agencies and bodies to set a clear timeline for the greater inclusion of associated knowledge and skills into existing programs. This is then even further complicated by the fact that both personnel undertaking the accreditation assessment and engineering education staff tasked with including such material require capacity building and supporting resources.

This understanding led to the creation of the Energy Efficiency Education Resources for Engineering (EEERE) project as part of the Australian Government's Clean Energy Future Plan. The project was funded by the Australian Government Department of Industry and was undertaken by a consortium of universities led by Dr Desha and myself and involving Queensland University of Technology, The University of Adelaide, University of Wollongong, La Trobe University, RMIT University, and Victoria University. The project was advised by Engineers Australia, the Australian Council of Engineering Deans, The Australasian Association for Engineering Education, the Energy Efficiency Council, and the Australian Sustainable Built Environment Council.

The focus of the project was to provide education material targeted to each of the disciplines represented by Engineers Australia (along with mining and metallurgy) to assist engineering educators to increase the coverage of energy efficiency related topics. The project created a suite of energy efficiency education resources, namely:

- Ten 'flat-pack' supporting teaching and learning notes for each of the key disciplines of engineering (University of Adelaide and Queensland University of Technology);

- Ten short 'multi-media bite' videos to compliment the flat-packs (Queensland University of Technology and the University of Adelaide);

- Two 'deep-dive case studies' including worked calculations (University of Wollongong); and

- A 'virtual reality experience' in an energy efficiency assessment (Victoria and LaTrobe Universities).

The section of the EEERE program led by myself was the development of the flat-packs, which included the development of the following items:

- A general introduction to Energy Efficiency for Engineers multi-media bite (MMB) video,

- A general introduction to Energy Efficiency Assessments flat-pack document,

- 9 discipline specific introductions to energy efficiency flat-pack documents, and

- 9 discipline specific introductions to energy efficiency multi-media bite videos.

The development of the material was informed by the colleges of Engineers Australia and peer-reviewed by engineering educators to ensure it draws directly on the input from the national engineering professional body and is delivered in such a way as to be user friendly and promote uptake by engineering educators.

Each flat-pack contains a summary of the key points raised in the MMB video's to provide educators with a summary of the area's covered to inform discussion. Many of the case studies presented in the MMB's are expanded on in the various flat-pack documents. The intention of the flat-pack design was not to provide a prescriptive 'lecture notes' format but rather to provide a resource that the educators draw from to put together the type of curriculum that works best for them and their students. The documents can be used as pre-lecture reading, follow-up reading, or provocations for an interactive teaching style. The introductory unit provides the structure for the tutorial question for all disciplines, and each of the flat-pack resources feeds into this discussion, permitting the tutorial to be undertaken by as many disciplines as desired.

Along with providing engineering educators with education resources to assist in the increased coverage of energy efficiency knowledge and skills in existing and new programs, the project sought to support calls for the accreditation body to request such material by providing a set of identifiable materials to assist accreditation assessors to identify the inclusion of energy efficiency content in courses. IT is recommended that further research be undertaken to investigate the link between informing and supporting curriculum renewal to include greater coverage of content related to the reduction of greenhouse gas emissions (such as energy efficiency in engineering education) and the level of support for changes to education program accreditation and requirements.

8.5 CHAPTER SUMMARY AND CONTRIBUTION TO THESIS

Based on the premise that typically there is a 2 decade timeframe for the renewal of higher education curriculum, and the further premise that such as timeframe is too long when considering the timeframe established in Chapter 2-4 of one to two decades to decisively respond to climate change, the chapter calls for greater effort to be made to accelerate higher education curriculum renewal. The chapter then outlines the rationale for the selection of engineering education and the content area of energy efficiency and provides associated supporting evidence.

The second part begins by establishing a baseline for a longitudinal study into the state of engineering education on energy efficiency by presenting findings of a study led by myself and Dr Desha into the state of engineering education on energy efficiency in Australia between 2007 and 2011. The chapter outlines the trends over the 5 year timeframe of the longitudinal study and concludes that there has been an overall increase in the perceived level of coverage of nominated energy efficiency knowledge and skills. However it also cautions that even in 2011 some 60% of engineering education programs in Australia did not cover key topics, concepts, or principles related to energy efficiency, which is a significant finding.

The chapter then presents an assessment of the findings related to engineering educator perceptions of the level of coverage and relative importance of nominated energy efficiency knowledge and skills, for example the topic of ‘energy recovery’ was perceived by 75% of respondents to be important with only 12% indicating it was covered in detail in their programs. The findings of the longitudinal study informed the creation of a short list of energy efficiency content that a high level of engineering educators participating in the survey perceived as important that were also perceived to have very low coverage as important leverage points for encouraging curriculum renewal.

The third part of the chapter then outlined the findings of an investigation of options to increase the coverage of such content based on the unique application of ‘Community Based Social marketing’ to the community of engineering educators, led by myself and Dr Desha. The part outlines a research process to identify the potential impact of a 10 short-listed types of curriculum renewal activity on the coverage of energy efficiency in a program of study (such as including a case study in an existing course) along with the likelihood that engineering educators would undertake such an action, based on a detailed literature review and series of phone interviews with engineering educators. The part then maps the 10 options to the perceived barriers identified in the 2007 survey of engineering educators (receiving responses for 27 of the 32 engineering schools in Australia). The part then provides commentary on the main barriers and how they can be overcome to accelerate the greater coverage of energy efficiency content in engineering programs.

The final part then suggests that the findings presented in the chapter provide valuable insight in to how to informing changes to 'Education Program Accreditation and Requirements' as part of an agenda of Carbon Structural Adjustment. The part presents a brief overview of the role of accreditation in the context of engineering education and suggests that a key barrier to the both the greater uptake of energy efficiency content in courses and the greater inclusion of energy efficiency education requirements in engineering education programs by accreditation agencies or bodies is a lack of capacity building of engineering educators and accreditation assessors. The chapter then concludes by presenting a brief overview of a project focused on addressing such barriers led by Dr Desha and myself.

The original contribution of this chapter is the interpretation of stakeholder engagement findings that inform both the increased coverage of energy efficiency content in programs by engineering educators, and also provide greater precedent and clarification to accreditation agencies and bodies to consider ratcheting up the requirement for such content in programs. The findings include the quantification through a longitudinal study of trends related to the coverage of energy efficiency content in engineering education. These trends where then compared to perceived importance levels of such content to identify specific topics that were perceived by engineering educators to be of high importance to engineering graduates but had low levels of coverage in existing programs. These findings provide a critical basis for efforts to increase the coverage of energy efficiency content and provide a valuable research methodology for identifying such topics in other professions. The findings also included specific guidance as to how barriers to preferred options for increasing eh coverage of energy efficiency can be overcome.

SHIFTING FROM INCREASING THE WILLINGNESS TO DELIVERING CARBON STRUCTURAL ADJUSTMENTS

Chapter 9: Industry Led Performance Assessment and Reporting Systems

Reports by the Sustainable Built Environment National Research Centre (SBEnrc) include parts of this chapter written by me. I wish to thank Prof. Peter Newman and Rick Walters (ISCA Technical Director) for stimulating through discussion the creation of some of the arguments contained in this chapter, identifying resources for consideration to develop such arguments, and for providing valuable peer review. The development of the chapter was informed by my participation in the IS Foundation Training by ISCA.

9.1 INTRODUCING THE INFRASTRUCTURE SUSTAINABILITY RATING TOOL

Following the development of a strategic approach to informing the adjustment of key structures of an economy to achieve a transition to low greenhouse gas emissions in the previous chapters, this chapter investigates a method identified to increase the willingness to adjust a specific structures – namely industry led performance assessment and reporting systems – that has led to the delivery of structural changes in civil infrastructure procurement in Australia.

This chapter outlines an investigation of an existing industry led sustainability performance and rating tool that is developing increased willingness of government agencies and firms to adjust 'Investment and Procurement Policies' and has led to the inclusion of greater sustainability performance through the requirement for a minimum performance level. The sustainability reporting tool selected was developed by the Infrastructure Sustainability Council of Australia (ISCA) and is called the '*Infrastructure Sustainability Rating Tool*' or the '*IS Rating Tool*' (ISCA, 2014). According to the ISCA Technical Director Rick Walters, '*Many government departments are now making it a compulsory requirement, for certain projects, that they register and apply the IS rating tool during design, construction, and operation of the asset. Recently, this commitment has also often been tied to the contractual performance of the primary contractor*'. (R Walters, 2014, pers. comm., 28 July)

The IS Rating Tool is designed to be used to evaluate the sustainability of infrastructure across design, construction, and operational phases. The tool can be used for self-assessment as well as being able to be formally certified as ‘Commended’, ‘Excellent’, or ‘Leading’. Considering specific themes nominated in the tool that cover a range of social, economic and environmental sustainability categories across each project, the users of the tool nominate a performance level (1, 2, or 3) that they believe they have achieved for each credit and provide supporting evidence as outlined in the tool’s technical manual (ISCA, 2014). An assessment is carried out and based on predetermined weightings designed into the tool the overall rating is calculated. For example Figure 9.1 shows a sample rating across the various performance areas, for example a score of 6 is attained for ‘Management Systems’ out of a possible 10.5.

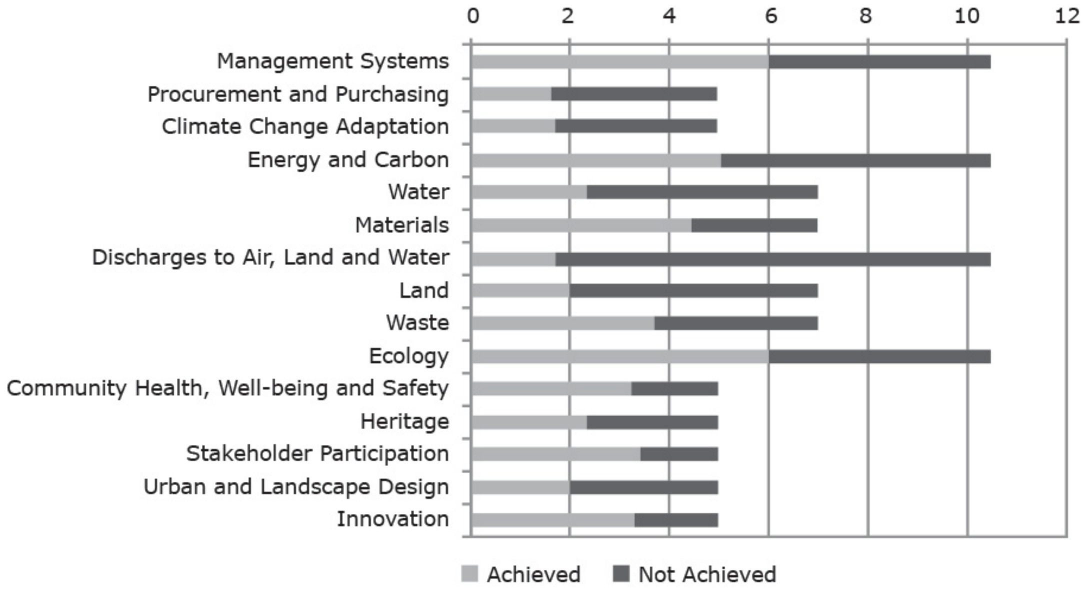


Figure 9.1: An example of IS rating tool outputs.

Source: ISCA (2012)

The tool provides governments with a standard industry developed framework to investigate the sustainability performance of projects. This is particularly important as it removes the potential for ambiguity, inconsistency, or a lack of transparency in the process used to assess the sustainability performance of contractors as part of pre-qualification or of specific projects. This reduces the political risk of calling for evidence to be provided related to the sustainability performance, which is a significant contributor to the willingness to adjust procurement requirements. Further it provides clear guidance to contractors as to how to develop and demonstrate their sustainability performance credentials.

According to Walters, '*The North West Rail Link project, which is an $8.3 billion Transport for NSW project in Western Sydney, has made it a contractual requirement that all major packages, Tunnel and Station Civils (TSC), Surface and Viaduct Civils (SVC), and Operations, Trains and Systems (OTS), will achieve an Excellent rating through IS, with a minimum score of 65. Transport for NSW included similar requirements within the CBD and South East Light Rail project, which is a $1.6 billion new light rail line extending 12 kilometers from Circular Quay along George Street to Central Station, then to Kingsford via Anzac Parade and Randwick via Alison Road. Main Roads WA made a similar organization wide commitment during 2013, and announced it within their Annual Report in Brief (2013), to adopt the IS rating tool for all projects greater than $100 million*'. (R Walters 2014, pers. comm., 28 July)

The IS Rating Tool has been designed by industry to provide a standardised and independent process for interrogating the sustainability performance of infrastructure projects in Australia. As such it provides a valuable resource to inform the adjustment of procurement processes to include nominated sustainability performance requirements as outlined above. In addition to providing the ability to set a minimum performance requirement the tool also provides standardised evidence documentation that can be requested as part of pre-qualification or tender documentation, as described in the following parts.

A key item of evidence documentation required by the IS Rating Tool is the 'Materials Calculator' (ISCA 2012). The tool provides a materials calculator that creates the potential to standardised tender submissions of quantity surveying / bill of materials reporting to simplify comparisons. In order to gain an IS rating the calculator must present both a 'reference design' and an 'actual design' where tenderers can differentiate sustainability inclusions compared to the standard design and quantify the impact on performance in both a tonnes CO_2e measure and a generic sustainability measure, '*eco-points'*. This is important as there is often a lack of time at the tender assessment stage to investigate innovative technologies or processes and undertake specific comparisons with standard designs to identify the low greenhouse gas emissions contribution.

Hence the development of the IS rating Tool to provide an industry led standardised tool for assessing the sustainability performance of infrastructure projects has increased the willingness of government agencies to adjust procurement processes to call for greater sustainability performance. This is an outstanding example of industry leadership that overcomes barriers to making adjustments to government requirements. The following part provides a summary of the low greenhouse gas emissions related credits included in the tool and introduces the potential to use these credits to gain an indication of the 'low carbon readiness' of tenderers. The final part provides an overview of each of the low greenhouse gas emissions related credits and provides a summary of the aim, evidence requirements, and points available. Further the final part comments on how the credit supports low carbon tending, informs an appreciation of the low carbon readiness of tenderers, and provides key interpretation of associate requirements for assessment of performance related to the criteria. It is intended that these two parts provide greater evidence of the value to government agencies and other infrastructure clients to further increase the willingness of adjusting procurement processes and requirements.

9.2 GAINING AN INDICATION OF 'LOW CARBON READINESS'

This part presents the notion that in addition to enabling the nomination of a minimum sustainability performance level infrastructure project contracts, the IS Rating Tool can be used as part of the prequalification and tender assessment processes to provide an indication of '*Low Carbon Readiness*' of contractors.

> "Low Carbon Readiness = *A term to describe the current ability of an entity to provide products, services, and solutions that deliver reductions in greenhouse gas emissions.*"

This could be done on a tender by tender basis or on an industry level through a survey of the supply chain to gain an overall sense of industry readiness. As Rick Walters from ISCA pointed out previously, infrastructure project clients are beginning to set a minimum IS rating to be met in the project/asset. Hence tenders are likely to be aligning submissions to the tools evidence requirements, providing the potential to aggregate the low greenhouse gas emissions related credit scores, such as those identified in Table 9.1.

The IS Rating Tool has a maximum score of 100 points with each credit allocated a specific maximum score based on industry informed weightings. The IS Rating Tool contains credits related to numerous 'sustainability' categories, namely:

- Management Systems
- Procurement and Purchasing
- Climate Change Adaptation
- Water
- Materials
- Discharges to Air, Land and Water
- Land
- Waste
- Ecology
- Community health, Well-Being and Safety
- Heritage
- Stakeholder Participation
- Urban and Landscape Design
- Innovation

Table 9.1 provides an indication of the credits that are related to low greenhouse gas emissions performance, and suggests those that could be considered to be 'directly' related and 'in-directly related'. Appendix B provides a detailed assessment of each of the credits shown in Table 9.1 and outlines the aim of the credit, the evidence requirements, the taxonomy for awarding points, the potential to support low carbon tendering, the contribution to identifying low carbon readiness, and associated key points for low carbon outcomes.

