Cyber-Sustainability:
Towards a Sustainable Digital Future

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Abstract

In response to a growing popular concern for ‘sustainability’, Green Computing has emerged as a new ‘sustainability’ discourse in which researchers explore solutions to reduce the environmental impact of computing technologies themselves, as well as solutions to reduce the environmental impact of other activities and behaviours through the development of new technologies. Despite good intentions and enthusiasm for the cause, there is little evidence of Green Computing having had significant or long-term impacts, and indeed, as one potential indicator, even combined with all of the efforts of many other disciplines, the exponential curve of growth in carbon emissions continues unabated. This dissertation aims to understand the reasons why Green Computing may have had a limited impact to date, and explore alternative approaches to ‘sustainability’ that may enable greater impact by computing. To begin, key assumptions underpinning Green Computing discourse are exposed in order to contextualise it within the broader debate surrounding an agenda for ‘sustainability’ — the term itself, while gaining significant traction in popular culture, is deeply contested. It is shown that the discursive characteristics of Green Computing, along with its specific appropriation of the term ‘sustainability’, reinforce a set of values that ultimately undermine its solutions and limit its impact. An alternative discourse is proposed that avoids reinforcement of problematic values, and a radically different conception of ‘sustainability’, and the role that computing may play in contributing to a ‘sustainable’ future, is proposed in a new discourse, namely Cyber-Sustainability. To illustrate the difference in solutions that might emerge from Cyber-Sustainability, an initial set of propositional solutions are presented in the form of patterns, which are offered here as an invitation for others to join in the further elaboration of these patterns towards a comprehensive pattern language.

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Declaration

This thesis is submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

I declare that this thesis is my own work and has not been submitted in substantially the same form for the award of a higher degree elsewhere. To the best of my knowledge it does not contain any materials previously published or written by another person except where due references is made in the text.

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Abbreviations

Abbrevations

CO_2: Carbon dioxide

CO_2e: Carbon dioxide equivalent (total greenhouse gasses, converted into equivalent impact of carbon dioxide)

HCI: Human-Computer Interaction

ICT: Information and Communication Technology

IS: Information Systems

IT: Information Technology

QBL: Quadruple Bottom Line of 'sustainability'

SE: Self-Enhancement (values)

SLR: Systematic Literature Review

ST: Self-Transcendence (values)

TA: Thematic Analysis

TBL: Triple Bottom Line of 'sustainability'

Chapter 1

Introduction

Thesis aims and overview

Introduction

In response to a growing concern for the health of the natural environment, the discipline of computing has begun to explore the potential of technological contributions to 'sustainability'. As might be expected of an emerging research area, a range of titles have been proposed to refer to these efforts[1], some of which are used interchangeably, and some of which are perceived as philosophically different categories. These differences, however, are not well articulated, leading to confusion and misappropriation of terms. The result is the creation of a vast research area oriented broadly around what is perceived as an environmental 'problem'[2], which is herein referred to by the title 'Green Computing'.

While 'Green Computing' is a potentially imperfect moniker — in part because it is sometimes used synonymously with specific sub-genres within what is here called 'Green Computing' — a term for these efforts is nonetheless necessary for the purposes of critique. Uniting this research under one umbrella heading is intended to communicate the discovery (presented here) of a shared foundation amongst these

[1] e.g. Green IT, Green ICT, Green IS, ICT for Green, ICT for Sustainability, Sustainable Computing, Sustainable HCI, Sustainable Interaction Design, and Environmental HCI, to name some of the more common titles.

[2] i.e. the byproducts of our consumption are contributing to increasing vulnerability and declining health of the environmental ecosystems on which we depend.

various manifestations of 'sustainability' research in computing. As this dissertation will show, the research effort to date reflects a particular *mode* of conceptualising and addressing 'sustainability', which precludes and obscures other arguably equally valid modes, as explored in Part II.

What comprises Green Computing?

Within Green Computing, there are two broad approaches to 'sustainability'. The first, described as 'sustainability *in* design' (Mankoff et al., 2007)[3], is motivated by an awareness that technology itself is a major contributor to environmental pollution (e.g. CO_2 emissions, electronic waste) and resource denudation. This involves a range of tactics for developing more 'sustainable' technological products, including:

- incremental improvements in the energy efficiency of technology,
- powering technologies with renewable energy,
- enabling device re-use,
- increasing product longevity, and
- enabling the sharing of devices or energy resources (ibid: p. 2122).

The second approach, described as 'sustainability *through* design'[4], offers technological interventions for supporting more 'sustainable' behaviour. Much of this research is inspired by the notion of 'persuasion' (Fogg, 2003) as a means of influencing behaviour. Other research explores social and psychological factors involved in environmentally destructive activities, and investigates the potential of technological interventions to disrupt these behaviours and/or facilitate more 'sustainable' ones.

The two prominent discourses (see Glossary for definition of 'discourse') within Green Computing are 'Green IT' (or Green Information Technology) and 'Sustainable HCI' (or Sustainable Human-Computer Interaction), both of which are themselves somewhat nebulous categories which require clarification:

Green IT: In this dissertation, the term Green IT is used to refer to self-described 'Green IT' research, as well as closely related 'Green ICT', 'Green IS', and

[3] Green IT refers to this category of research as 'greening *of* IT' (Murugesan et al., 2013).
[4] Green IT refers to this category of research as 'greening *by* IT' (Murugesan et al., 2013).

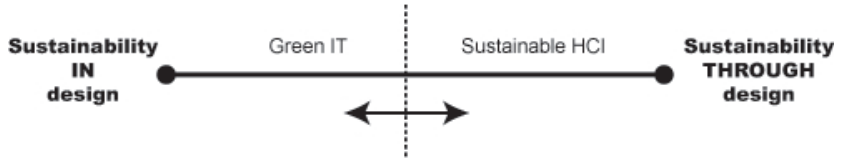


Figure 1.1: The Green Computing continuum, representing the permeable barrier between Green IT and Sustainable HCI, which are associated with, respectively, 'sustainability in design' and 'sustainability through design'.

'ICT for Green' research (abbreviations defined in the Abbreviations list, page xvii), which regularly appear in designated Green IT conferences and journals. This research tends to be grounded in engineering and computer programming traditions, and overwhelmingly focuses on 'sustainability *in* design' problems[5].

Sustainable HCI: This term emerged in the computing lexicon in 2007, but its precise scope and definition has yet to reach broad consensus. Various categories of research activity have been identified within Sustainable HCI, including 'Sustainable Interaction Design' (cf. Blevis, 2007), 'Persuasive Technology', 'Ambient Awareness', 'Formative User Studies', and 'Pervasive and Participatory Sensing' (DiSalvo et al., 2010). Further categories of research activity have been identified within what has also been described as 'Environmental HCI' (Goodman, 2009) — including 'Re-visioning Consumption' and 'Citizen Sensing' — which has been subsumed under the more commonly used name of Sustainable HCI. This research tends to be grounded in social science traditions, and is dominated by the 'sustainability *through* design' approach, but occasionally crosses over into 'sustainability *in* design' territory.

A glossary of these many terms is provided at the end of this dissertation; and the relationship of these two broad categories to Green Computing is crudely captured by Figure 1.1. An alternative, and potentially more informative categorisation of the various research activities within Green Computing, however, has been proposed as part of this work (Knowles et al., 2013b). This publication shows that while Green Computing began as a response to environmental concerns, it has since begun to embrace a more inclusive understanding of 'sustainability', which addresses environmental needs first and foremost, but also now includes considerations of social and economic needs (see Figure 1.2). Nonetheless, as this dissertation will argue, much of this research appears to demonstrate a naïveté about issues related

[5]Recently, however, Green IT has begun to embrace a 'sustainability *through* design' approach, referred to in this community as 'greening by IT' (as opposed to 'greening of IT') (Murugesan et al. 2013; To et al., 2013; Penzenstadler, 2013).

Figure 1.2: Framework of Green Computing research concerns.

to 'sustainability' — potentially both by the majority of researchers themselves, as well as by the gatekeepers[6] who profoundly influence the research agenda by determining which research gets funded and published. While there has been critique of the field by certain researchers who appear knowledgable about the issues below[7], the overwhelming majority of work that is being published in mainstream, high rated venues does not adequately address the following issues, which will be addressed herein:

(a) the rebound effect (see Glossary, Appendix A), whereby environmental gains enabled by efficiency improvements are largely eradicated by the increased usage consumers feel free to enjoy due to the perception that this consumption is now 'less bad' (Berners-Lee & Clark, 2013: pp. 50–4; Berners-Lee, 2010: p. 16);

(b) the numerous externalities that are not being accounted for, including, for example, the embodied carbon footprints of technology, and the large-scale disposal of less efficient machines — which often results in toxic landfill that pollutes soil and water;

[6] e.g. computing institutions such as the Association for Computing Machinery, ACM, and the Institute of Electrical and Electronics Engineers, IEEE; as well as key funding bodies like the Engineering and Physical Sciences Research Council, EPSRC.

[7] Notable examples include Eli Blevis, Bonnie Nardi, Paul Dourish, Six Silberman, Bill Tomlinson and Lisa Nathan.

(c) the long-term consequences of targeting marginal behaviour change through self-interested consumer enticements, which reinforces fundamentally unsustainable consumerist orientations;

(d) the scale of change required to mitigate climate change, which in the UK would amount to an 80% reduction in carbon emissions by the year 2050, according to the government's 2008 Climate Change Act (Crown, 2008), and may indeed require as much as a 97% reduction in carbon emissions compared with 1990s levels (Harrison, 2012); and

(e) the deeply contested nature of key concepts such as 'the environment' and 'sustainability', which are generally neither articulated nor debated within Green Computing.