Table 9.1: Summary of 'IS Rating Tool' credits related to Low Carbon Readiness and Performance

Code	Credit	Evidence requirements relevance to Low Carbon Readiness and Performance
Credits Directly Related to 'Low Carbon Readiness' (27.54 Points Possible)		
Energy and Carbon		

Ene-1 4.67	Energy and carbon monitoring and reduction	Evidence of the modelling and monitoring of actions to reduce energy use and greenhouse gas emissions (Scope 1, 2, and 3 emissions).
Ene-2 4.67	Energy and carbon reduction opportunities	Evidence that opportunities to reduce energy use and greenhouse gas emissions are identified and implemented.
Ene-3 1.17	Renewable energy	Evidence that renewable energy opportunities have been investigated and implemented.
Procurement and Purchasing		
Pro-1 1.25	Commitment to sustainable procurement	Evidence of a commitment to sustainable procurement that includes environmental, social and economic considerations.
Pro-2 1.25	Identification of suppliers	Evidence of supplier pre-qualification questionnaires including items related to the presence and implementation of a sustainability policy.
Pro-3 1.25	Supplier evaluation and contract award	Evidence of sustainability consideration in supplier evaluation criteria and contract documentation, including provision for auditing.
Pro-4 1.25	Managing supplier performance	Evidence of the sustainability performance monitoring of suppliers, with active management of non-compliance and rewards available.
Materials		
Mat-1 6.29	Materials lifecycle impact measurement and reduction	Evidence of the modelling and monitoring of materials lifecycle impacts across infrastructure lifecycle, and demonstrated reductions.

Mat-2 0.74	Environmentally labelled products and supply chains	Evidence of the use of major material products with environmental credentials nominated or approved by ISCA.
Innovation		
Inn-1 5.00	Innovation	Evidence of contribution to broader market transformation towards sustainable development, locally, nationally and internationally.
Credits In-Directly Related to 'Low Carbon Readiness' (15.5 Points Possible)		
Management Systems		
Man-1 1.07	Sustainability leadership and commitment	Evidence of a commitment to sustainability through a sustainability policy and inclusion in management plans and project contracts.
Man-2 0.43	Management system accreditation	Evidence of accreditation of asset management systems to ISO14001 standard for environmental management systems.
Man-3 0.86	Risk and opportunity management	Evidence of the assessment of environmental, social, and economic risks and opportunities in a risk register with annual reviews.
Man-4 1.07	Organisational structure, roles and responsibilities	Evidence of a member of the project senior management with central responsibility for managing sustainability, with position description.
Man-5 0.86	Inspection and auditing	Evidence of regular environmental and sustainability inspection of on-site performance and reported auditing of the management system.
Man-6 0.86	Reporting and review	Evidence of sustainability reporting that is reported to senior management and the public and involves

		community participation.
Man-8 3.21	Decision-making	Evidence of decision making guidelines that evaluate options by considering environmental, social, and economic aspects.
Climate Change Adaptation		
Cli-1 2.50	Climate change risk assessment	Evidence of the assessment of climate change risks, including direct, indirect and flow on risks with system and regional implications.
Cli-2 2.50	Adaptation options	Evidence of the assessment and implementation of climate change adaptation measures for extreme, high and medium risks.

* This is default 'As Built' rating point value including all credits.

In the case that some of the credits included in Table 9.1 are not relevant to the particular panel of providers or specific project the client can work with ISCA to seek approval to direct tenderers to assume the omission of particular credits. According to ISCA (2014), '*Credits can be scoped out if they are truly not applicable to the project or asset. They cannot be scoped out simply because they were outside the scope or very difficult to achieve. Note that for a certified rating, credits scoped out must be agreed with ISCA. Scoped out credits assume a weight of zero and therefore do not contribute to the overall score*.' This will allow a level playing field for tenderers, especially when the request for tenders nominates a minimum IS rating tool score.

Considering the credits presented in Table 9.1 there are a number of credit specific items that can be included in pre-qualification requirements and/or requests for tender, namely:

– *Nomination of preferred energy saving options (Ene-1 and Ene-2)*: As part of the 'Energy and Carbon' category projects are rewarded for monitoring and minimising of energy use and GHG emissions across the infrastructure lifecycle. Requests for tender may nominate preferences for energy saving initiatives for specific projects, such as fuel economy of plant, to focus tenderers in areas of most interest.

- *Nomination of preferred renewable energy options (Ene-3)*: As part of the ‘Energy and Carbon’ category projects are also rewarded for investigating, and using, renewable energy. Requests for tender may provide a list of preferred renewable energy sources for specific projects to focus tenderers in areas of most interest. Further the request for tender may nominate specific criteria to be used by tenderers to assist selection of renewable energy options, and may nominate preferred options for carbon offsetting, should this be proposed.

- *Preferred aspects to include in sustainability procurement (Pro-1)*: As part of the ‘Procurement and Purchasing’ category projects are rewarded for having a commitment to sustainable procurement. Requests for tender may nominate preferred low carbon related aspects to be included in such documentation.

- *Preferred questions to be included in pre-qualification questionnaire (Pro-2)*: As part of the ‘Procurement and Purchasing’ category projects are also rewarded for the identification of suitable suppliers and the incorporation of sustainability criteria in the engagement process. As part of the evidence requirement there is a request to provide a pre-qualification questionnaire that involves sustainability criteria. Requests for tender may nominate specific low carbon related aspects that are either required or preferred to be included in the questionnaire.

- *Preferred criteria to be included in supplier evaluation (Pro-3)*: As part of the ‘Procurement and Purchasing’ category there is a requirement to provide evidence of the consideration of sustainability in supplier evaluation and contract documentation. Requests for tender may nominate preferred low carbon related aspects to be included in supplier sustainable evaluation criteria, and in supplier contracts.

- *Nomination of objectives and/or targets for suppliers (Pro-4)*: As part of the ‘Procurement and Purchasing’ category there is a requirement to provide evidence of the provision of sustainability related objectives and/or targets for suppliers. Requests for tender may nominate specific low carbon related objectives and/or targets that the client would prefer be included. Further, ISCA accepts such supplier objectives to be formalised only in the case of '*high impact procurement goods and services*', which the client may identify in tendering documentation.

- *Provision of Reference Design (Mat-1)*: As part of the 'Materials' category projects are rewarded for design and practice that reduce lifecycle environmental impacts of materials. Requests for tender may set the reference design to be used by all tenderers as the assumed business as usual option. This can be done by populating the ISCA Materials Calculator (ISCA, 2012) for the reference (or base) design. If this is done the reference design can be verified by ISCA prior to the request for tender being issued to ensure compliance with requirements when the rating assessment is undertaken in the future. This will streamline the assessment process along with assisting with the comparisons of the sustainability and low carbon performance of tenderers.

- *Preferred 'Environmental Labels' or product certification (Mat-2)*: As part of the 'Materials' category projects are also rewarded for procurement of major materials that have environmental labels or that are from sustainable supply chains. The client may nominate a preference for a particular environmental label or product certification scheme that is suitable for low carbon outcomes. Note that if this is not one of the ISCA preferred ones listed in the technical manual it may be possible to gain approval from ISCA for a specific preference.

- *Preferred areas of innovation*: As part of the 'Innovation' category projects are rewarded for pioneering initiatives in sustainable design, process, or advocacy. Requests for tender may nominate a preference for areas of low carbon innovation.

- *Preferred inclusions in sustainability policies (Man-1)*: As part of the 'Management Systems' category projects are rewarded for a commitment to sustainability, and in particular to both mitigate and contribute to restorative actions across a range of negative environmental, social, and economic impacts. Requests for tender may nominate a preference for low carbon commitments by tenderers.

– *Preferred risks and opportunities to be explored (Man-3)*: As part of the 'Management Systems' category projects are also rewarded for the assessment of sustainability risks and opportunities to inform project management. Requests for tender may nominate a preference for low carbon related risks and opportunities to be explored by tenderers. This may include a preference for consideration of threats from a greater frequency and intensity of natural disasters, and/or a preference for consideration of opportunities associated with providing local energy supply or co-generation opportunities with surrounding infrastructure.

– *Preferred responsibilities for sustainability-related roles (Man-4)*: As part of the 'Management Systems' category projects are also rewarded for the allocation of responsibility for sustainability appropriately. Requests for tender may nominate a preference for low carbon items to be included in position descriptions for sustainability related roles in project teams.

– *Preferred inspection and auditing criteria (Man-5)*: As part of the 'Management Systems' category projects are also rewarded for regular inspection of on-site performance and auditing of the management system. Requests for tender may nominate a preference for low carbon criteria to be included in inspections and audits, for instance in the area of reducing plant and equipment fuel consumption onsite.

– *Preferred sustainability reporting topics (Man-6)*: As part of the 'Management Systems' category projects are also rewarded for regular, comprehensive, and transparent sustainability reporting and review. Requests for tender may nominate a preference for low carbon topics to be included in sustainability reports, which may include performance against specific goals or targets set by external bodies.

– *Preferred decision making aspects (Man-8)*: As part of the 'Management Systems' category projects are also rewarded for incorporating sustainability aspects into decision making. Requests for tender may nominate a preference for low carbon aspects to be included in the decision making process and guidelines, such as a preference for inclusion of fuel efficiency of plant and equipment in procurement decision making processes.

- *Nomination of climate change risks (Cli-1)*: As part of the ‘Climate Change Adaptation’ category projects are rewarded for assessing climate change risks. Requests for tender may nominate a preference for a particular climate change projection(s) to be used, along with a preferred list of potential risks and impacts to be included in the assessment, such as a preference for the use of the new AS 5334-2013 standard as the basis of the consideration of climate change risks.

- *Nomination of climate change adaption measures (Cli-2):* As part of the ‘Climate Change Adaptation’ category projects are also rewarded for the assessment and implementation of climate change adaptation measures. Requests for tender may nominate a preference for particular climate change adaptation measures to be assessed for implementation, such as those that strengthen the resilience of infrastructure.

9.3 AN EXAMPLE OF INFORMING CHANGES TO THE STRUCTURAL AREA OF ‘PROCUREMENT AND INVESTMENT POLICIES’

This section provides a summary of my research into the provision of guidance by Australian government to support the greater inclusion of low carbon considerations in procurement. This research has been contributed to a research project led by myself with the CRC for Low Carbon Living that was initiated by UrbanGrowth NSW and is being developed in collaboration with Curtin University, Swinburne University, UrbanGrowth NSW, and the Infrastructure Sustainability Council of Australia. This part first investigates key Australian Federal Government documents related to procurement for the presence of sustainability and low carbon related items. The part then highlights the NSW State Government as a case study to investigate how the Federal Government procurement policies associated with low carbon outcomes inter-relate with state government considerations. (CRC Low Carbon Living, 2015)

An assessment of the alignment of the ‘*IS Rating Tool*’ to specific items recommended or required in the policy documents has been undertaken and the results are indicated throughout, for instance the item “*Does the supplier have a green/sustainable purchasing policy in place?*” appears is the Australian Government’s Guide for Sustainable Procurement of Services (Commonwealth of Australia, 2013b) and aligns to the IS Rating Tool items ‘*Pro-1*’ and ‘*Man-1*’. The findings of the assessment suggest that all items recommended or required in both the Federal Government and NSW Government procurement documents that have been investigated align directly to criteria in the IS Rating Tool, presenting further evidence for its use as an industry standard.

Low Carbon Tendering Provisions in Commonwealth Government Procurement

Commonwealth Procurement Rules

The 'Commonwealth Procurement Rules' (CPRs) are the core of the procurement framework for the Australian Government. The CPRs have been designed to lay out the rules '… *with which entities must comply when undertaking procurement*' (Commonwealth of Australia, 2014). The rules focus on the following areas related to public procurement: value for money; encouraging competition; efficient, effective, economical and ethical procurement; accountability and transparency in procurement; procurement risk; and the procurement method. The area where consideration of low carbon outcomes is made in this structure is in the area of 'Value for Money', with the Commonwealth Sustainable Procurement Guide, a complimentary guide to the CPRs, pointing out that '*Value for money is the core principle underpinning Australian Government procurement. This means that all relevant financial and non-financial costs and benefits should be taken into account over the entire life of the procurement. Sustainability should be considered as part of the value for money assessment*'. (Commonwealth of Australia, 2013b)

As part of the 'Value for Money' area the CPRs stipulate that '*When conducting procurement, an official must consider the relevant financial and non-financial costs and benefits of each submission including, but not limited to:*

a) the quality of the goods and services;

b) fitness for purpose of the proposal;

c) the potential supplier's relevant experience and performance history;

d) flexibility of the proposal (including innovation and adaptability over the lifecycle of the procurement);

e) *environmental sustainability of the proposed goods and services (such as energy efficiency and environmental impact); and*

f) *whole-of-life costs'*.

Item e) above is the main inclusion of low carbon related consideration in the CPRs however there is no guidance given as to how the associated direct and in-direct costs are calculated. This is a very important barrier to informing low carbon procurement. After analysing a broad range of potential costs of delayed action on responding to climate change, such as those shown in Table 9.2, and as mentioned previously, Stern (2006) concluded that each year on average, '*The costs of action to the global economy would be roughly 1% of GDP, while the costs of inaction could be from 5-20% of GDP*', cautioning that, '*The investment that takes place in the next 10-20 years will have a profound effect on the climate in the second half of this century*'.

According to Smith, Hargroves, and Desha (2010), '*The challenge, however, is that these reductions in GDP will hit hardest in the future, while political attention and business strategy is firmly focused on performance in the very short term. Balancing the conflict between short and long term imperatives will be a significant challenge for nations in the coming century, one that if not met, may well lead to significant impacts on economies*'. The challenge is to enable meaningful calculations of costs related to greenhouse gas emissions in such a way as to inform public procurement.

Table 9.2: Considering the Costs of Inaction on Climate Change (Smith, Hargroves, and Desha, 2010)

Considering the Costs of Inaction on Climate Change	
Damage to infrastructure from an increase in frequency and intensity of natural disasters, including fires, storms, hailstorms, ocean surges, flooding, and cyclones.	Health related costs due to more frequent heat waves and extreme cold, along with the spread of communicable diseases, such as Dengue Fever and Ross River virus.
Reduced agricultural production from increased temperature affecting crops	Reduced revenue from nature based tourism, such as coral reefs, forests and

along with more intense and less frequent rainfall.	alpine regions.
Costs related to relocation or protection from rising sea levels and enhanced storm surges.	Reductions to the carrying capacity of grazing land for livestock due to higher temperatures and lower availability of water.
Increases in peak electricity loading due to the use of air-conditioners in response to rising temperatures, along with more frequent ‘heat waves’.	Increased losses from forest fires due to reduced water availability and higher average temperatures.
Increased risk of conflict over resources such as oil, water and timber, and declining food production.	

Guide for Sustainable Procurement of Services

In 2013 the Federal Government Department of Sustainability, Environment, Water, Population and Communities released a ‘*Guide for Sustainable Procurement of Services*’ (‘Guide’) that provides an overview of key considerations for sustainable procurement, including those related to low carbon, along with suggesting possible performance criteria for sustainable tendering. (Commonwealth of Australia, 2013b)

The Guide suggests a number of questions may be asked related to the sustainability of potential service providers, with the following examples of questions related to low carbon considerations for land development projects.