In the main, what Green Computing has offered to date is a range of solutions that fit within a particular — and *narrow* — understanding of 'sustainability' and technological 'progress', which even collectively, have thus far not helped to dent the exponential curve of rising carbon emissions (Berners-Lee & Clark, 2013: pp. 7–15[8]) that Green Computing purports to be actively targeting (see Table C.1). And as this dissertation argues, these understandings are themselves antagonistic to Green Computing ever making a significantly positive impact for the environment, not least because this premise appears to do very little to promote a *way of being* that is fundamentally 'sustainable'. It will be argued in this work that to make significant progress towards any serious notion of a sustainable[9] digital society, an altogether different kind of thinking and academic discourse is required.

1.1 Dissertation overview

The main motivator of this work is to identify an alternative pathway for 'sustainability' research in computing that is capable of making a significantly positive impact for society. As part of this, this work seeks to present a nuanced and fully articulated vision of what this sustainability *means*, and to offer initial ideas for how this

[8] Indeed, there appears to be a slight increase in annual carbon emissions since 2000 (Berners-Lee & Clark, 2013: p. 12).

[9] The word sustainable is used without quotes throughout the dissertation to indicate that it is the in accordance with the author's definition of sustainability. When in quotes, this indicates others' definitions of the term.

might shape future computing outputs. The hope is that this work lays an important foundation for this new research direction so that other researchers can join this effort and develop a range of new research outputs that contribute towards this new sustainability vision.

The nature of this enquiry is necessarily multidisciplinary[10], and this work applies research from fields such as psychology, linguistics, design and computing towards this new problem domain. Techniques established in these fields have been borrowed where appropriate — e.g. discourse analysis, thematic analysis, situational analysis, positional mapping, systematic literature review and content analysis. Since the aim is to set a new course for research, however, in some instances entirely new techniques have been developed, which themselves represent significant research contributions. These main new methodological contributions include *values analysis* (Chapter 3) and *frames analysis* (Chapter 4). Given that values and frames play such a vital role throughout the dissertation, these terms are defined briefly below.

Values: Although there are competing understandings of values amongst various philosophical orientations and traditions, this dissertation adopts an understanding of values consistent with the publications that inspired this inquiry into values. Throughout this dissertation, values are defined as self-orienting beliefs that are core to an individual's sense of self and help guide actions that are in accordance with this sense of self. There is a long history of psychology research into values, which consistently demonstrates their importance in motivating people's behaviour. Behaviour change is a popular target for a range of progressive campaigns, and appealing to particular values can have important consequences for the success or failure of meeting stated behaviour change goals. Specifically, psychology research suggests that ostensibly common sense strategies for motivating behaviour change — i.e. through capitalising on people's self-interest — are self-defeating, inadvertently reinforcing negative behaviour in the long term by appealing to the values that perpetuate that behaviour[11].

While these findings have thus far been strategically leveraged to increase the impact of campaigns for organisations such as WWF-UK and Oxfam, this dissertation provides the first application of these findings to the domain of Green Computing, to

[10] See Acknnowledgements, which briefly explains the HighWire Centre for Doctoral Training.

[11] Note that this dissertation uses a small number of Common Cause publications as key references for this values and frames research. These works have been chosen because they assimilate a vast body of relevant research contributions. Chapter 3 provides some additional detail about how robust this values research has proven to be, including reference to additional sources.

offer new insight into a) the current limitations of Green Computing's strategy for affecting behaviour change, and b) a radically different strategy that values research suggests will be more successful. An entirely new methodology has been developed in Chapter 3 for operationalising this values research as an evaluation tool for assessing Green Computing's 'sustainability' strategies, which can be applied by future researchers towards any number of other problem areas.

Frames: The term 'frames' was first popularised by Minksy in 1974, originally referring to the way in which the brain packages information into bundles in order to make rapid sense of stimuli. A frame will contain both '*factual* and *procedural*' information, 'in that it encapsulates both what to do and how to do it' (Darnton & Kirk, 2011: p. 68). Related to this is the idea of social 'scripts' (cf. Schank & Abelson, 1977), in which cognitive bundles about behavioural norms are invoked as a means of navigating appropriate behaviour in given situations (Darnton & Kirk, 2011: p. 69). Other famous usages of 'frames' are by Goffman (1974), who emphasises the social importance of frames for 'governing' human behaviour (Darnton & Kirk, 2011: p. 69), and by Fillmore (1975), who emphasises the linguistic importance of frames as providing 'coherence' to experiences (Darnton & Kirk, 2011: p. 69). These understandings of frames are similar to what Common Cause[12] researchers refer to as 'surface frames' (Chilton et al., 2012; Darnton & Kirk, 2011). Common Cause differentiates surface frames from 'deep frames', which are perceived as more fundamental cognitive narratives about how the world works — i.e. surface frames only make sense because they point to and make use of existing deep frames. This dissertation does not make this distinction between surface and deep frames, in part because it is difficult to determine just how 'deep' any frame might be. What is important, however, is the fact that some frames can be deeper than others, in the sense that one frame might integrate other frames. (Such dynamics will be elaborated as necessary throughout the dissertation.)