- Does the supplier have a green/sustainable purchasing policy in place? (IS Tool Pro-1, Man-1)

- Has the supplier established sustainable purchasing guidelines or criteria for choosing its direct suppliers, such as guidelines that address environmental management and labour practices? (Pro-2)

- What steps will the supplier take to improve the energy/resource efficiency of its activities associated with delivery of the contracted service, such as energy consumption related to equipment use? (Ene-1,2)

- What steps will the supplier take to reduce travel and transport, such as change to holding a certain proportion of meetings with your agency via tele/video conferencing rather than face to face? (Ene-2)

- Can the supplier provide a statement of the sources of purchased electricity (for example: accredited GreenPower, coal)? (Ene-3)

Following the nomination of potential sustainability questions to ask service providers the Guide then nominates potential sustainability considerations in specifications for the procurement of services. The Guide suggests the specification of a number of '*minimum performance criteria*' related to sustainability and suggests that, '*Minimum performance criteria can be used as a starting point in an approach to market if sustainable procurement is fairly new to your agency, where the supply market does not have a track record of minimising adverse environmental or social impacts or where many of the potential suppliers are small businesses*'. (Commonwealth of Australia, 2013b)

The Guide suggests the following minimum performance criteria related to low carbon:

- Tenderers are to have an environmental or sustainability policy in place, or under development with a timeline for implementation. (Pro-1, Man-1)

- Tenderers are to have a program or system in place to identify environmental impacts relevant to the organisation, or a program/system under development with a timeline for implementation. (Man-3)

- Tenderers are to provide details of actions to improve the energy/resource efficiency or reduce energy consumption associated with delivery of the contracted service. (Ene-1.2)

- Tenderers are to provide details of actions to reduce fuel use, reduce air pollution and mitigate emissions associated with transport. (Ene-2)

- Tenderers can provide a statement of the sources of purchased electricity (for example: GreenPower, coal). (Ene-3)

In cases where there is confidence that suppliers can deliver the minimum performance criteria related to sustainability the Guide suggests the specification of '*better practice performance criteria*' as '*a tool to help drive continuous improvement and communicate to the supply market that you are serious about sustainability*'. The Guide suggests the following better practice performance criteria related to low carbon:

- Tenderers should provide evidence of explored opportunities to improve the energy/resource efficiency of activities associated with delivery of the contracted service. (Ene-2)

- Tenderers should provide evidence of steps taken to reduce energy consumption associated with the delivery of the contracted service, such as energy consumption related to equipment use. (Ene-1,2)

- Tenderers should provide quantifiable evidence of implemented initiatives that reduce fuel use, reduce air pollution and mitigate emissions associated with transport – for example: change to holding a certain proportion of meetings via tele/video conferencing. (Ene-1,2)

- Tenderers should have implemented and maintained an environmental management system, certified to ISO 14001 or equivalent, to reduce environmental impacts and continually improve environmental performance. (Man-2)

- Tenderers should have a publicly available environmental or sustainability policy in place. (Pro-1)

- Tenderers should purchase a proportion of GreenPower, or if no proportion of renewable electricity is purchased, tenderers should offset a minimum proportion of non-renewable energy sources in line with the National Carbon Offset Standard (NCOS). (Ene-3)

- Tenderers should measure and record energy use on a minimum quarterly basis (for example: of electricity, gas, renewable energy) based on receipts. (Man-6)

- Tenderers should install energy efficient lighting in offices and other work areas where applicable. (Ene-2)

- Tenderers should install power-saving features on appliances where possible. For example, an appliance could be programmed to enter 'suspend' mode within 15 mins of becoming inactive. (Ene-2)

- Tenderers should demonstrate that a green/sustainable purchasing policy is in place. (Pro-1)

- Tenderers should demonstrate that sustainable purchasing guidelines or criteria are in place for choosing direct suppliers – for example: guidelines that address environmental management and labour practices. (Pro-2)

The Guide then considers how to assess the sustainability aspects of tender submissions and suggests that once sustainability performance criteria has been specified, '*weightings should be assigned according to the agency's objectives, priorities and targets. For example, if an agency's priority is to reduce the greenhouse gas emissions associated with its activities, it makes sense to encourage suppliers of services to follow emissions-reduction principles and assign a higher weighting to emissions-specific criteria in the tender evaluation process*'. The Guide concludes by asserting that '*Contract reporting requirements should highlight the sustainability outcomes achieved by procuring environmentally and socially preferable goods and services*' and suggests that contracts may specify reporting such as:

- The supplier should implement and report quarterly on initiatives to reduce energy use associated with transport, to reduce kilometres travelled and greenhouse gas emissions. (Pro-4)

- The supplier should implement and report on initiatives to achieve a continual reduction in energy use associated with the travel to/from client meetings over the contract period – for example, change to holding a certain proportion of meetings via tele/video conferencing. (Ene-2)

- The supplier is required to provide bi-annual reports stating environmental impacts (including those related to energy and water consumption and waste production) measured against a baseline over the term of arrangement. (Man-3)

- The supplier is required to continually increase the proportion of GreenPower that is purchased over the term of the arrangement. (Ene-3)

- The supplier is required to communicate its sustainability practices to its suppliers and stakeholders. (Man-6)

Low Carbon Tendering Provisions in New South Wales Government Procurement

NSW Code of Practice for Procurement

The NSW Code of Practice for Procurement ('Code') includes the following mention of low carbon related considerations: (NSW Government, 2005)

- The Code states that '*Commitment to continuous improvement and best practice performance is expected of all those involved in government procurement'*, and suggests a number of areas '*where this commitment may be demonstrated*' including '*environmental management*'.

- The Code states that, '*In addition to prices tendered, evaluation criteria shall contain the critical factors to be used in the evaluation of tenders*', and lists the following related to low carbon tendering:

  - Tenderer's environmental management practices and performance, and

  - Value adding components such as economic, social and environmental development initiatives, if appropriate and relevant to the procurement.

The Code has an Appendix related to Environmental Management that states that, '*The Government expects government agencies and all other parties to identify the potential environmental opportunities, risks and impacts of their activities and to adopt measures to:*

- *Realise those opportunities, manage those risks, and enhance and protect the environment,*

- *Encourage recycling and re-use of materials and minimise waste, and*

- *Support effective use of scarce resources - including energy, water and materials'.*

Procurement Policy Framework for NSW Government Agencies

The NSW Procurement Policy Framework ('Framework') sets out the '*policy and operating framework for the NSW public sector procurement system and provides a single source of guidance on the rules for procurement*'. (NSW Government, 2014a) As part of the 'Procurement Practice Checklist - Stage 3: Project Procurement Plan' the Framework suggests that procurement strategies embed a number of other requirements, including that of the 'NSW Government Resource Efficiency Policy' which delivers actions from the 'NSW Energy Efficiency Action Plan'.

The Framework reiterates the need for 'value for money' from procurement as outlined in the Commonwealth Procurement Rules however unlike the CPRs it does not include specific mention of the financial and non-financial costs and benefits of the '*environmental sustainability of the proposed goods and services (such as energy efficiency and environmental impact)*' (Commonwealth of Australia, 2013b). However the Framework includes an element on 'Sustainable Procurement', stating that '*Sustainable procurement achieves the Government's commitment to spend public money efficiently, economically and ethically*', and requires that as part of the consideration of sustainable procurement the procurement process obtains 'value for money'.

Considering the NSW Procurement Policy Framework, in the area of environmental management each of the following relates to low carbon outcomes:

- *Pollution control, waste minimisation, recycling and disposal options*. (This may include reducing air pollution from the combustion of fossil fuels which leads to health issues from combustion particulates and enhances the greenhouse gas effect, reducing the wastage of fossil fuel intensive materials and energy along with reducing municipal waste that generates methane, and encouraging recycling that can significantly reduce the fossil energy required to deliver materials and goods.)

- *Energy efficiency and resource consumption*. (This may include the reduction of direct consumption of fossil fuels such as vehicle fuels, along with the reduction in electricity demand in various process or products through innovative approaches.)

- *Adopting environmental technologies and biodiversity.* (This may include the adoption of innovative technologies that can deliver enhanced services with reduced environmental damage, such as variable speed drives on pumping systems to match the pumping level to the level required and significantly reducing unnecessary energy consumption.)

The procurement policy framework then suggests that '*Principles guiding sustainable procurement can be used by agencies to develop sustainable procurement strategies, policies, guidance material, training and tools by*:

- *Incorporating sustainability practices into every aspect of the business management from planning through the procurement process to measurement of results,*

- *Adopting strategies to avoid unnecessary consumption and managing demand,*

- *Selecting products and services with lower environmental impact across their life cycle, and*

- *Fostering a viable market for sustainable products and services by supporting businesses that support socially responsible suppliers, adopt ethical practices and demonstrate innovation in sustainability'.*

Each of these items provides the potential for reducing fossil energy demand and encouraging renewable energy generation. In particular, the avoidance of '*unnecessary consumption and management of the demand of energy provides*' opportunities to both reduce energy costs and reduce greenhouse gas emissions.

A number of other elements of the Framework support low carbon tendering, such as:

- *Innovation*: The Framework suggests that innovation can be '*sought and encouraged at three levels of market engagement*', namely State economic level, the sourcing level and the contract management level. Each of these levels provides an opportunity for creative approaches to harness new innovations to deliver low carbon outcomes. In particular:

  - At the State economic level the Framework suggests that '*through effective, early, structured and open communication of needs to the market to encourage appropriate research and development and attract the right suppliers for the government customer base*'. Hence, it is important to consider mechanisms to encourage industry to enhance current low carbon offerings and prepare to deliver a greater level of low carbon goods and services in the future. (The 'Low Carbon Readiness' assessment outlined in Part 9.2 can identify the areas that the supply chain is currently strong and areas that are in need of improvement related to the delivery of low carbon outcomes).
  - At the sourcing level through pre-qualification criteria and request for tender inclusions.
  - At the contract management level where the Framework suggests the adoption of performance based contracts KPIs that measure innovation (such as those provided by the ISCA 'IS Rating Tool').

- *Effective Internal Engagement*: The Framework recommends '*early engagement across the organisation (and across multiple agencies/whole of government if applicable) to ensure business needs are identified, agreed and approved. This includes relevant operational, policy and legal areas, and areas responsible for change management within the organisation*'. This will be a key area of focus as low carbon inclusions are considered and adopted. The Framework recommends the development of '*overarching guidance documents*' for procurement and it may be of benefit to consider the development of a '*Low Carbon Procurement Guidance Document*'.

- *Market Engagement*: Given the transition to low carbon operation will require changes across the build environment sector (along with all other sectors) it is important that low carbon procurement is enhanced by strong industry engagement. The Framework suggests that '*with effective industry engagement, sourcing strategies can be better aligned with market structure and dynamics, and provide government with knowledge about new and innovative approaches, leading to improved procurement outcomes*'. It will be important to understand the low carbon strengths and current weaknesses of suppliers and contractors in order to ensure that the strengths are fully capitalised on and the current weaknesses are systematically addressed.

NSW Government Resource Efficiency Policy

The NSW Government Resource Efficiency Policy ('Policy') aims to '*reduce the NSW Government's operating costs and lead by example in increasing the efficiency of the resources it uses*'. (NSW Government, 2014b) According to Rob Stokes MP, '*Our vision is for a resource productive public sector that provides better services to the NSW community with less impact on the environment*'.

The Policy states that it will ensure the following three outcomes and that performance against the policy is to be published in annual statements. Each of the three outcomes relate to low carbon procurement and tendering for land development projects, such that:

a) *Meet the challenge of rising costs for energy, water, clean air and waste management*: Reducing the cost of contractor fuel bills through efficiency and energy management requirements will reduce project costs and government expenditure,

b) *Use purchasing power to drive down the cost of resource-efficient technologies and services*: Given the imperative for the transition to low carbon living the use of government purchasing power to provide clear market signals that favour low carbon goods and services will be a powerful mechanism to strength the built environment sector, and

c) *Show leadership by incorporating resource efficiency in decision-making:* The consideration of the including of low carbon related inclusions into prequalification and tendering documentation will demonstrate significant leadership.

The following table shows the structure of the Policy with a focus on energy, water, waste and clean air.

Table 9.3: Structure of the NSW Government Resource Efficiency Policy

Energy
E1: Targets to undertake energy efficiency projects
E2: Minimum NABERS Energy ratings for offices and data centres
E3: Minimum standards for new electrical appliances and equipment
E4: Minimum standards for new buildings
E5: Identify and enable solar leasing opportunities
E6: Minimum fuel efficiency standards for new light vehicles
E7: Purchase 6% Greenpower
Water
W1: Report on water use
W2: Minimum water standards for office buildings
W3: Minimum standards for new water-using appliances
Waste
P1: Report on top three waste streams
Waste
A1: Air emission standards for mobile non-road diesel plant and equipment
A2: Low-VOC surface coatings

The current Policy includes the following items related to low carbon tendering of land development projects:

– *Clean Air*: This section focuses on 'air emissions standards for mobile non-road diesel plant and equipment' both contractor supplied and government purchased (over 19kW and purchased or contracted after December 2015) and stipulates that:

  – '*Procurement contracts requiring the use of mobile non-road diesel plant and equipment will require reporting of engine conformity with relevant*

United States Environmental Protection Agency (US EPA), European Union (EU) or equivalent emission standards and the fitting of any exhaust after-treatment devices', and

– '*The tender selection process will incorporate a weighting for air-emission standards in conjunction with other environmental considerations to ensure it is factored into the selection process and apply a consistent weighting to preference the lowest emission engine*s'.

NSW Energy Efficiency Action Plan

The NSW Energy Efficiency Action Plan ('Action Plan') is intended to '*place downward pressure on electricity bills by assisting households to reduce their energy use, and improve energy productivity for business*'. (NSW Government, 2013)

> *The Energy Efficient Business program will unlock business energy productivity by working with industry to accelerate the uptake of energy efficiency opportunities.*

The Action Plan is focused primarily on households, businesses, and government operations and does not directly relate to land development projects. The Plan has 30 actions across five streams with some in-direct association to land development projects:

1) *Strengthen the Energy Efficiency Market*: The Action Plan is focused on '*actions to investigate policy options to provide the market with the structures, incentives, tools and skills it needs to mature*' and as such can support an investigation into low carbon tendering of land development projects. In particular the Action Plan includes a focus on positioning NSW as a leading centre of energy technology and services in the Asia-Pacific Region which may include delivering reduced fuel and materials consumption in land development projects in the region.

2) *Energy Efficient Homes*: This section of the Action Plan is focused on households.

3) *Energy Efficient Business*: This section of the Action Plan includes a focus on accelerating the uptake of energy efficiency and suggests:

    a. The creation of 'Energy Saving Scheme Tools and business-case guides.

b. The provision of upfront incentives for ‘*businesses and their product and service providers that reflect equipment lifetimes and require best practice measurement and verification of energy savings’*, which could include civil works contractors to invest in improving plant fuel efficiency.

c. Encouraging quality energy efficiency projects by ‘*publishing lists of eligible products*’, which could include low carbon pavement and construction materials, along with energy efficient pumps, generators, temporary lighting, and earthworks plant.

d. Offering ‘*hands-on training for site managers to help them apply business-case guides and best practice maintenance plans to their own circumstances*’, including civil works site managers responsible for plant, equipment, and vehicle fuel consumption, along with materials selection (such as low carbon recycled rubble and alternative low carbon cements).

4) *Energy Efficient Government*: This section of the Action Plan includes a commitment to *'Provide a dedicated team of energy efficiency specialists in the Office of Environment and Heritage to help key agencies to identify and implement energy efficiency projects*’, which would provide the civil works sector with a valuable resource to inform the assessment and implementation energy saving activities and technologies.

5) *Statewide Delivery*: This section of the Action Plan includes a focus on providing ‘*local communities with face-to-face links to the energy efficiency programs offered by the NSW Government*’, which would be of value to land development projects in regional areas.

9.4 A METHODOLOGY FOR INFORMING THE RATCHETING OF LOW CARBON INCLUSIONS

As part of the project with the CRC for Low Carbon Living, and building on from the findings presented above, a methodology for informing the ratcheting of low carbon inclusions in procurement was developed by myself (advised by Professor Peter Newman from Curtin University, and Professor Russell Kenley and Julianna Bedggood from Swinburne University).

The methodology is based on the understanding that the call for greater low carbon inclusions in procurement documentation needs to be complimented by effective supply chain interventions, such that:

1. Low carbon inclusions in procurement documentation may be in the form of the of minimum performance requirement or the nomination of specific items from a rating tool, such as the ‘IS Tool’:

    a. *Evidence that opportunities to reduce energy use and greenhouse gas emissions are identified and implemented.*

    b. *Evidence of the modelling and monitoring of materials lifecycle impacts across infrastructure lifecycle, and demonstrated reductions.*

2. Direct supply chain intervention activities are undertaken to support the greater inclusion of low carbon items in procurement documents, such as:

    a. *The provision of information seminars, training sessions, or briefing materials,*

    b. *The requirement for supplier prequalification prior to inclusion in tender submissions,*

    c. *The provision of an indication of future demand for particular low carbon products or services,*

    d. *Investment in research and development of specific low carbon related goods or services.*

The methodology is based on a multi-stage approach that identifies the current status of low carbon procurement, identifies the current ability of the supply chain to offer low carbon outcomes, and recommends changes to existing procurement documentation based on the trialling of potential new inclusions, as outlined below and shown in Figure 9.2.

1. The identification of the current level of both the low carbon inclusions in procurement documentation and the associated interaction with the supply chain around low carbon outcomes.

2. The identification of both the '*Low Carbon Readiness*' of contractors and/or suppliers based on the IS Rating Tool as outlined in Part 9.2 and proposed in Appendix C, and the '*Co-Creation Potential*' of the supply chain based on the client, contractor and supplier willingness to participate in supply chain interventions, the ability to participate in such interventions, and preferences for the type of supply chain intervention.

3. The classification of low carbon inclusions and supply chain interaction options as either:

    a. *Level 1: 'Minimum Low Carbon Performance'* – As recommended by the Commonwealth Government '*Guide for Sustainable Procurement of Services*' the first level of the classification is considered the '*starting point'* and is deemed to be the minimum performance level. (Commonwealth of Australia, 2013b)

       Based on the findings of the low carbon readiness and the co-creation potential assessments a short list of both low carbon inclusions and options for supply chain interactions would be identified that are deemed as 'minimum performance'. These would be drawn from the areas of strong low carbon readiness that are not already included in procurement documentation that are deemed to not require quantification of the impact of inclusion on project outcomes, along with supply chain interactions with a strong track record.

    b. *Level 2: 'Better Practice Low Carbon Performance'* – As recommended by the Commonwealth Government '*Guide for Sustainable Procurement of Services*' the second level of the classification is deemed to be the better practice level that can be a '*tool to help drive continuous improvement and communicate to the supply market that you are serious about sustainability*'. (Commonwealth of Australia, 2013b)

       Based on the findings of the low carbon readiness and the co-creation potential assessments a short list of both low carbon inclusions and options for supply chain interactions would be identified that are deemed as 'better practice'. These would be drawn from likely areas of strong low carbon readiness that are not already included in procurement documentation and are deemed to require quantification of the impact of inclusion on project outcomes, along with supply chain interactions that are deemed as being feasible but require quantification of the co-creation value achieved.

c. *Level 3: 'Leading Practice Low Carbon Performance'* – The third level of the classification is deemed to be the industry best practice level. Activity at this level is part of a cycle of continual improvement with the ratcheting of low carbon inclusions and associated supply chain interaction building on successive initiatives.

Based on the findings of the low carbon readiness and the co-creation potential assessments a short list of both low carbon inclusions and options for supply chain interactions would be identified that are deemed as 'leading practice'. Unlike the previous two levels of performance the level of leading practice will seek to encourage innovation in the supply chain to deliver greater levels of low carbon outcomes. Given these outcomes are likely to be underdeveloped in the supply chain this level would focus on assisting the supply chain to deliver aspirational outcomes. This may involve the development of world leading supply chain interaction options to significantly increase the low carbon readiness across the sector.

4. The trialling, assessment, and recommendation of options to ratchet low carbon inclusions and associated supply chain interactions and the development of recommendations for agency wide uptake.

   a. *Level 1: 'Minimum Low Carbon Performance'* – The trialling of Level 1 low carbon performance would focus on adding low carbon inclusions to procurement documentation (such as pre-qualification and invitation to tender documentation) that are deemed to be able to be currently delivered by the supply chain, and would use established supply chain interaction options. It is recommended that level of assessment of the Level 1 performance is done by confirmation in contractor tenders of the ability to deliver such performance, rather than quantification of actual performance; given the performance level has been deemed as being the minimum level of performance.

b. *Level 2: 'Better Practice Low Carbon Performance'* – The trialling of Level 2 low carbon performance would focus on adding low carbon inclusions to procurement documentation that are deemed very likely to be able to be currently delivered by the supply chain, however that are also deemed to require validation through the quantification of low carbon outcomes in projects prior to recommendation of wider adoption by the procurement agency. This level of trial would use both established supply chain interaction options and introduce new options based on the findings of the 'Co-Creation Potential' investigation. It is recommended that level of assessment of the Level 2 performance is done by quantification of the low carbon outcomes in projects prior to recommendation of wider adoption by the procurement agency.

c. *Level 3: 'Leading Practice Low Carbon Performance'* – The trialling of Level 3 low carbon performance would focus on adding low carbon inclusions to procurement documentation that are unlikely to be able to be currently delivered by the supply chain and would require validation through the quantification of low carbon outcomes in projects prior to recommendation of wider adoption by the procurement agency. This level of trial will focus on the road-testing of new supply chain interaction options based on the findings of the 'Co-Creation Potential' investigation. It is recommended that level of assessment of the Level 3 performance is done by quantification of the low carbon outcomes in projects prior to recommendation of wider adoption by the procurement agency.

In summary the my proposed methodology for informing the ratcheting of low carbon inclusions in procurement is structured in the following steps, as shown in Figure 9.2, namely:

1. The identification of the current level of 'low carbon inclusions' in procurement documentation and associated level of interaction with the supply chain,

2. The identification of both the '*Low Carbon Readiness*' of contractors and/or suppliers and the '*Co-Creation Potential*' of the supply chain,

3. The classification of low carbon inclusions and supply chain interaction options as either minimum performance, better performance or leading performance,

4. The trialling, assessment, and recommendation of options to ratchet low carbon inclusions and associated supply chain interactions and the development of recommendations for agency wide uptake.

The methodology outlined above is shown diagrammatically in Figure 9.2.

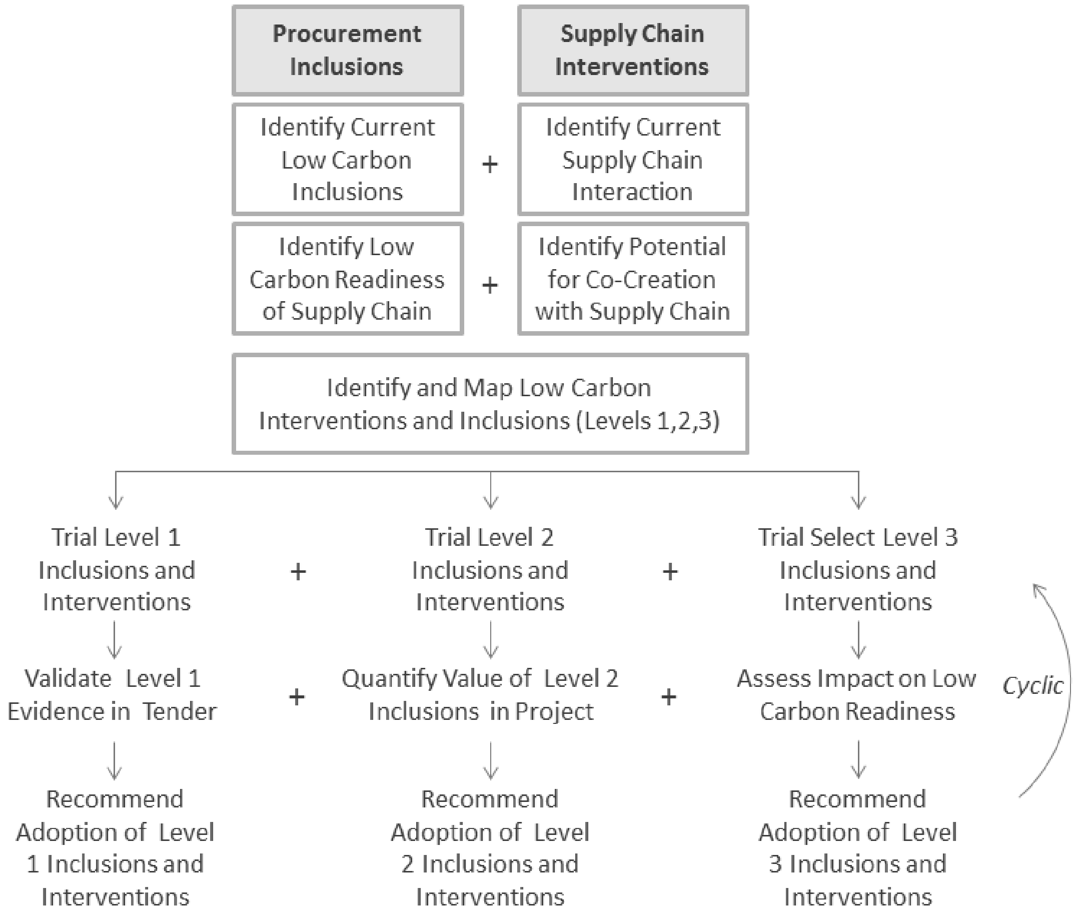


Figure 9.2: A Methodology for Informing the Ratcheting of Low Carbon Inclusions in Procurement based on supply chain engagement and interactions

9.5 CHAPTER SUMMARY AND CONTRIBUTION TO THESIS

The chapter is focused on investigating the use of sustainability performance assessment tools for infrastructure design, construction, and operation as a mechanism for increasing the willingness to adjust investment and procurement policies. The chapter selects the 'Infrastructure Sustainability Rating Tool' (IS Rating Tool) as the focus of this investigation. The first part of the chapter overviews the rating tool and provides context as to its relevance to the research question, namely that as the tool was created by industry it provides both a standardised framework that avoids duplication, and reduces the political risk of requesting disclosure of sustainability related performance, both having led to its inclusion in procurement requirements and project contracts.

The second part of the chapter introduces the term 'Low Carbon Readiness' as an indication of how well placed an contractor or supplier is to deliver on low carbon outcomes, using the low carbon related criteria in the IS Tool as a proxy. The chapter then nominates specific criteria in the IS Tool related to low carbon outcomes and highlights possible inclusions in pre-qualification and tendering requirements. Appendix A supports this part by providing an assessment of the low carbon related criteria in the IS Tool including consideration of the evidence requirements, awarding of points, support for low carbon tendering, indication of low carbon readiness, and key points when considering the specific criteria based on a study of the fine print from the design of the rating tool. Appendix C then provides a proposed research questionnaire based on the IS Tool to investigate the low carbon readiness.

The third part then provides an investigation in to considerations when designing changes to the structural area of 'Procurement and Investment Policies' and provides a summary of key Australian Federal Government documents related to procurement for the presence of sustainability and low carbon related items. The part then highlights the NSW State Government as a case study to investigate how the Federal Government procurement policies associated with low carbon outcomes inter-relate with state government considerations. An assessment of the alignment of the '*IS Rating Tool*' to specific items recommended or required in such policy documents has been undertaken and the results are indicated throughout. The findings of the assessment suggest that all items recommended or required in both the Federal Government and NSW Government procurement documents that have been investigated align directly to criteria in the IS Rating Tool, presenting further evidence for its use as an industry standard.

The final part then provides a methodology for informing the ratcheting of low carbon inclusions in procurement based on supply chain engagement and interactions. The methodology is based on the findings of the assessment of the low carbon readiness and co-creation potential of the supply chain and outlines a strategic approach to the trialling and assessment of new low carbon related inclusions and supply chain interaction.

The original contribution of this chapter is that it provides evidence of how the willingness to adjust 'Investment and Procurement Policies' has been increased by the creation of a performance rating tool based on industry designed criteria and associated evidence requirements that has led to changes to procurement requirements in Australia. The chapter provides an in-depth assessment of the rating tool and highlights specific options for inclusion of low carbon related requirements in procurement procedures. This is then compared to calls for greater sustainable procurement from both National and State government agencies.

This is a significant example as it demonstrates that adjustments to structures in the economy need not be led by government and that industry can play a leading role. The chapter then develops a new methodology for informing the ratcheting of low carbon inclusions in procurement based on supply chain engagement and interactions. This methodology provides a structured and robust process for procurement agencies around the world to undertake appropriate due diligence in the greater consideration of low carbon outcomes and the associated interaction with the supply chain.

CONCLUSIONS

Chapter 10: Conclusions

10.1 CONCLUSIONS

Based on the research undertaken to inform a response to the research question of '*How can structural changes across economies to accelerate the transition to low greenhouse gas emissions be designed, motivated, and delivered?*', I have come to the following conclusions.

Based on a literature review to justify the need to swiftly respond to human induced climate change through the rapid reduction of greenhouse gas emissions, I conclude that:

> ***"Due to human induced climate change the early part of the 21st century is going to be a time of major transition that will affect all sectors in all economies on the planet."***

After coming to this conclusion it is further concluded that:

- The 21st Century will be seen as the period in the history of the Earth when the impacts of its civilisations on the world's biosphere rose to a level where it changed the conditions of life on Earth. Given the wealth of evidence regarding the negative economic, social, and environmental impacts associated with human induced climate change (in particular the generation of greenhouse gas emissions) it is clear that an urgent international response is needed. If undertaken in a robust fashion such a response could not only alleviate pressures on the environment that stand to impact negatively on economies, but also contribute positively to delivering sustained economic growth, job creation, and poverty eradication.

- Humanity is at a point in its development that offers the most sophisticated and technologically advanced platform upon which to tackle large scale complex problems, one that has the potential to underpin a transition in the coming decades to a global society that is able to sustain its preferred living conditions. To achieve such a future this platform needs to be harnessed and directed to address the significant complexities involved in reducing greenhouse gas emissions, along with other pressing environmental and social challenges.

- It will be important that a balance in the timing of the peaking of emissions and the corresponding requirement for a tailing off of emissions annually is achieved in a manner that supports economic growth and social well-being. If the peak is too soon it may overstress the economy and undermine efforts to sustain gradual reductions over time, and if the peak is too late the corresponding annual reductions may be too much for the economy to bear, jeopardising their achievement.

- And finally, that much of the policy and industrial strategy used to achieve development in the past will need to be critically re-assessed if it is to continue to deliver progress into the future. All sectors of the economy will be affected to differing degrees by the imperative to reduce greenhouse gas emissions, some requiring minor changes and others requiring significant overhauls, and even closure. This presents a significant challenge as if the process takes too long we may fail the ecological imperative, and if it is forced too soon we may fail the economic and social imperatives.

Based on an investigation of various strategies to achieve structural level changes in economies to inform the design of strategic approaches to transition economies to low greenhouse gas, I conclude that:

> "***In order to achieve significant reductions in greenhouse gas emissions globally a structural change approach needs to be designed to induce a new wave of innovation, and governments, the private sector, and civil society must collaborate***."

After coming to this conclusion it is further concluded that:

- The response to climate change will result in the first wave of innovation that has been called for based on concerns of future economic and social impacts of current practices rather than emerging from the enhanced profitability of new technology and process advances. There are valid concerns about the viability of such a wave of innovation being autonomously established in time to avoid dangerous climate change using the same mechanisms and relying on the same drivers that were used to create the previous waves.

- In order to induce changes across economies to significantly reduce greenhouse gas emissions effort needs to be made to build on precedent for government working with business, universities, and the community, to rapidly transform the focus of entire economies. It may be the case that in the same way that fiscal structural adjustment was formulated as a solution to underdevelopment in third world economies in the 20th century, a new form of structural adjustment, such as '*carbon structural adjustment*', may need to be formulated as a solution to unsustainable development around the world in the 21st century. The scope of traditional structural adjustment can be expanded to include mechanisms that lead to a significant reduction in environmental pressures, especially the reduction of greenhouse gas emissions.

- A pragmatic approach is needed to inform the design of structural changes. The Thesis presents the '*Carbon Structural Adjustment Roadmap*' and recommends that it is used to initially focus on the following structural areas: standards and codes, government requirements, taxation and subsides, investment and procurement policies, professional accreditation requirements, and education program accreditation and requirements. The Thesis recommends that each structural area is investigated by: Identifying key aspects of areas to adjust; identifying the potential for value creation; identifying steps, enablers, and actors; identifying roadblocks, challenges, and delays; identifying and mapping tools; and developing strategic approaches.

- And finally, given the representative democracy nature of the governance system in many countries, combined with the structure of market based economies, it is unlikely that despite identifying areas of various structures across the economy that need adjustment that efforts will be undertaken in the short term. In order to accelerate changes to structures of the economy to deliver reductions in greenhouse gas emissions not only do such changes need to be carefully designed and implemented, but the willingness to do so must be increased. Increasing the willingness to adjust structural areas across economies will require a multi-pronged approach that both:

a) Increases the general willingness across communities and society for structural changes to deliver reduced greenhouse gas emissions reductions, and

b) Increases the willingness to change specific structural areas, such as those outlined in the '*Carbon Structural Adjustment Roadmap*'.

It is anticipated that such activities will not only increase the willingness in society for carbon structural adjustment to take place but also to increase the capacity of various actors to do so.

Based on an investigation into key potential opportunities to motivate carbon structural adjustment by increasing the willingness to adjust structural areas across economies in order to achieve a transition to low greenhouse gas emissions, I conclude that:

> "***Increasing the willingness to undertake structural adjustments to significantly reduce greenhouse gas emissions in the coming 2-3 decades is imperative and will involve a complex set of efforts, staged out in appropriate activities and timelines, and involving a range of stakeholders***."

After coming to this conclusion it is further concluded that:

- Industry led sustainability performance tools provide a robust approach to reduce the political risk of greater low carbon inclusions in public procurement. And further to this such tools provide: standardised evidence requirements that can be adopted by a sector to avoid ambiguity, inconsistency, or duplication and ensure streamlined documentation; clear guidance to contractors as to how to develop and demonstrate their sustainability performance credentials; and a structure to identify the '*Low Carbon Readiness*' of the supply chain to inform the ratcheting of such inclusions by identifying areas of strength and informing the selection of areas to support greater performance.

- The effective design of community behaviour change programs that encourage residents to undertake behaviours related to the reduction of greenhouse gas emissions stands to provide a valuable mechanism for increasing the willingness of communities (the voting public) to support associated structural changes and further research should be undertaken in this area.

- Efforts to inform and support curriculum renewal efforts in higher education stands to provide a valuable mechanism for increasing the willingness to adjust education program accreditation and requirement to include greater coverage of knowledge and skills related to reducing greenhouse gas emissions. And further to this despite findings that suggest that between 2007 and 2012 there was a general increase in the perceived level of coverage of energy efficiency in engineering education programs in Australia, as some 60% of engineering programs did not mention a number of key topics related to energy efficiency there is a significant need to accelerate efforts.