Chapter 2 undertakes a discourse analysis of various 'sustainability' discourses, including Green Computing research, in order to identify the frames that are relevant to the sustainability debate, and the particular set of frames that characterise competing discourses. In Chapter 2, the 'discourse analysis' involved a process of reading a large collection of publications for a given identifiable and/or self-identified

[12] In 2009, a multidisciplinary group of researchers known as 'Common Cause' united around a concern about 'the inadequacy of current responses to challenges like climate change, global poverty and biodiversity loss' (see `http://valuesandframes.org/about/#past`), and a desire to increase the impact of those working to address these issues.

group (e.g. Green IT, Sustainable HCI), gradually building an understanding of commonly identifiable elements that comprise the written language of these publications[13], and assimilating that understanding as being indicative of characteristics of that given group. This discourse analysis technique not in itself new — methodological precedents for this technique include Lakoff (2008), Westen (2007), Chilton et al. (2012) and Darnton & Kirk (2011) — though this work offers a more extensive examination of frames than has yet been undertaken by others in this specific domain (e.g. Goodman, 2009; Dourish, 2010). The unique methodological contribution made in this dissertation, however, is the frames analysis of Chapter 4 (see Appendix E.1), which offers the first systematic[14] technique for evaluating the link between frames and behaviour by bridging frames with values.

1.2 Dissertation aims and objectives

The aims of this dissertation are as follows:

- Explore the differences between various discourses on 'sustainability', and develop a contemporary understanding of the term;
- Develop a comprehensive understanding of the computing response to 'sustainability' as it relates to the above contemporary understanding and other competing interpretations, with particular emphasis on the dominant approaches within Green Computing, i.e. Green IT and Sustainable HCI;
- Illuminate gaps in computing research as it pertains to various possible interpretations of 'sustainability';
- Evaluate and understand the reasons for the current successes and/or limitations of Green Computing with respect to the stated objectives of Green IT and Sustainable HCI;
- Elaborate an alternative discourse for 'sustainability' research in computing based on the above contemporary understanding of the term, and justify the need for this discourse on the basis that it has potential to have a significant and/or longterm impact;

[13] These elements are summarised in Tables 2.1, 2.3 and 2.6.

[14] The main critique of the above cited precedents for frames analysis is that they are largely intuitive, and that findings cannot be validated because of a lack of documentation of the thinking that has led to the identification of various frames.

- Propose alternative 'solutions' that might be undertaken within computing towards realisation of this contemporary notion of 'sustainability';

- Articulate plans for future research in this new area.

To achieve these aims, this work will satisfy the following objectives:

- Conduct a comprehensive literature review and analysis of a) competing discourses on 'sustainability', and b) current computing research that self-identifies as being related to 'sustainability';

- Conduct a comprehensive literature review of values and frames research with a view towards applying insights to the domain of 'sustainability' research in computing;

- Evaluate Green Computing's successes and limitations by adapting existing techniques from various disciplines and operationalising values and frames research;

- Conduct a comprehensive review of the current issues and trajectories for digital development with a view to identifying primary areas of concern with respect to a nuanced understanding of 'sustainability' (i.e. one that differs from that which underpins Green Computing);

- Through that analysis, yield potential points of intervention towards this 'sustainability', and develop design patterns that address the identified areas of concern.

1.3 Dissertation organisation and impact

Below, a brief summary is provided for each chapter, including a description of the outputs[15] pertaining to each chapter.

[15]Note that 'Richards, B.', above, refers to the author, prior to adopting the married name Knowles in September 2012.

1.3.1 Part I

The first part of the dissertation offers an analysis and critique of the current state of Green Computing, contextualising its contribution in relation to the range of competing discourses on 'sustainability', and evaluating its success in making progress towards 'sustainability' as defined by Green Computing.

Chapter 2 provides background about the many different uses of the term 'sustainability', and how Green Computing researchers understand 'sustainability' in the context of their work. Discursive characteristics of Green IT and Sustainable HCI are identified and classified according to an existing set of axes (Dryzek, 2005). It is argued that Green Computing is reformist (as opposed to radical), and that there is a gap for an alternative, radical approach to sustainability. (For outputs pertaining to this chapter, see Appendix B.1.1.)

Chapter 3 uses values analysis to assess Green Computing's strategy for motivating behaviour change and shows that it uses a similar strategy to historically unsuccessful progressive campaigns. It is argued that Green Computing's three-fold articulation of 'sustainability' (Triple Bottom Line) is itself problematic in terms of values, and therefore that fundamental change is required within Green Computing if the community is going to make a significant impact towards their 'sustainability' goals. (For outputs pertaining to this chapter, see Appendix B.1.2.)