10.2 FURTHER RESEARCH

Given the significant imperative to reduce greenhouse gas emissions across the world's economies there is a great deal of research that will be needed to inform such efforts. Based on the findings of the research undertaken to inform this thesis the following areas of further research are recommended in-line with the three areas of focus of the thesis:

1. *Demonstrating the imperative to swiftly respond to human induced climate change through the rapid reduction of greenhouse gas emissions*: There is extensive research on the topic of qualifying the urgency and scope of the response to climate change and it will be important that this research is updated on an ongoing basis to ensure that the trends and impacts are clearly stated and monitored.

2. *Strategies to achieve structural level changes to transition economies to low greenhouse gas*: There is a need for further research into informing strategic approaches to changes to structural areas to deliver significant reductions in greenhouse gas emissions. The following areas of further research as aligned to the '*Carbon Structural Adjustment Roadmap*' (CSA roadmap) presented in the thesis:

   - *Identifying structural areas that need adjustment to achieve low carbon transitions*: It is recommended that research be undertaken into existing structural areas of each nation's economy to identify specific structures that influence the generation of greenhouse gas emissions and that through adjustment stand to provide emissions reductions (such as those presented in the CSA roadmap). It is anticipated that much of this research has been undertaken and the further research required is to collate and analyse the aggregate of such findings to identify and fill gaps. Once compiled this research stands to uncover similar structures in various countries' economies that need adjustment and may warrant international cooperation to inform and assist adjustment efforts. It will be critical that knowledge and experience from early adjustment efforts is compiled and robustly reported to inform such efforts.

- *Identifying key aspects of structural areas to adjust*: It is recommended that research be undertaken to identify specific aspects of the structural areas identified above that stand to deliver greenhouse gas emissions reductions in each country, such as 'taxation and subsidies'. Again it is anticipated that much of this research has been done and the further research required is to compile this for each country and identify and fill gaps. It is again likely that different country economies will have similar aspects of structural areas that stand to deliver reduced greenhouse gas emissions through adjustment, and it will be critical to the global pace of the response to climate change that knowledge is shared quickly and effectively to inform efforts.

- *Identifying the potential for value creation from adjustment efforts*: Once specific aspects of various structural areas that stand to reduce greenhouse gas emissions through adjustment efforts across the world's economies have been identified it will be critical to identify the potential for value creation, both direct and in-direct, and in relation to the range of stakeholders involved both current and future. It is anticipated that this research is likely to involve a range of stakeholders and may provide the platform for engaging a wider set of society in the response to climate change. It will be important to ensure that the costs on in-action are understood however much has been done in this area and the further research required is to place the value adding potential of responding to climate change in the context of specific stakeholders in each economy. A key element of further research to inform the value creation potential is to interrogate assumptions made in economic models of the cost of action to reduce greenhouse gas emissions as it may be the case that these costs are unnecessarily inflated.

- *Identifying steps to be taken, enablers to assist, and actors to involve*: Once it is clear where efforts need to be focused it will be critical to identify tangible steps to be undertaken, the current enablers to such steps, and the various actors that would be involved. This research is vital as it provides clear guidance to actions to be undertaken and allows for greater understanding of the timeframes for such action. It is anticipated that this research will involve stakeholder engagement activities and stands to be a mobilising action to bring current and new stakeholders into the process.

- *Identifying roadblocks, challenges, and delays*: Once efforts required to achieve carbon structural adjustment are clear it will be critical to understand the likely roadblock, challenges and delays that may be faced and consider ways to avoid, amend, or remove such barriers. It will be important for this research to be specific to the economy under consideration to identify those related to the local context and also those that are experienced in other economies to allow for knowledge sharing to inform and accelerate efforts.

- *Identifying and mapping carbon structural adjustment tools*: An important area for further research is in identifying tangible tools that can be used to adjust specific aspects of structural areas in particular economies. Once identified such tools can be mapped to the overall structural area to create the basis for a strategic approach that may also inform international efforts. It is anticipated that such mapping will identify nodes of initial focus given the political and private sector biases and interest areas.

- *Develop strategic approaches to carbon structural adjustment*: The areas of further research outlined above will culminate in the development of strategic approaches to carbon structural adjustment in each of the economies of the world, with the potential for knowledge sharing identified. Such strategic approaches will draw on the outcomes of the above research to build consensus and involvement across society to support adjustments of key structures that will underpin economies to deliver strong economic growth and social well-being while significantly reducing greenhouse gas emissions. Developing such approaches will be the defining aspect of the 21st century with the quality of such approaches having lasting impacts on the economies of the world and the earth's biosphere.

3. *Investigating the potential opportunities to increase the willingness to adjust structural areas across economies in order to achieve a transition to low greenhouse gas emissions to lead to such structural level changes*: It is recommended that further research be undertaken in each of the following areas:

   - The viability of the use of existing sustainability reporting frameworks as an indication of low carbon readiness of the supply chain and how this can affect the public procurement process to deliver reduced greenhouse gas emissions. In particular it is recommended that ascertaining the low carbon readiness of contractors and suppliers can lead to an updating of existing pre-qualification and request for tender requirements. Further it is recommended that research be undertaken to quantify the direct and in-direct costs associated with low carbon procurement considerations in order to provide meaningful calculations of costs related to greenhouse gas emissions in such a way as to inform public procurement.

   - The link between the effective design of community behaviour change programs related to reducing greenhouse gas emissions and the level of support for associated structural changes. In the case of the three behaviours presented in Chapter 7 this may include investigating the level of support from the community for a) a ban on the use of electric storage hot water systems, b) a ban on black or dark coloured roofs, and c) a requirement for new homes to have approved shade planting provided. The link between community behaviour change programs and the willingness to adjust associated structural areas forms a new area of research and is one that stands to inform an agenda of carbon structural adjustment.

   - The link between informing and supporting curriculum renewal to include greater coverage of content related to the reduction of greenhouse gas emissions (such as energy efficiency in engineering education as outlined in

Chapter 8) and the level of support for changes to education program accreditation and requirements.

Appendix A: Overview of IS Rating Tool Credits related to Low Carbon Performance

For each of the credits that are related to low carbon performance, as shown in Table 9.1, the following part outlines the aim of the credit, the evidence required, the points available, and highlights the support provided for low carbon procurement.

Energy and Carbon

Ene-1 Energy and carbon monitoring and reduction (4.67)

Aim: To reward monitoring and minimising of energy use and GHG emissions across the infrastructure lifecycle.

Evidence: Asked to provide evidence of initiatives taken to reduce energy use and GHG emissions.

Awarding of Points: Points are awarded as follows,

- 1.56 pts for provision of a report on initiatives undertaken to reduce energy use and GHG emissions, including a summary of actual and modelled GHG emissions across the infrastructure lifecycle,
- 3.11 pts for the above evidence along with a report comparing actual and modelled GHG emissions to a reference footprint,
- 4.67 pts for the above evidence along with a method for identifying significant sources of Scope 3 emissions.

Support for Low Carbon Tendering: This credit directly relates to low carbon tendering by requesting evidence of the modelling and monitoring of actions to reduce energy use and greenhouse gas emissions (Scope 1, 2, and 3 emissions).

Indication of 'Low Carbon Readiness': This is a very strong indicator of low carbon readiness as if tenderers perform well against this credit, it is likely that they have process for modelling and monitoring energy use and greenhouse gas emissions, and using the outputs to inform the selection of actions to be taken.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- It is encouraged that monitoring and reporting to be undertaken in line with existing tools, such as the Australian Governments 'NGER Reporting Guidelines'.

- It is recommended that reporting includes: total energy use and greenhouse gas emissions both during design and construction, and over the full life of the infrastructure, monthly energy use and greenhouse gas emissions, and annual operational energy use and greenhouse gas emissions over the forecast life of the asset.

- Carbon offsets can be used to achieve greenhouse gas emissions reductions but it must be demonstrated that they are only used when other options have been exhausted (such as design, efficiency improvements, sourcing renewable energy, and sourcing low-emissions energy.)

Ene-2 Energy and carbon reduction opportunities (4.67)

Aim: To reward identification and implementation of opportunities to reduce energy use and GHG emissions.

Evidence: Asked to provide evidence of design reports and as built drawings demonstrating carbon reductions.

Awarding of Points: Points are awarded as follows,

- 1.56 pts for provision of a report outlining how opportunities to reduce energy use and GHG emissions from Scope 1 and 2 and land clearing have been identified and implemented.

- 3.11 pts for the above evidence along with a report demonstrating how all feasible opportunities with a financial payback period of four years or less have been implemented,

- 4.67 pts for the above evidence along with an opportunity analysis that covers Scope 3 energy use and emissions, and evidence that at least one opportunity with a financial payback period of more than four years has been implemented, and demonstration that feasible opportunities to reduce peak demand on electricity grids have been considered and implemented.

Support for Low Carbon Tendering: This credit directly relates to low carbon tendering by requesting evidence that opportunities to reduce energy use and greenhouse gas emissions are identified and implemented.

Indication of '*Low Carbon Readiness*': This is a very strong indicator of low carbon readiness as if tenderers perform well against this credit, it is likely that they have process for analysing opportunities to reduce energy use and greenhouse gas emissions across the infrastructure lifecycle. Further that they have the ability to identify specific opportunities with both less than and greater than a four year payback period, including consideration of reductions to peak demand on electricity.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- Land clearing or land use change impacts are to be included in opportunity analysis.

- The method to undertake the opportunity analysis is not specified however it must comply with ISO 50001 International Standard for Energy Management.

- The Federal Government Energy Efficiency Opportunities program is directly referenced as a supporting resource.

- Marginal abatement cost curves are recommended for achieving a ‘fair comparison and prioritisation of opportunities to reduce greenhouse gas emissions.

- It is recommended that an energy and Carbon Management Plan be developed or embedded in existing management plans, to include: ‘The process used to identify opportunities to reduce energy use and GHG emissions, a list of all the opportunities identified (with explanations), the process used to analyse and evaluate opportunities, commitments to implement particular opportunities during delivery and operation, and explanations of why other identified opportunities were not taken up.

Ene-3 Renewable energy (1.17)

Aim: To reward investigation of, and use of, renewable energy.

Evidence: Asked to provide evidence of design reports, management plans, and monitoring reports demonstrating the use of renewable energy.

Awarding of Points: Points are awarded as follows,

- 0.39 pts for provision of a report demonstrating that opportunities for the use of renewable energy has been fully investigated,

- 0.78 pts for the above evidence along with a report demonstrating that 20-40% of energy is from renewable sources for the infrastructure lifecycle.

- 1.17 pts for the above evidence along with a report demonstrating that greater than 40% of energy is from renewable sources for the infrastructure lifecycle.

Support for Low Carbon Tendering: This credit directly relates to low carbon tendering by requesting evidence that renewable energy opportunities have been investigated and implemented.

Indication of ‘*Low Carbon Readiness*’: This is a very strong indicator of low carbon readiness as if tenderers perform well against this credit, it is likely that they have a process for investigating the potential use of renewable energy in the project and taking action to implement specific options.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- Options for renewable energy are considered to have been fully investigated if it includes:

    1. Establishing criteria for deciding whether to invest in a renewable energy option,
    2. Identifying renewable energy options available to the project or asset,
    3. Assessing each option against the criteria to enable a decision on which options to implement,
    4. Justifying the options selected for implementation and the options not selected,
    5. Investigating at least three renewable energy technologies or fuel types.

- The purchase of standard grid electricity that is partially supplied from renewable sources does not qualify for this credit as it 'requires specific support for new renewable energy'.

- The use of carbon offsets for this credit is acceptable as long as it is demonstrated that the offsets are sourced from renewable energy projects.

Procurement and Purchasing

Pro-1: Commitment to Sustainable Procurement (1.25)

Aim: To reward commitment to sustainable procurement.

Evidence: Asked to provide a procurement policy for the project, or other high level document, to demonstrate a commitment to sustainable procurement.

Awarding of Points: Points are awarded as follows,

- 0.42 pts if it includes a commitment to require environmental aspects be considered,
- 0.84 pts if it includes consideration of environmental, social, and economic aspects, and
- 1.25 pts if it is publically available and embedded into overall sustainability objectives and/or targets.

Support for Low Carbon Project Tendering: This credit directly relates to low carbon tendering by requesting evidence of a commitment to sustainable procurement that includes environmental, social and economic considerations.

Indication of '*Low Carbon Readiness*': This is a strong indicator of low carbon readiness as if tenderers perform well against this credit, they will potentially increase, or at least reinforce, their commitment to incorporate sustainability (and therefore to some degree low carbon tendering) into their procurement on the project i.e. through their supply chain.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- It is deemed that senior management is commitment is essential to achieving sustainable procurement outcomes,
- Making a policy available to a client and/or other stakeholders is not sufficient to demonstrate that it has been publically stated, and it should not have to be requested to be viewed.

Pro-2: Identification of suppliers (1.25)

Aim: To reward the identification of suitable suppliers and the incorporation of sustainability criteria in the engagement process.

Evidence: Asked to provide a pre-qualification questionnaire, evidence of forward commitment procurement, and evidence of engagement with potential suppliers.

Awarding of Points: Points are awarded as follows,

- 0.42 pts for provision of a pre-qualification questionnaire including questions related to an environmental policy and its implementation,
- 0.84 pts for the above evidence and including questions related to a sustainability policy and its implementation,
- 1.25 pts for the above two items and evidence of a commitment to purchase '*a product or service that currently does not exist, at a specified future date, providing it can be delivered to agreed performance levels and cost.*'

Support for Low Carbon Project Tendering: This credit directly relates to low carbon tendering by requesting evidence of supplier pre-qualification questionnaires including items related to the presence and implementation of a sustainability policy.

Indication of 'Low Carbon Readiness': This is a strong indicator of low carbon readiness as if tenderers perform well against this credit, they will have data to compare suppliers based on the existence and implementation of both an environmental and sustainability policy (that are very likely to include items related to energy and greenhouse gas emissions). This will put them in a strong position to select products and services from suppliers with demonstrated sustainable procurement offerings.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- The method to demonstrate implementation is noted to be flexible, and the credit is 'assessing the quality of information requested, not the quality of responses received from suppliers',
- It is deemed acceptable for 'organisations to only apply these practices to suppliers of high impact procurement category goods and services'.
- Achieving Level 3 requires at least one example of forward commitment procurement, which is explained to involve 'an agreement to purchase a

product or service that currently does not exist, at a specified future date, providing it can be delivered to agreed performance levels and costs'. The manual also states that a further requirement is that there is 'engagement with potential suppliers to explain sustainability requirements and expectations in advance'.

Pro-3: Supplier evaluation and contract award (1.25)

Aim: To reward the consideration of sustainability in supplier evaluation and contract documentation.

Evidence: Asked to provide supplier evaluation criteria, contract documentation including sustainability requirements, summary of scheduled and completed audits, and audit reports.

Awarding of Points: Points are awarded as follows,

- 0.42 pts for provision of supplier evaluation criteria,
- 0.84 pts for the above evidence and contract documentation clearly identifying sustainability requirements of the supplier,
- 1.25 pts for the above two items and a summary of scheduled and completed audits and audit reports.

Support for Low Carbon Project Tendering: This credit directly relates to low carbon tendering by requesting evidence of sustainability consideration in supplier evaluation criteria and contract documentation, including provision for auditing.

Indication of 'Low Carbon Readiness': This is a strong indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process to evaluate the sustainability aspects of suppliers using qualitative means (that are very likely to include items related to energy and greenhouse gas emissions), and to embed such aspects into contract documentation.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- This credit does not apply to the Design Rating,
- The supplier contracts need to incorporate specific sustainability objectives and/or targets,
- The evaluation of suppliers must incorporate at least one 'sustainability (non-financial) criterion and the weighting of the non-financial criteria must be greater than 20% in total'.

Pro-4: Managing supplier performance (1.25)

Aim: To reward the adoption of measures to ensure long-term implementation of sustainability initiatives for the duration of contracts.

Evidence: Asked to provide documentation identifying sustainability related objectives and/or targets for suppliers, sustainability performance monitoring reports, and a supplier reward program.

Awarding of Points: Points are awarded as follows,

- 0.42 pts for provision of documentation identifying sustainability related objectives and/or targets for suppliers,
- 0.84 pts for the above evidence and supplier sustainability performance monitoring reports showing objectives and targets and corrective actions taken to address non-compliances or poor performance,
- 1.25 pts for the above two items and a supplier reward program (or similar) and examples of rewards given.

Support for Low Carbon Project Tendering: This credit directly relates to low carbon tendering by requesting evidence of the sustainability performance monitoring of suppliers, with active management of non-compliance and rewards available.

Indication of '*Low Carbon Readiness*': This is a strong indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process to monitor the sustainability performance of suppliers against specific objectives, targets and/or indicators (that are very likely to include items related to energy and greenhouse gas emissions) and will have a process in place to actively manage non-compliance.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- This credit does not apply to the Design Rating,
- For level 2, evidence from at least three example contracts is requested,
- For level 3, evidence of contract managers working with suppliers to identify emerging or new sustainability opportunities is requested,
- It is deemed acceptable for 'organisations to only apply these practices to suppliers of high impact procurement category goods and services'.

Materials

Mat-1 Materials lifecycle impact measurement and reduction (6.29)

Aim: To reward design and practice that reduces lifecycle environmental impacts of materials.

Evidence: Asked to provide a completed copy of the materials calculator, or other suitable Lifecycle Assessment technique.

Awarding of Points: Points are awarded as follows,

- 2.10 pts for provision of copy of the materials calculator, or equivalent, to demonstrate that monitoring and modelling of materials lifecycle impacts has been undertaken across the infrastructure lifecycle.
- 4.19 pts for provision of copy of the materials calculator, or equivalent, to demonstrate that monitoring and modelling demonstrates a reduction in material lifecycle impacts compared to a reference case.

- 6.29 pts for provision of copy of the materials calculator, or equivalent, to demonstrate that monitoring and modelling demonstrates a *significant* reduction in material lifecycle impacts compared to a reference case.

Support for Low Carbon Project Tendering: This credit directly relates to low carbon tendering by requesting evidence of the modelling and monitoring of materials lifecycle impacts across infrastructure lifecycle, and demonstrated reductions.

Indication of 'Low Carbon Readiness': This is a strong indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process to model and monitor the materials lifecycle impacts across infrastructure lifecycle (that are very likely to include items related to energy and greenhouse gas emissions), and identify and implement actions to reduce them.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- The term modelling refers to 'reasonable estimates or predictions'.
- The number of points is determined by using the ISCA Materials Calculator, however an equivalent lifecycle assessment technique may be used upon agreement with ISCA.
- The Materials Calculator output needs to be dated and signed as a true record by the 'engineer of record' or other responsible professional.
- ISCA may require proof of the claimed quantities and services used in the form of purchase requisitions and invoices for the project/asset.

Mat-2 Environmentally labelled products and supply chains (0.74)

Aim: To reward procurement of major materials that have environmental labels or are from sustainable supply chains.

Evidence: Asked to provide a report showing the use products with specified environmental credentials, along with a product certificate.

Awarding of Points: Points are awarded as follows,

- 0.25 pts for provision of a report showing the use products with one of the following environmental credentials (Ecospecifier Green Tag, Good Environmental Choice Australia, ISEAL Alliance compliant, or other ISCA approved Type 1 Environmental label), including product certificates,

- 0.49 pts for the above evidence with 10-20% of material/products by value with the above credentials, including product certificates,

- 0.74 pts for the above evidence with greater than 20% of material/products by value with the above credentials, including product certificates.

Support for Low Carbon Project Tendering: This credit directly relates to low carbon tendering by requesting evidence of the use of major material products with environmental credentials nominated or approved by ISCA.

Indication of '*Low Carbon Readiness*': This is a strong indicator of low carbon readiness as if tenderers perform well against this credit, they will have experience in procuring products with recognised environmental credentials (that are very likely to include performance related to energy and greenhouse gas emissions).

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- This credit does not apply to the Design Rating,

- The points allocated are based on the proportion of products or materials that have achieved the listed environmental credentials.

- The products or materials must be used on the permanent infrastructure which makes up the project or asset.

Innovation

Inn-1: Innovation (5.00)

Aim: To reward pioneering initiatives in sustainable design, process or advocacy.

Evidence: Asked to provide a design or investigation report demonstrating the use of a technology or process that is a 'first' either in the state or territory, in Australia or in the world, or to demonstrate a contribution to the wider market transformation towards sustainability.

Awarding of Points: Points are awarded as follows,

- 1.67 pts for provision of a report demonstrating the use of an innovative technology or process that is <u>'first' in the state or territory</u>, or substantially contributes to the broader market transformation towards sustainably in the state or territory, or an initiative that viably demonstrates sustainability outside the current scope of the rating tool.

- 3.33 pts for the provision of a report demonstrating the use of an innovative technology or process that is <u>'first' in Australia</u>, or substantially contributes to the broader market transformation towards sustainably in Australia.

- 5.00 pts for the provision of a report demonstrating the use of an innovative technology or process that is <u>'first' in the world</u>, or substantially contributes to the broader market transformation towards sustainably in the world.

Support for Low Carbon Project Tendering: This credit directly relates to low carbon tendering by requesting evidence of contribution to broader market transformation towards sustainable development, locally, nationally and internationally.

Indication of '*Low Carbon Readiness*': This is a strong indicator of low carbon readiness where the contribution is in areas related to reducing energy use or greenhouse gas emissions reductions. If tenderers perform well against this credit, they will have demonstrated leadership in their sector in innovating solutions for low carbon outcomes.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- The innovation must have been implemented,

- Initiatives claimed to be a ‘first’ must ‘demonstrate that the initiative is either first, or if not, that it was in place prior to the ISCA awarding the initiative for another infrastructure project’.

- Initiatives that claim to be a contribution to the market need to demonstrate the development of a ‘product to comply with an IS rating tool requirement that was previously unavailable in the market’.

Management Systems

Man-1: Sustainability leadership and commitment (1.07)

Aim: To reward a commitment to sustainability.

Evidence: Asked to provide a sustainability policy or equivalent, management plans, project contracts, and evidence that sustainability policies have been made public.

Awarding of Points: Points are awarded as follows,

- 0.36 pts for provision of a sustainability policy or equivalent including commitments to mitigate negative environmental, social, and economic impacts, that are embedded into sustainability objectives and/or targets.

- 0.71 pts for provision of the above evidence and project contracts to demonstrate such sustainability objectives and/or targets have been reflected in project contracts,

- 1.07 pts for provision of for the above evidence and evidence that sustainability commitments go beyond mitigating negative impacts to restorative actions, and these commitment are publicly stated. Further, for operation, there is a commitment to continuous improvement in sustainability performance.

Support for Low Carbon Project Tendering: This credit in-directly relates to low carbon tendering by requesting evidence of a commitment to sustainability through a sustainability policy and inclusion in management plans and project contracts.

Indication of 'Low Carbon Readiness': This is a medium strength indicator of low carbon readiness as if tenderers perform well against this credit, they will have incorporated commitments to mitigating negative environmental, social and economic impacts into key documents (which are very likely to include commitment related to reducing impacts from energy consumption and greenhouse gas emissions).

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- Policies must have been in place for the entire duration of the relevant Rating phases and must be endorsed by senior management,

- Every policy commitment must have at least one objective and/or target linked to it,

- Evidence of implementation of the policy is not required as this is covered in other credits.

Man-2: Management system accreditation (0.43)

Aim: To reward the adoption of accredited management systems that support sustainability.

Evidence: Asked to provide accreditation certificates.

Awarding of Points: Points are awarded as follows,

- 0.43 pts for provision of accreditation certificates to demonstrate that the project or asset management systems have accreditation to all of the following: ISO14001 (Environment), ISO9001 (Quality), and AS/NZS4801 (OH&S) or equivalent.

Support for Low Carbon Project Tendering: This credit in-directly relates to low carbon tendering by requesting evidence of accreditation of asset management systems to ISO14001 standard for environmental management systems.

Indication of '*Low Carbon Readiness*': This is a medium strength indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process to develop an environmental management system (which is very likely to include items related to energy and greenhouse gas emissions). Further if the tender has accreditation to ISO 14064 they will have a system for measuring, quantifying, and reducing greenhouse gas emissions.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- Projects may be 'managed under an accredited parent or client organisation's management system but where this is the case, project management documents must state this. In these circumstances, parent organisations must have audited the project at least annually or at least once for projects which are shorter than one year in duration'.

Man-3: Risk and opportunity management (0.86)

Aim: To reward the assessment of sustainability risks and opportunities to inform project management.

Evidence: Asked to provide a risk register, minutes of risk assessment meetings and records of risk reviews.

Awarding of Points: Points are awarded as follows,

- 0.43 pts for provision of a risk register, minutes of risk assessment meetings, and records of risk reviews demonstrating environmental, social and economic <u>risks</u> have been assessed and updated at least annually.

- 0.86 pts for provision of a risk register, minutes of risk assessment meetings, and records of risk reviews demonstrating environmental, social and economic <u>opportunities</u> have been assessed and updated at least annually.

Support for Low Carbon Project Tendering: This credit in-directly relates to low carbon tendering by requesting evidence of the assessment of environmental, social, and economic risks and opportunities in a risk register with annual reviews.

Indication of ‘Low Carbon Readiness’: This is a medium strength indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process to assess environmental, social, and economic risks and opportunities (which, if comprehensive is very likely to include items related to energy and greenhouse gas emissions).

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- The risk register must include estimates of the level of risk, suggested controls to treat or manage the risk, or justification of acceptance of the risk,
- The term ‘opportunities’ is intended to mean ‘risks with positive consequences.
- A sustainability initiatives register would meet the requirement for opportunity assessment.

Man-4: Organisational structure, roles and responsibilities (1.07)

Aim: To reward the allocation of responsibility for sustainability appropriately.

Evidence: Asked to provide organisational chart(s), position description(s) that detail sustainability-related role(s) and responsibilities, evidence that a principle participant is an ‘IS Accredited Professional’.

Awarding of Points: Points are awarded as follows,

- 0.36 pts for provision of an organisational chart(s) and position description(s) that detail sustainability-related role(s) and responsibilities,
- 0.71 pts for provision of for the above evidence and evidence that a principle participant is an ‘IS Accredited Professional’, along with a letter of

appointment or position description, and evidence of their ongoing involvement,

- 1.07 pts for provision of for the above and evidence that an independent sustainability professional is engaged to monitor and review sustainability performance.

Support for Low Carbon Project Tendering: This credit in-directly relates to low carbon tendering by requesting evidence of a member of the project senior management with central responsibility for managing sustainability, with position description.

Indication of '*Low Carbon Readiness*': This is a medium strength indicator of low carbon readiness as if tenderers perform well against this credit, they will have a member of senior management with responsibility for managing sustainability, a principle participant who is an IS Accredited Professional, and a process to engage an independent sustainability professional (all of which are very likely to have responsibilities or expertise in areas related to energy and greenhouse gas emissions).

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- ISCA considers the role with 'central responsibility' for managing sustainability if that person or persons 'have specific accountabilities in relation to decision making and management of sustainability including environmental, social and economic aspects and this should make up more than 50% of their role',

- The participation of the 'IS Accredited Professional' must be demonstrated throughout the relevant rating phases,

- The independent sustainability professional needs to have 'qualifications in an environmental, social or economic field, and at least 10 years' experience practicing in one or more of these aspects and at least five years' experience providing sustainability advice'.

Man-5: Inspection and auditing (0.86)

Aim: To reward regular inspection of on-site performance and auditing of the management system.

Evidence: Asked to provide a summary of scheduled and completed inspections and audits, a sample of internal inspection reports, audit reports, and details of auditor qualifications.

Awarding of Points: Points are awarded as follows,

- 0.43 pts for provision of a summary of scheduled and completed inspections and audits, including a sample of internal inspection reports, audit reports, and auditor qualifications, for:
    - Internal environmental inspections of site management undertaken weekly during construction and monthly during operation,
    - Internal environmental audits of the management system undertaken at least quarterly.
    - External environmental audits of the management system undertaken at least annually.
- 0.86 pts for provision of a summary of scheduled and completed inspections and audits, including a sample of internal inspection reports, audit reports, and auditor qualifications, for:
    - Internal sustainability inspections of site management undertaken weekly during construction and monthly during operation,
    - Internal sustainability audits of the management system undertaken at least quarterly.
    - External sustainability audits of the management system undertaken at least annually.

Support for Low Carbon Project Tendering: This credit in-directly relates to low carbon tendering by requesting evidence of regular environmental and sustainability inspection of on-site performance and reported auditing of the management system.

Indication of '*Low Carbon Readiness*': This is a medium strength indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process for undertaking both environmental and sustainability inspections of site management and audits of management systems (both of which are very likely to have elements related to energy and greenhouse gas emissions).

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- Internal audits must be conducted by a person who is qualified to meet the competency requirements of ISO19011:2011, or equivalent,

- External audits are to be conducted by a suitably qualified auditor who is' not part of the project or asset management team'; however they 'may be from a parent company, a client, or a third party'.

- Sustainability inspections must use a 'checklist which covers environmental, social and economic aspects and the inspection must be documented in a report'.

Man-6: Reporting and review (0.86)

Aim: To reward regular, comprehensive and transparent sustainability reporting and review.

Evidence: Asked to provide a sustainability report, minutes of senior management review meetings, action plans, and evidence that sustainability reports are made public with minutes of community meetings.

Awarding of Points: Points are awarded as follows,

- 0.29 pts for provision of a sustainability report that includes sustainability objectives or targets with indicators and areas for improvement identified, evidence that sustainability performance is reported to management annually, and evidence that sustainability performance is reviewed at least annually by senior management with minutes of senior management review meetings.

- 0.57 pts for provision of for the above evidence and action plans or similar that demonstrate how improvements and/or changes have been made to the management system as a result of management review.

- 0.86 pts for provision of for the above evidence and evidence that sustainability performance is reported to management quarterly, sustainability performance is reported publically at least annually, and the management review incorporates community participation.

Support for Low Carbon Project Tendering: This credit in-directly relates to low carbon tendering by requesting evidence of sustainability reporting that is reported to senior management and the public and involves community participation.

Indication of '*Low Carbon Readiness*': This is a medium strength indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process for creating a sustainability report that has objectives, targets, and indicators and identifies areas for improvements (which is very likely to have elements related to energy and greenhouse gas emissions).

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- The technical manual highlights the Global Reporting Initiative and states that 'while reporting in accordance with GRI guidelines is not required for this credit, sustainability reports that comply with GRI guidelines (at level C or higher) are deemed acceptable',

- The sustainability report must be specific to the project or asset, unless 'relevant project details are reported in a separable subset'.

Man-8: Decision-making (3.21)

Aim: To reward incorporating sustainability aspects into decision making.

Evidence: Asked to provide decision-making guidelines, or equivalent, along with a design report or similar evidence of implementation of the above guidelines for one or more significant issues.

Awarding of Points: Points are awarded as follows,

- 1.07 pts for provision of evidence of a decision making process that considers options including business as usual and proven approaches taken in comparable situations, evaluates options primarily on the basis of financial aspects but considering environmental, social and economic aspects qualitatively through risk assessment, constraint analysis or other non-scored means, and evaluates options based on the forecast useful life of infrastructure asset.

- 2.14 pts for provision of evidence as above and evidence of a decision making process that evaluates options by considering environmental, social and economic aspects through the use of multi-criteria analysis or other scored means, on the forecast useful life of the infrastructure asset.

- 3.21 pts for provision of the above evidence and evidence of a decision making process that considers options including business as usual, non-asset, technical limits, and an option that specifically aims to address sustainability aspects, evaluates options by considering environmental, social and economic aspects through incorporating their value into cost-benefit analysis or other quantified means, and evaluates options based on the forecast useful life of infrastructure asset and using social rates of return for discounting.

Support for Low Carbon Project Tendering: This credit in-directly relates to low carbon tendering by requesting evidence of decision making guidelines that evaluate options by considering environmental, social, and economic aspects.

Indication of ‘*Low Carbon Readiness*’: This is a medium strength indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process for evaluating options by considering environmental, social, and economic considerations (which is very likely to have elements related to energy and greenhouse gas emissions).

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- The evaluation must consider the ‘forecast useful life of the infrastructure, rather than take a narrow view of just operating or capital costs and benefits’,

- For Level 2, ‘the analysis must incorporate at least one sustainability (non-financial) criteria and the weighting of the non-financial criteria must be greater than 20% in total’.

- For Level 3, ‘Cash flow discounting used in the analysis must use social rates of return for discounting (typically less than 5%) and provide justification. Higher rates of return tend to rapidly de-value the future and therefore do not provide proper consideration of the forecast useful life of the infrastructure asset’.

Climate Change Adaptation

Cli-1: Climate change risk assessment (2.50)

Aim: To reward the assessment of climate change risks.

Evidence: Asked to provide a climate change study report, a risk register or report, minutes of meetings and a model(s) of impacts from high and extreme priority climate change risks.

Awarding of Points: Points are awarded as follows,

- 0.83 pts for provision of evidence that a readily available climate change projection is identified and adopted for the asset region over the forecast useful life of the asset, and a direct climate change risks to the asset over the forecast useful life are identified and assessed.

- 1.67 pts for provision of evidence as above and evidence that a number of readily available climate change projections were identified and adopted for the asset region over the forecast useful life of the asset, the climate change risk assessment also considered indirect climate change risks to the asset, and a multi-disciplinary team participated in identifying climate change risks and issues.