Chapter 4 argues that Green Computing is premised in deeply problematic understandings of human nature (frames) that manifest in its flawed strategy (values) for motivating change, significantly hindering its overall impact for 'sustainability'. A case is made that a new, radical computing discourse on sustainability is required that is premised in alternative frames that are consistent with a set of values conducive to sustainability. (For outputs pertaining to this chapter, see Appendix B.1.3.)

1.3.2 Part II

Having shown in Part I that a new discourse in computing is needed, and identified the frames and values that might underpin such a discourse, Part II describes an alternative understanding of sustainability, around which is developed a new computing discourse called Cyber-Sustainability. This discourse necessarily suggests different design criteria than those being offered by Green IT and sustainable HCI,

and the dissertation concludes by offering and evaluating a number of propositional 'solutions', in the form of patterns, that address this more nuanced understanding of sustainability.

Chapter 5 describes the characteristics of Cyber-Sustainability discourse and identifies a new set of research concerns. (For outputs pertaining to this chapter, see Appendix B.1.4.)

Chapters 6 provides a set of design criteria that aligns with the principles of Cyber-Sustainability. This is done in the form of design patterns, and forms the beginnings of a pattern language for a sustainable digital future. (For outputs pertaining to this chapter, see Appendix B.1.5.)

Chapter 7 integrates Chapters 5 and 6, pulling out key design issues for Cyber-Sustainability and developing a more detailed framework than that presented in Chapter 5. The limitations of the patterns are discussed, and the dissertation concludes with a plan for future work.

Values and Frames

Part I Overview

The purpose of Part I is to provide an in-depth analysis of contemporary research in Green Computing in order to understand how the community appropriates and then addresses the notion of 'sustainability'. The two dominant orientations within Green Computing, Green IT and Sustainable HCI, are elaborated separately to highlight important discursive distinctions within this larger community. Discourse analyses are performed on publications from both research orientations as a means of critiquing the current approaches to 'sustainability' within computing research. Through this process, contributions are made to the Green Computing community, which include the following:

- Explicitly articulating the (largely) tacit understandings of what 'sustainability' means within Green Computing as a whole, and what the similarities and differences are between Green IT and Sustainable HCI — both necessary pre-requisites of fruitful debate and collaboration between research communities;
- Situating Green Computing research within the broader context of competing discourses on 'sustainability', thereby enabling researchers to engage in this broader (i.e. beyond computing communities) debate;
- Providing insight into why Green Computing may not be realising its ambitions for significant behaviour change (Preist et al., 2013; Brynjarsdóttir et al., 2012), as well as how researchers might adjust their strategy to make a greater impact.

In addition to making these contributions to Green Computing, Part I critiques Green Computing along several dimensions. The first is that the Green Computing strategy is unlikely to produce desired behaviour change because both the discourse and the technology outputs work to reify a set of values that tend to exacerbate unsustainable behaviour. Secondly, there are fundamental tensions

embedded within Green Computing's Triple Bottom Line framing of 'sustainability' that create strategic conflict and make it unlikely that simultaneous pursuit of these three goals will be successful. Finally, Green Computing is premised in deeply problematic understandings of human nature that manifest as a flawed strategy for motivating change, which serves to significantly hinder its overall impact for 'sustainability'.

Chapter 2

Perspectives on Sustainability

Understanding the evolution of the term ‘sustainability’ and its current meaning in the digital context

Introduction

As in nearly every other domain today, ‘sustainability’ has become an area of recent focus in computing. This is evidenced perhaps most clearly by the increase in funding calls that target ‘sustainability’ research, and the veritable explosion of ‘sustainability’-themed conferences and journals within the computing community. However, while a vague notion of ‘sustainability’ has been widely accepted as worthy of pursuing, there is no single, robust definition of ‘sustainability’ around which the computing community can coalesce. Popular conceptions of ‘sustainability’ as being related to the continuance of humanity and ‘the environment’ appear to have been adopted as the foundation of much of this computing research, without acknowledgement of the contested nature of the term and the deep-seated philosophical differences represented by the range of definitions offered over the last five decades.

The purpose of this chapter is to explore how ‘sustainability’ is understood within competing discourses, and how these discourses differ, in order to better understand how ‘sustainability’ has been appropriated within Green Computing.

This chapter comprises three main sections. Section 2.1 provides a comprehensive background of key terms for this dissertation, including 'sustainability'. The method of discourse analysis used in the remainder of the chapter is introduced by comparing various environmental discourses along four dimensions, and important differences in orientation and worldview (cognitive frames) exposed through this analysis are given labels, which are used throughout the remainder of the dissertation.

In Section 2.2, the same discourse analysis tools are used to arrive at a comprehensive understanding of 'Green Computing'. The discursive differences between two key orientations within Green Computing — namely, Green IT and Sustainable HCI — are explored, and analysis reveals that both are based on an understanding of 'sustainability' that the first part of the chapter demonstrates is somewhat outdated (if not outmoded).

The chapter concludes (2.3) by highlighting the important implication of Green Computing being comprised of two reformist discourses (Green IT and Sustainable HCI), namely that radical approaches to 'sustainability' are not accounted for within the discipline. While one prosaic/radical response has recently emerged, i.e. Collapse Informatics, a gap remains for the emergence of an imaginative/radical discourse, which may present opportunities for new forms of sustainability research in computing[1].

2.1 Discourses on sustainability

The aim of this section is to clarify the terminology of 'sustainability' so that it may be usefully employed in later discussion about the sustainability of digital technologies. It begins (Section 2.1.1) by undertaking a broad survey of competing environmental discourses, as interpreted by Dryzek in the book, *The Politics of the Earth: Environmental Discourses* (2005). Dryzek's categorisations are adopted as the foundation of discussion throughout this section because this publication offers a comprehensive lexicon for differentiating the numerous competing discourses related to 'sustainability', thereby providing an academically verified heritage for this dissertation. While this dissertation makes pragmatic use of these categorisations

[1] Note that when underlined, the terms reformist, radical, prosaic and imaginative shall refer to these specific discursive classifications. This is primarily to differentiate between other uses of the term 'radical', which will be explored later.

as a starting point, frame analysis (inspired by the work of Danton & Kirk, 2001, and others) is used to restructure Dryzek's argument into groupings of constituent cognitive frames. These frames are then used in Section 2.1.2 as a means of discussing the evolution of the term 'sustainability' from a Triple Bottom Line to a Quadruple Bottom Line configuration of concerns, and understanding the cognitive transformations undergone to bring about the evolution of a sub-category of sustainability discourse defined herein as 'Radical Sustainability'. Section 2.1 concludes by reiterating the importance of the distinctions between these competing discourses on 'sustainability' and arguing that the loose association of 'sustainability' with a striving for 'continuance' is an inadequate basis for the emerging Green Computing discourse.

2.1.1 Environmental discourses

A discourse is a particular way of constructing 'meanings and relationships' and therefore helps orient individuals around 'a shared way of apprehending the world' (Dryzek, 2005: p. 9). One way of analysing the distinctions between different discourses is to compare the following (ibid: p. 17-18):

- Which basic entities are recognised or constructed?
- What assumptions are made about the natural relationships between entities?
- Who or what has agency, and what are their motivations?
- What metaphors or rhetorical devices are employed in communicating these messages?

These four elements are the building blocks in framing a target 'problem'. Importantly, *how a problem is framed determines the kinds of solutions available for solving that problem* (Lakoff & Ferguson, 2006). Therefore, in order to understand why particular solutions are proposed, and are then either accepted or rejected by different individuals, one must seek to understand the way individuals apprehend the world, and how this then motivates their decisions in navigating this world.

It is also important to recognise that discourses are historically situated, in that they only make sense within a greater historical context. Dryzek argues that 'Environmental discourse begins in industrial society, and so has to be positioned in the context of the long-dominant discourse of industrial society, which we can call

industrialism' (2005: p. 13). This industrial discourse represents an 'overarching commitment to growth in the quantity of goods and services produced and to the material wellbeing that growth brings' (ibid: p. 13).

While environmental discourses are rooted in industrial discourse, they do not merely accept the industrial premise. The degree of departure from these terms is one of the key differentiators of various environmental discourses. For example, reformist departures, including what Dryzek calls 'Problem Solving' approaches and 'Sustainability'[2], seek solutions within familiar modes of rational management; whereas radical departures, which argue for a comparatively significant movement away from industrial modes of living and being, include 'Survivalism' and 'Green Radicalism' (ibid: p. 15). Furthermore, these departures can be characterised either as prosaic — in that they accept the rules of the 'game' that industrialism plays, i.e. aiming to increase material wellbeing through growth — or imaginative — meaning that the rules and purpose of this industrial 'game' are challenged, and along with that, the means of growth and its relationship to other 'sustainability' concerns (e.g. environmental and social). Prosaic approaches include 'Problem Solving' and 'Survivalism'; and imaginative approaches include 'Sustainability' and 'Green Radicalism' (ibid: p. 15) (these different dimensions are illustrated at the end of Section 2.1.2 in Table 2.2).

Whether one tends towards the reformist or radical side of the debate, or towards the prosaic or imaginative side, is less a personality indicator than it is an indicator of the way in which one apprehends the world. These worldviews can be differentiated into discrete but interrelated 'cognitive models' (Cognitive Policy Works, 2013) — i.e. the 'frames' introduced in Chapter 1 — which individuals invoke in making sense of a situation or problem such as 'sustainability'. In order to understand some of the differences between competing environmental discourses, therefore, several key frames are discussed below with respect to Dryzek's four building blocks of discourses.