- 2.50 pts for provision of the above evidence and evidence of the use of an appropriate model to obtain site specific climate change projections, or justification for why site-specific modelling was not required. Also evidence that the climate change risk assessment also considered flow on climate change risks to and from the asset that have regional or whole of infrastructure system implications, that modelling is undertaken to characterise the likely impacts of the projected climate change for all High and Extreme priority climate change risks, and that a comprehensive set of affected external stakeholders participated in identifying climate change risks and issues.

Support for Low Carbon Project Tendering: This credit in-directly relates to low carbon tendering by requesting evidence of the assessment of climate change risks, including direct, indirect and flow on risks with system and regional implications.

Indication of '*Low Carbon Readiness*': This is a medium strength indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process to identify climate change risks both at the regional and project site level (which are likely to include risks related to ongoing fossil energy use and greenhouse gas emissions generation) that involves a multi-stakeholder team and considers affected external stakeholders.

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- The manual refers users to 'AS/NZS ISO 31000:2009 Risk management - Principles and guidelines' and 'AS 5334-2013 Climate change adaptation for settlements and infrastructure - A risk based approach'.

Cli-2: Adaptation options (2.50)

Aim: To reward the assessment and implementation of climate change adaptation measures.

Evidence: Asked to provide a risk register or report, along with report(s) or management plans demonstrating that adaptation measures from the risk register have been implemented.

Awarding of Points: Points are awarded as follows,

- 0.83 pts for provision of evidence that adaptation options to treat all extreme and high priority climate change risks are identified and assessed for implementation, adaptation measures to treat all extreme and high priority climate change risks are implemented, and that after treatment there are no extreme priority residual climate change risks.

- 1.67 pts for provision of evidence as above and evidence that adaptation options to treat all medium priority climate change risks are identified and assessed for implementation, and adaptation measures to treat all medium priority climate change risks are implemented.

- 2.50 pts for provision of the above evidence and evidence of that the optimal scale and timing of options is addressed (which may be triggered by when a specific climate threshold is likely to be achieved), and that after treatment there are no high priority residual climate change risks.

Support for Low Carbon Project Tendering: This credit in-directly relates to low carbon tendering by requesting evidence of the assessment and implementation of climate change adaptation measures for extreme, high and medium risks.

Indication of 'Low Carbon Readiness': This is a medium strength indicator of low carbon readiness as if tenderers perform well against this credit, they will have a process to assess and implement climate change adaptation measures (which are likely to include measures related to energy use and greenhouse gas emissions).

Key Points for Low Carbon Outcomes: The IS rating tool technical manual provides additional guidance as to the interpretation of this credit with the following of particular relevance to low carbon tendering:

- For level 3 it is noted that 'Some climate change risks are best not treated immediately' as 'the impact may not occur for many decades, a satisfactory treatment may not yet be available, or greater certainty about climate change projections is required before a difficult decision can be made'.

Appendix B: List of Residential Energy Demand Reduction Behaviours

Residential Energy Demand Reduction Behaviours Identified Appropriate to Townsville, Australia (including an indication of the [Impact:Likelihood] estimates out of 5). (TCC, 2010a)

Reducing Electricity Consumption – Hot Water Systems (~28%)

1. Avoiding the installation and use of continuously circulating hot water systems [0.34:2]

2. Switching from an electric storage system to a gas storage or instant system [1.7:4]

3. Switching from an electric storage system to a heat pump water heater [1.25:4]

4. Switching from an electric storage system to a solar hot water heater [1.7:4]

5. Switching off the booster on a solar hot water system during summer months [0.34:4]

6. Installing correctly sized hot water system for need as a retrofit or replacement [0.5:1.5]

7. Fixing the hot water system if it is dumping hot water from the overflow pipe [0.10:1]

8. Turning the hot water system off when going away for a few days [0.03:1]

9. Reducing the length of time taken for showering (to a recommended 4 minutes) [0.33:2]

10. The installation of water efficient shower heads [0.38:2.5]

11. The installation of low flow aerators on taps to reduce hot water consumption [0.34:2]

12. The repair of dripping hot water taps [0.08:2]

13. Placing mixer taps to full cold when using cold water to avoid inadvertent use of hot water [0.08:1]

14. Washing clothes in cold water rather than warm or hot [0.26:4]

15. Turning the thermostat to 60oC to 65oC on storage hot water systems, and 50oC on instantaneous hot water systems [0.11:2]

16. Ensuring that the hot water system is properly maintained [0.10:0.5]

17. Draining sediment from a storage hot water system annually [0.1:2]

18. Contracting a plumber to repair leaks on a hot water system [0.10:3]

19. Conducting home –repairs on leaks on a hot water system [0.10:1]

20. The installation of the hot water heater to minimise total pipe length during house construction [0.1:0.5]

21. The relocation/retrofitting of the hot water system to minimise total pipe length [0.10:0.5]

22. Insulating the hot water tank using a thermal blanket [0.25:1]

23. Insulating hot water pipes as a retrofit [0.1:1.50]

24. Installing a thermostat timer on electric hot water systems

<u>Reducing Electricity Consumption – Kitchen Appliances (Fridge 14%, Cooking 5%, Dishwasher 1%)</u>

25. The purchase of an energy efficient dishwasher (rather than a less efficient model) [0.23:4]

26. The purchase a water efficient dishwasher (rather than a less efficient model) [0.17:3]

27. Composting rather than using an ‘insinkerator’ (Food Waste Disposers) [0:1]

28. Cleaning the seals around the fridge [0.5:3]

29. Ensuring that nothing is blocking the fridge door from shutting [0:4]

30. Keeping bottles of water in the fridge if not otherwise well stocked [0:1]

31. Avoiding unnecessarily opening the fridge (considering what is wanted before the door's opened) [0:1]

32. Vacuuming the refrigerator coils regularly [0.08:1]

33. When designing the kitchen, locating the refrigerator away from the oven [0.1:1]

34. Buying less food more frequently to reduce the fridge capacity required [0.4:2]

35. Stacking the contents of the fridge to allow for good air circulation [0:1]

36. The purchase of a fridge without an ice and water dispenser [0.05:3]

37. Defrosting the freezer regularly [0.1:4]

38. Washing dishes by hand rather than using a dishwashing machine [0:1]

39. Only using the dishwasher when full [0.23:2]

40. Using economy settings on dishwashers [0.16:3]

41. The purchase of a frost free fridge over a cyclic defrost fridge [0.1:4.5]

42. Buying the most energy efficient fridge possible [0.11:3]

43. Replacing an existing fridge with a more efficient model [0.55:1]

44. The purchase an appropriately sized fridge [0.1:3]

45. Placing the fridge to allow for air circulation around the coils [0.12:2]

46. Putting the fridge and freezer in a cool spot [0.08:2]

47. Ensuring the temperature of the fridge and freezer is set to recommended levels [0.1:4.5]

48. Refitting old and damaged seals on refrigerators and freezers [0:1.5]

49. Putting cold items back in the fridge as soon as possible [0:2]

50. Turning the fridge and freezer off when going away for longer periods [0:2]

51. Having the fridge inspected if the motor runs continuously [0.35:2]

52. Turning off a second fridge where possible [0.6:1.5]

53. Purchasing an energy efficient freezer [0.33:4]

54. Avoiding the use of large, second freezers [0.4:2]

55. Not refrigerating / freezing items unnecessarily [0:2]

56. Cooking extra food when preparing meals which can be frozen and reheated [0.1:2]

57. Planning ahead to cook several things at once when using the oven [0.1:1]

58. Cleaning oven and stovetops to promote maximum heat reflection [0.01:4]

59. Checking oven seals, and replacing if necessary [0.02:1.6]

60. If using aluminium foil when cooking, putting the dull side down [0:1]

61. Using a gas hotplate to boil water rather than a microwave [0.03:1]

62. Using an electric kettle to boil water rather than a microwave [0.05:4.5]

63. Not boiling more water than you need at that time. [0.03:1]

64. Simmering rather than boiling food when cooking [0.11:3]

65. Putting lids on pots when cooking to keep the heat in and reduce heat losses [0:3]

66. Thawing food in the fridge or in the sink rather than in the microwave or oven [0.1:3]

67. Using frypans or microwaves over ovens [0.05:3]

68. Using a toaster rather than the grill [0.01:4.5]

69. Turning the oven off ten minutes before cooking is finished to use the residual heat [0.05:2]

70. When using the oven, avoiding opening the door unnecessarily [0.1:1]

71. Matching the size of the saucepan to the size of the element to reduce heat losses [0.1:1]

72. Avoiding pre-rinsing dishes in hot water [0.4:3]

73. Purchasing an oven with triple glazing [0.1:2]

74. Purchasing an appropriately sized oven [0.03:1]

75. Purchasing a fan-forced oven [0.21:5]

76. Purchasing a pressure cooker for use rather than other cooking appliances [0.08:2]

77. Buying / Installing electric induction hotplates [0.01:1

78. Buying and installing gas cooktops and oven rather than electric [0.5:3]

<u>Reducing Electricity Consumption – Entertainment Equipment (TV/VCR 3%)</u>

79. Reducing the number of televisions in the house [0.5:1]

80. Switching televisions off when not being watched [0.2:2]

81. Using a radio for background noise rather than a television [0.2:2]

82. Using timers on the television when watching in bed to go to sleep [0.4:1.5]

83. Avoiding screensavers on computers and using the sleep option instead [0.10:3]

84. Switching computers off overnight [0.34:2]

85. Unplugging mobile phone chargers when not being used [0.05:4]

86. Purchasing an energy efficient television [0.60:1]

87. Switching microwaves off at the wall when they’re not being used [0.03:2]

88. Switching the VCR or DVD player off at the wall when they’re not being used [0.05:2]

89. Switching televisions off at the wall when they’re not being used [0.06:2]

90. Turning off the computer monitor when leaving the room for a few minutes or more [0.05:1]

91. Buying a television with low standby power usage [0.08:1.5]

92. Buying a computer with low stand by power usage [0.05:1]

93. Buying a DVD or VCR with low stand by power usage [0.10:1.5]

94. Purchasing a cathode ray tube television rather than plasma screen [1.9:1]

95. Purchasing an LCD television rather than a plasma screen television [0.11:3]

96. Purchasing and using a laptop rather than desktop [0.20:2]

97. Purchasing an LCD monitor rather than a conventional monitor [0.10:4.5]

<u>Reducing Electricity Consumption – Laundry Appliances and Bathroom (Clothes 2%)</u>

98. Waiting for full loads of washing (to reduce both electricity and water usage) [0.12:3]

99. Washing linen and clothes less frequently (if overwashing) [0.12:1]

100. Purchasing a water efficient washing machine [0.25:4]

101. Choosing a clothes dryer with a dryness sensor [0.02:3]

102. Spin drying clothes before putting them in a clothes dryer [0.10:4]

103. Drying clothes partially on the clothes line before putting them in the dryer [0.08:2]

104. If using the clothes dryer, drying several loads consecutively to use the residual heat in the machine [0:1]

105. Cleaning the filters on clothes dryers regularly [0.01:4]

106. Using standard toothbrushes rather than electric ones [0.01:2]

107. Using regular razors rather than electric shavers [0:1]

108. Drying hair naturally rather than with a hairdryer [0.04:1]

109. Avoiding using a heated towel rail to dry towels [0.20:4]

110. Using iron on dry setting when possible [0.01:2]

111. Ironing in larger batches to reduce heating up periods [0.01:1]

112. Ironing delicate garments first while iron is heating up [0.01:3]

113. Not ironing clothes, or other items [0.10:1]

114. Emptying and replacing vacuum cleaner filter bags regularly for greater efficiency [0.01:4]

115. Insulating the bathtub during construction [0.04:1]

116. Insulating the bathtub as a retrofit [0.04:0.05]

117. Taking a shower rather than a bath [0.050:2]

118. “Bucket bathing” rather than showering [0.65:1]

119. Washing clothes by hand [0.08:1]

120. Buying the most energy efficient clothes dryer possible [0.09:1]

121. Buying the most energy efficient washing machine possible [0.76:3]

122. Buying a washing machine which is sized to the household needs [0.09:4]

123. Purchasing a gas clothes dryer rather than electric [0.20:1]

124. Avoiding using a clothes dryer when it is possible to dry clothes naturally instead [0.17:3]

125. Using the heat from the hot water system for clothes drying [0.12:1]

126. Using a broom rather than a vacuum cleaner [0.03:2]

<u>Reducing Electricity Consumption – Pools, Hot Tubs and Saunas</u>

127. Avoiding the use of the heating function on a water bed [0.50:3]

128. Replacing existing swimming pool pumps, chlorinators and heaters [0.50:3]

129. Installing the smallest pump possible for the swimming pool [0.21:1]

130. Using solar heaters and/or solar blankets in heated pools [0.50:1]

131. Maintaining the pool to keep it free of debris to enhance pump efficiency [0.13:3]

132. Reducing the use of pool pumps / filters during cooler months [0.45:4]

133. Avoiding the installation of hot spas [0.50:3]

134. Minimising the use of baths and spas [0.03:1]

<u>Reducing Electricity Consumption – Heating & Cooling (Cool 14%, Heat 4%)</u>

135. Buying the most energy efficient air conditioner possible [0.60:4]

136. Buying an air conditioner which is appropriately sized the area needing cooling [0.1:2]

137. Placing rugs on the floor to reduce winter heating demands [0:3]

138. Installing and using curtains to provide a thermal layer between the window and the room [0.66:4]

139. In summer, opening windows and louvers during the night (when cooler) and shut during the day (hot air purging) [1.31:3]

140. Keeping air conditioning thermostats away from lamps, televisions and computers [0.22:3]

141. Pointing the louvers of the air conditioner towards the floor [0.10:2]

142. Using a programmable thermostat on air conditioners [0.22:2]

143. Setting the thermostat to (no lower than) 25oC in summer [0.44:3]

144. Replacing old model air conditioners with a more efficient model [0.66:2]

145. Installing pelmets (or a structure to prevent air flow) above curtains [0.22:4]

146. Using a hot water bottle rather than electric blanket in winter [0.01:2]

147. Cleaning the filters of air conditioners to ensure they are working efficiently [0.22:4]

148. Regularly servicing air conditioners to maintain optimal efficiency [0.60:2]

149. Switch off the air conditioner in rooms not being used and when you leave the house [0.42:2]

150. Dressing appropriately to minimise the need for mechanical cooling [0.22:4.5]

151. Shutting internal doors to rooms not being used when the air conditioner is being used [1.09:3]

152. The installation of centralised systems (if required) with zone controls and thermostats [0.01:3]

153. Using ceiling fans rather than, or in addition to, an air conditioner [0.06:3]

154. Setting the air conditioner to recirculate cool air from inside rather than cooling warmer air from outside [0.25:2]

155. Don’t use heating appliances (oven, dryer etc) while air conditioner is in use [0.22:2]

156. Avoiding excessive lighting, especially with incandescent bulbs and halogen downlights, which add to the heat load of air conditioners [0.01:2]

157. Restricting air conditioner usage [0.43:2]

158. Avoiding the installation of an air conditioner [2.18:2]

159. Dressing in warm clothes in winter rather than turning on a heater [0.19:4]

160. Avoiding the use of portable electric heaters to heat large spaces [0:3]

161. Pruning trees in winter or using deciduous plants to allow extra sun on the north and south walls and windows [0.012:3]

162. Rolling back awnings in winter to allow more sun through windows [0.04:2]

163. Removing fly roof in winter to allow greater solar access to the house [0.04:2]

164. Planting trees to provide a wind break from prevailing winter winds [0.15:2]

165. In winter, opening curtains during the day in winter to heat the house and closing during the night to trap the heat in [0.05:4]

166. Putting an under-blanket on the bed in winter, and an extra blanket on top [0.05:3]

167. If heating is required in the bedroom, using a timer to turn it off during the night [0.29:1]

168. Setting thermostat on heaters as low as is comfortable [0.04:3]

169. Using a reversible ceiling fan in winter to push warm air downwards [0.02:1]

170. Only setting the heater thermostat to the ultimately desired temperature and not higher (avoiding using the thermostat as an ‘accelerator’) [0.05:3]

171. Avoiding heating the kitchen, or the room where the refrigerator is located [0:3]

172. Utilising residual heat by turning off mechanical heating earlier [0.01:1]

173. Reducing the heating temperature when being more active in the house [0.01:2]

174. Heating fewer rooms [0. 55:3]

175. Using electric blankets rather than heating the entire bedroom [0. 40:1]

Reducing Electricity Consumption – Lighting (8%)