Recognition and construction of basic entities

The various entities that are recognised and constructed within a discourse are the building blocks of its 'ontology' (Smith, 2001); i.e. they are the things that the discourse talks *about*. Critical differences between environmental discourses can be

[2] Throughout this dissertation, when 'Sustainability' is used in quotes and capitalised, it shall refer to the discourse heading that Dryzek uses to refer to both 'Sustainable Development' and 'Ecological Modernization' discourses. When lowercase ('sustainability'), this shall refer to the concept, not the discourse.

seen in the way entities such as 'the environment', 'the human' and 'the economy' are understood, as demonstrated below.

'The environment' Among competing environmental discourses, there is a commonly shared sentiment that the environment is 'good', and therefore protecting the environment is 'good'. Precisely why the environment is 'good', however, is contested:

Instrumental value: For some the environment is *instrumentally* good, in the sense that it provides useful things for humans. Individuals framing the environment in this way tend to recognise environmental *resources* rather than the integrity of environmental systems (e.g. 'Survivalism'; Dryzek, 2005: p. 41). When viewed in this way, the value of protecting it is often weighed against other instrumental goals, such as economic profitability. The resulting moral statement often becomes, 'Protecting the environment is good, but...' followed by enumeration of other (assumed) conflicting ambitions. For example, one might say, 'Protecting the environment is good, but it is important to ensure that the economy is prosperous.'

Intrinsic value: For others the environment is *inherently* good, in that it is spiritually or otherwise significant to the world and to being human, above and beyond being a vital source of resources. Framing the environment in this way prescribes a moral obligation to protect it because it is *worthy of protection* (e.g. 'Green Radicalism'; ibid: p. 197), as opposed to (simply) because of what we can continue to get or extract from it. In recognition of an inherently good environment, the statement 'Protecting the environment is good' is unambiguous and assumed correct.

The difference between these perspectives might be summarised by the following frames:

Instrumentally Valuable Environment vs. *Intrinsically Valuable Environment*[3].

'Ecomodernism' (Davison, 2001), for example, exemplifies the *Instrumentally Valuable Environment* mindset, because it is centrally preoccupied with the rational management of perceived 'valuable' resources. So-called Romantic writers (e.g.

[3] cf. Chilton et al. (2012: p. 39): 'the intrinsic value of nature frame'.

Thoreau, Emerson, Wordsworth and Coleridge) on the other hand, promote a vision of the environment as pristine and intrinsically worth preserving against the encroachment of industrialism.

The other major point of contention between discourses regarding 'the environment' is whether environmental resources are inherently finite, or human ingenuity determines natural limits. For example, 'Problem Solving' and 'Sustainability' discourses reject inherent environmental limits in favour of a more relativist interpretation that makes room for the possibility of technological innovations that may infinitely stretch these resources[4]. In contrast, 'Survivalist' discourse includes an eschatology of resource depletion, referencing impending crises such as 'peak oil' (Heinberg, 2009; Greer, 2008) and overshoot of the earth's carrying capacity[5]. Meanwhile, 'Green Radicalism' largely side-steps this debate by insisting on the importance of not doing damage to a 'worthy' entity.

The above differences might be described as the frames *Finite Resources* and *Unlimited Resource Potential*; though in defining these frames in terms of 'resources', it is important to reiterate that concern for resources is not the central concern of imaginative/radical discourses but rather protecting the environment for its intrinsic value — a position apparently unique to this discursive quadrant (see Table 2.2). A more important distinction to make, therefore, is the degree of change proposed to the current modes of consumption — whether or not this is motivated by a concern about resource limits. This difference is sufficiently captured by the distinction between reformist and radical discourses.

'The human' There are three politically contested aspects of 'the human' amongst competing environmental discourses. The first is the question of our 'uniqueness' as a species, and how that then influences our understanding of our relationship to other species and the environment. (This will be discussed in the section to follow on the natural relationships between entities; page 24.) The second is whether humans have an inherent 'nature' (i.e. characteristics that define us), and what that is. (This will be discussed in the section on agency; page 25.) And the third relates to the nature of our sentience, namely the degree to which our actions are motivated by rational thought. The conflicting views on this matter have been identified as the *Rational Actor* frame versus the *Embodied Mind* frame (Danton & Kirk, 2011: p. 83):

[4] Related to this are the similar 'Promethean' 'supply and demand' economic arguments (cf. *Scarcity and Growth*, Barnett & Morse, 1963), that oil reserves will never dry up because as reserves become more scarce, it will become more valuable and more expensive; and in turn this will promote more sparing use of oil and increase the appeal of alternative energy usage.

[5] This problem was popularised by the so-called Club of Rome (Meadows et al., 1972)

Rational Actor understands the mind as a cost-benefit analysis machine, a calculator used to determine maximally beneficial decisions. 'Economic Rationalism' is perhaps the best exemplar of this frame in action: by taxing pollution, governments leave the decision to pollute up to rational actors, who will weigh the costs and benefits of this pollution (Dryzek, 2005: p. 130). 'Ecoefficiency' discourse (cf. Davison, 2001) also assumes rational actors, as does 'Ecological Economics' and many other environmental discourses.