176. Using natural light rather than electric lights during the day [0.08:1]

177. Using candles rather than electric lights [0.35:1]

178. Switching lights off when not in use [0.23:4.5]

179. Replacing incandescent bulbs with fluorescents [0.19:4.5]

180. Avoiding halogen downlights for room lighting [0.41:1.15]

181. Change incandescent bulbs to halogen bulbs (same fitting) [0.02:2]

182. Only installing the required wattage for the use: use lower wattage light bulbs where possible [0.10:4]

183. Using reflectors to direct the light where it is needed to minimize additional wattage [0.24:2]

184. Avoiding coloured glass bulbs [0.01:4.5]

185. Switching incandescent bulbs to LED light bulbs [0.13:2]

186. Install solar powered garden lights rather than mains powered electric lights [0.10:4]

187. Using a desk lamp for task lighting rather than overhead lighting [0:2]

188. Connecting fewer lights to each switch to reduce unnecessary lighting [0.02:1.6]

189. Installing light switches at either end of halls and rooms with multiple exits [0.02:3]

190. Using sensors or timers on outdoor lights [0.31:3]

191. Installing and using dimmer controls on lights [0.02:3]

192. Using lighter coloured paints to reduce lighting requirements [0.10:3]

193. Cleaning lights and light fittings to remove dust and make them more effective [0.04:2]

Complimenting Energy Efficiency Behaviours with Onsite Generation

194. Installing solar photovoltaic panels [1.63:1.5]

195. Cleaning solar panels regularly [0.08:2]

196. Purchasing a portion of electricity from GreenPower [na:1.7]

197. Purchasing all the household’s electricity from GreenPower [na:2]

198. Clearing vegetation to reduce shading on solar PV panels [0.17:4]

199. Performing tasks requiring hot water early in the day when using solar hot water [0.54:2]

200. Setting the booster on a solar hot water system to 60oC [0.01:4.5]

201. Installing a wind generator [5:1]

Options for House Construction and Retrofit

202. Install automated systems to control appliances [1:1.7]

203. Considering the location of hot water using fixtures when designing and building a home [0.10:1.7]

204. Using smaller diameter pipes for hot water in building construction [0.05:2]

205. Installing caulking to fix draughts in the home [0.28:2]

206. Shading the outdoor components of the air conditioner from the sun [0.22:2]

207. Insulating verandah roofs as a retrofit [0.637:1]

208. Installing eave vents [0.66:3]

209. Planting conical trees to the south west and south east to provide shading during summer [1.5:3]

210. Planting trees and / or constructing physical structures to direct summer breezes towards the house [0.22:1]

211. Installing a fly roof to shade the entire building [1.70:1]

212. Installing a green roof [0.55:1.5]

213. Installing green walls [0.90:2]

214. Construct outdoor living areas (protected from the elements) [0.30:3]

215. Avoiding paving or concrete in front of windows [0.22:2]

216. Positioning furniture to make use of natural breezes and heating / cooling effects [0.66:3]

217. Plugging fireplaces which are not in use [0.01:4]

218. Installing insulation in the ceiling as a retrofit [0.77:4]

219. Installing insulation in the walls as a retrofit [0.43:1]

220. Installing weather stripping to fix draughts in the home [0.22:3]

221. Paint the roof white, or a light colour [1.28:4]

222. Installing roof ventilation as a retrofit [0.37:4]

223. Planting deciduous vines to shade the northern aspects [0.65:2]

224. Double glazing windows as a retrofit [0.22:1]

225. Tinting windows as a retrofit [0.87:2]

226. Installing eaves [0.46:4]

Additional Behaviours related to housing construction

227. Tinting windows during construction [0.87:2]

228. Installing double glazed windows during construction [0.22:3]

229. Installing insulation in the walls during construction [0.43:3]

230. Installing insulation in the ceiling during construction [0.77:4]

231. Designing the kitchen to allow for optimal placement of fridges when designing and building a home (in a cool, well ventilated area away from heating appliances) [0.20:3]

232. Putting doors at the bottom of stairwells

233. Orientate house (during construction) so that main walls and windows face north, locate living areas to the north and east

234. Group rooms into ‘zones’ when designing houses

235. Preference open plan houses with verandas during construction

236. Build with light weight construction material

237. Select windows which maximize air flow

238. Design elevated houses for underneath air flow

239. Build house with high, raked ceilings

240. Maximising the amount of external walls in housing design

Appendix C: Proposed Supply Chain Low Carbon Readiness Questionnaire

The following questions should be answered ‘Yes’, ‘No’, ‘Not Applicable’ or’ ‘I Don’t Know’. We ask that answers are an honest representation of your organisation’s systems and capability as responses may influence future minimum evidence requirements requested as part of pre-qualification and project tenders by UrbanGrowth NSW.

Management Systems

1. Does your company have a ‘Sustainability Policy’ or equivalent that includes commitments to mitigate negative environmental, social, and economic impacts? [Man-1]

   ☐ ‘Yes’, ☐ ‘No’, ☐ ‘I Don’t Know’, or ☐ ‘Not Applicable’

   If Yes,

   a. <u>Does it include your greenhouse gas emissions performance?</u>
   b. Are commitments embedded into sustainability objectives or targets? (L1)
   c. Are sustainability objectives or targets reflected in project contracts? (L2)
   d. Is it publically accessible? (L3)
   e. Is there a commitment to continual improvement? (L3)
   f. Do commitments go beyond mitigating negative impacts to restorative actions (i.e. net positive benefits for society and the environment)? (L3)

2. Is your company accredited under ISO14001, ISO9001, and AS/NZ4801 or other similar accreditation? [Man-2]

   ☐ ‘Yes’, ☐ ‘No’, ☐ ‘I Don’t Know’, or ☐ ‘Not Applicable’

3. Does your company have a process for identifying risks related to sustainability (including estimate of risk level and controls to treat risk) [Man-3] (L1)

   ☐ ‘Yes’, ☐ ‘No’, ☐ ‘I Don’t Know’, or ☐ ‘Not Applicable’

If Yes,

<u>Does this include consideration of carbon related risks</u>?

4. Does your company have a process for identifying opportunities related to sustainability [Man-3] (L2)

    □ ‘Yes’, □ ‘No’, □ ‘I Don’t Know’, or □ ‘Not Applicable’

    If Yes,

    <u>Does this include consideration of carbon risks and opportunities</u>?

5. Does your company have a member of the project senior management team with central responsibility for managing sustainability? [Man-4] (L1)

    □ ‘Yes’, □ ‘No’, □ ‘I Don’t Know’, or □ ‘Not Applicable’

    If Yes,

    a. <u>Does this include low carbon outcomes?</u>
    b. Is this person an IS Accredited Professional? (L2)
    c. Is the sustainability performance monitored and reviewed by an independent sustainability professional? (L3)

6. Does your company have a process for undertaking **environmental** inspections and audits of site management? [Man-5] (L1)

    □ ‘Yes’, □ ‘No’, or □ ‘I Don’t Know’

    If Yes,

    a. <u>Do they consider low carbon aspects, such as greenhouse gas emissions?</u>
    b. Are internal inspections undertaken at least weekly during construction and monthly during operation?
    c. Are internal audits of the management system conducted at least quarterly?
    d. Are external audits of the management system undertaken at least annually?

7. Does your company have a process for undertaking sustainability inspections and audits of site management? (L2)

   Note: *Sustainability inspections must use a checklist which covers environmental, social and economic aspects and the inspection must be documented in a report. In practice, coverage of environmental, community and local business issues meets this requirement.*

   □ 'Yes', □ 'No', □ 'I Don't Know', or □ 'Not Applicable'

   If Yes,

   a. <u>Do they consider low carbon aspects, such as greenhouse gas emissions?</u>
   b. Are internal inspections undertaken at least weekly during construction and monthly during operation?
   c. Are internal audits of the management system conducted at least quarterly?
   d. Are external audits of the management system undertaken at least annually?

8. Does your company have an environmental management system?

   □ 'Yes', □ 'No', or □ 'I Don't Know'

9. Does your company undertake sustainability reporting? [Man-6]

   □ 'Yes', □ 'No', □ 'I Don't Know', or □ 'Not Applicable'

   If Yes,

   a. Does it use the Global Reporting Initiative (GRI) framework?
   b. Does it include sustainability objectives, targets or indicators? (L1)
   c. Does it identify areas for improvement in sustainability areas? (L1)
   d. <u>Does it include Low Carbon related objectives, targets or indicators</u>?
   e. <u>Does it identify Low Carbon areas for improvement</u>?
   f. Is it reported to senior management annually? (L1)
   g. Is it reported to senior management quarterly? (L3)
   h. Is it reported to the public at least annually? (L3)

10. Is the sustainability performance of the company reviewed formally by senior management at least annually? [Man-6] (L1 + above)

    Note; *Senior Management refers to the top level of operational management within the project or asset management organisation.*

    □ 'Yes', □ 'No', □ 'I Don't Know', or □ 'Not Applicable'

    If Yes,

    a. Does it result in plans to improve/change the project or management system? (L2 + above)
    b. Does it include community participation? (L3 + above)

11. Does your company have a process for sustainability knowledge sharing? [Man-7] (L1)

    □ 'Yes', □ 'No', □ 'I Don't Know', or □ 'Not Applicable'

    If Yes,

    a. Is the Sustainability knowledge within the project captured and shared? (L1)
    b. Is Sustainability knowledge outside the project captured and shared within the project? (L2)
    c. Does the knowledge sharing extend beyond the project to parent organisations and other key stakeholders? (L2)
    d. Does the knowledge sharing extend to the wider industry? (L3)
    e. Does this knowledge include 'mistakes' as well as 'good practices'? (L3)

    If yes, what forms of knowledge sharing does your company use?

    a. Internal training sessions,
    b. Company newsletters,
    c. Internal intranet site,
    d. Public website.

12. Does your decision making process include environment, social, and economic aspects? [Man-8]

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes,

a. Are they considered qualitatively through a risk assessment, constraint analysis or other non-scored means?

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes, are they evaluated based on the forecast useful life (design life) of the infrastructure asset? (L1)

b. Are they evaluated using a multi-criteria analysis (or other scored means)?

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes, are they evaluated based on the forecast useful life (design life) of the infrastructure asset? (L2)

c. Are they evaluated as part of cost-benefit analysis (or other quantified means)?

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes, are they evaluated based on the forecast useful life (design life) of the infrastructure asset and using social rates of return for discounting? (L3)

d. Does this consider options including business as usual options and proven approaches taken in comparable situations? (L1)

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes, does this include non-asset options, technical limits, and an option that specifically aims to address sustainability aspects? (L3)

Procurement

13. Does your company have a commitment to sustainable procurement? [Pro-1]

Note: *According to the Australian Procurement and Construction Council, 'Sustainable Procurement' can be defined as 'a process whereby organisations meet their needs for goods, works and utilities in a way that achieves value for money on a whole-life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whilst minimising damage to the environment' (APCC 2007).*

□ 'Yes', □ 'No', □ 'I Don't Know', or □ 'Not Applicable'

If Yes,

a. Does this require environmental aspects be considered? (L1)
b. Does this require social and economic aspects be considered? (L2)
c. <u>Does this include low carbon aspects?</u>
d. Are these commitments publically stated? (L3)
e. Are the commitments embedded into sustainability objectives and/or targets for suppliers? (L3)

14. Does your company ask suppliers about their sustainability performance? [Pro-2]

□ 'Yes', □ 'No', □ 'I Don't Know', or □ 'Not Applicable'

If Yes,

a. Does this include details of environmental policy and its implementation? (L1)
b. Does this include details of sustainability policy and its implementation? (L2)
c. <u>Does this include details of low carbon related policy and its implementation?</u>
d. Do you use forward commitment procurement to stimulate innovation related to sustainability? (L3)
e. Do you engage with suppliers to explain sustainability (including low carbon) requirements and expectations and their importance in the bid process? (L3)

15. Does your company's supplier evaluation criteria include sustainability considerations? [Pro-3]

 'Yes', 'No', 'I Don't Know', or 'Not Applicable'

If Yes,

a. Is it evaluated using qualitative criteria (non-scored)? (L1)
b. Is it evaluated using multi-criteria analysis (or other scored means)? (L2)
c. Do your supplier contracts include sustainability objectives and/or targets? (L2)
d. <u>Do you include low carbon considerations, such as greenhouse gas emissions?</u>

16. Does your company have a process to audit the sustainable procurement tenders of your suppliers? [Pro-3]

 'Yes', 'No', 'I Don't Know', or 'Not Applicable'

If Yes,

a. Does it verify claims made in tender documents? (L3)
b. Does it identify areas of key risk (environmental, social, and economic)? (L3)
c. Does it identify areas for improvement which need to be considered for possible inclusion in the contract negotiation and terms? (L3)

17. Do you impose sustainability objectives on your suppliers? [Pro-4] (L1)

 'Yes', 'No', 'I Don't Know', or 'Not Applicable'

If Yes,

a. <u>Do they include low carbon objectives?</u>
b. Do you monitor their performance for the duration of the contact? (L2)
c. Do you actively manage non-compliance or poor sustainability performance? (L2)
d. Do you work with suppliers to identify any emerging or new sustainability opportunities? (L3)

e. Do you encourage and reward success in achieving sustainability outcomes? (L3)

Energy and Carbon

18. Do you have a process to model the energy use and GHG emissions of a project over the infrastructure lifecycle [Ene-1] (L1)

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes,

a. Do you have a process to decide where to take action to reduce energy use and greenhouse gas emissions? (L1)
b. Do you have a process to monitor the actions taken? (L1)
c. Is the modelling and monitoring report audited internally? (L1)
d. Is the modelling and monitoring report subject to external audit? (L2)

19. Do you have a process to identify and implement opportunities to reduce energy use and GHG emissions? [Ene-2]

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes,

a. Does this include all NGER Scope 1 and 2 energy use and emissions? (L1)
b. Does this include all NGER Scope 3 energy use and emissions? (L3)
c. Does this include options to specifically reduce peak demand on energy grids? (L3)

20. Do you have a process to quantify the payback period of feasible options to reduce energy use and GHG emissions? [Ene-2]

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes,

a. Do you have experience in implementing those with a four year or less payback period? (L2 + above)

b. Do you have experience in implementing those with a more than four year payback period? (L3+)

21. Do you use ‘energy and carbon management’ plans or similar in projects? [Ene-2 notes]

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If No, do you think it would be useful in your projects?

22. Do you have a process to fully investigate opportunities for the use of renewable energy in projects? [Ene-3] (L1)

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes,

a. Do you have the potential to provide between 20 and 40% of energy (including electricity and fuels) from renewable sources for the life of the infrastructure lifecycle? (L2)
b. Do you have the potential to provide greater than 40% of energy from renewable sources for the infrastructure lifecycle? (L3)

Materials

2. Does your company undertake the modelling and monitoring of lifecycle impacts of materials used e.g. Lifecycle Assessment (LCA)? [Mat-1] (L1)

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

23. Does your company make material selection choices considering embodied energy? [Mat-1] (L1)

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes, for what materials:

a. Asphalt,
b. Concrete,

c. Aggregates,

d. Steel,

e. Aluminium,

f. Glass,

g. Timber,

h. Piping,

24. Do you use products with ‘eco-labelling’? [Mat-2] (L1)

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes, which ones:

 Ecospecifier Green Tag labelling,

 Good Environmental Choice Australia Ecolabel (or GBCA BEP) labelling,

 An ISEAL Alliance compliant whole supply chain Stewardship Scheme certification,

 Other ISCA approved Type 1 Environmental label.

If Yes, what percentage of materials or products are certified?

 less than 10%

 between 10 and 20% (L2)

 more than 20% (L3)

Climate Change Adaptation

25. Do you have a process to identify and adopt a suitable climate change projection(s) for the asset region over the useful life of the asset? [Cli-1] (L1)

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

If Yes, can you obtain a site specific projection or justify why it’s not required? (L3)

 ‘Yes’, ‘No’, ‘I Don’t Know’, or ‘Not Applicable’

26. Do you have a process to identify and assess climate change risks to the asset over the forecast useful life (design life)? [Cli-1]

□ ‘Yes’, □ ‘No’, □ ‘I Don’t Know’, or □ ‘Not Applicable’

If Yes,

a. Does this assessment consider direct risks to the asset? (L2)
b. Does this assessment consider in-direct risks to the asset? (L2)
c. Does the assessment involve a multi-disciplinary team? (L2)
d. Does the assessment consider flow-on risks to and from the asset that have regional or whole of infrastructure system implications? (L3 + above)
e. Does the assessment include modelling of likely impacts for all High and Extreme climate change risks? (L3+)
f. Does the assessment involve affected external stakeholders? (L3+)

27. Do you have a process to identify and implement climate change adaptation measures? [Cli-2] (L1)

□ ‘Yes’, □ ‘No’, □ ‘I Don’t Know’, or □ ‘Not Applicable’

If Yes,

a. Do you have a process to implement measures to treat extreme and high risks? (L1)
b. Do you have a process to implement measures to treat medium risks? (L2)
c. Do you have a process to identify the optimal scale and timing of treatment options? (L3)

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