Embodied Mind. A small minority of discourses adopt the *Embodied Mind* frame. This frame 'represents the human mind as an emergent phenomenon comprised of vital inputs from the brain, body, and physical/social environments . . . [and] asserts a world that is filled with complex social organisms whose reasoning is profoundly influenced by neurological and cultural processes' (Danton & Kirk, 2011: p. 83). For example, 'Eco-theology' discourse recognises both 'inner nature (that is, of the mind, body, and spirit) and outer nature'; 'Deep Ecology' talks of the notion of 'self-in-Self'; and 'Ecofeminism' emphasises 'a more intuitive and empathic human orientation to the natural world' (Dryzek, 2005: p. 194)[6].

This *Embodied Mind* frame forms the basis of the critique of the so-called Triple Bottom Line of 'Sustainable Development' (Elkington, 1999), which addresses environmental, social, and economic concerns. Recently, however, some researchers have been advocating the inclusion of a fourth concern, such as 'spirituality' (Inayatullah, 2005) or 'personal meaning', which includes spiritual considerations as well as the substantive values that inform personal ethics and conscience (Walker, 2011, 2006) (see section 2.1.2).

'The economy' As with the previous politically contested concepts, 'the economy' is contested along several dimensions. The first point of contention lies in characterising the nature of 'the economy' — i.e. whether it functions optimally (specifically, in this context, with respect to 'sustainability') with or without policy interventions. This will be discussed further in the section on agency (page 25).

The second point of debate is the weight of consideration that ought to be given to the health of the economy in comparison to other concerns, such as environmental protection, social justice and human fulfilment. Perhaps because economic concerns tend to be felt more immediately than environmental concerns (and closer to home than social justice concerns), and because the impacts of economic decline

[6] Note that these are subsets of 'Green Consciousness' discourse, and that 'Green Consciousness' is a subset of 'Green Radicalism'.

are less ambiguous than the impacts of environmental destruction[7], environmental discourses often rhetorically emphasise economic concerns (see Section 2.1.2)[8].

The third point of contention is the degree to which the economy ought to internalise environmental resources as part of any meaningful calculation. Most notably, 'Natural Capitalism' (Hawken et al., 1999), a proposed alternative to the dominant form of Western capitalism, recognises human wellbeing as 'the limiting factor' for any meaningful measure of prosperity. In line with this thinking, Berners-Lee & Clark (2013) suggest that the value of petroleum resources is grossly exaggerated when certain environmental and human factors are taken into account — namely that burning the world's current oil reserves will send the planet into catastrophic climate change crisis.

Natural relationships between entities

Each environmental discourse communicates beliefs about the natural or preferred dynamic between entities, often indicating explicit hierarchies. Three such relationships are discussed below for illustration.

Relationship between humans 'Survivalism', 'Administrative Rationalism', and 'Economic Rationalism' all tend to subordinate the individual to expert and/or governmental agents who must dictate appropriate actions to take with respect to the environmental 'problem' (Dryzek, 2005: respectively, p. 41, p. 89, p. 137). In contrast, 'Democratic Pragmatism' places decision-making responsibility more squarely on the shoulders of citizens and businesses (ibid: p. 116).

Relationship between humans and environment Most environmental discourses assume a hierarchy between humans and the environment, whereby humans are naturally dominant. A notable exception to this is the 'Deep Ecology' movement (cf. Naess, 1973; Devall & Sessions, 1985), the central tenet of which is the notion of 'biocentric equality', whereby 'no species, including the human species, is

[7] While climate scientists overwhelmingly agree that climate change is happening, is manmade, and is dangerous, the predicted effects differ somewhat between scientists. This, coupled with a highly successful disinformation campaign propagated by energy lobbyists, has turned climate change (and environmental protection generally) into a controversial subject (cf. Berners-Lee & Clark, 2013).

[8] As an illustration of this rhetorical strategy, Berners-Lee &Clark (2013) write,

> *It was reported recently... that Barack Obama made a conscious decision at the start of his first term as president to talk about climate change solely in terms of innovation, energy independence and economic progress* (p. 168).

regarded as more valuable or in any sense higher than any other species' (Dryzek, 2005: p. 184). Other imaginative/radical discourses recognise a qualitative distinction between humans and other species (cf. Schumacher, 1978: pp. 24–35; Scruton, 2012), but argue that our environmental destruction is symptomatic of our modernist alienation from our environmental *roots* (cf. Margolin; Orr; Mohawk; Davis; in Ausubel, 2004: p. 79, p. 193, p. 203 and p. 226, respectively). To correct this 'flawed' perception, these discourses consciously invert the hierarchy from one of human domination of the environment to one of the environment as 'teacher' (e.g. 'biomimicry') (Benyus; in Ausubel, 2004: p. 8).

Relationship between environment and economy In prosaic environmental discourses, 'the economy' is recognised as a distinct entity from 'the environment' — a consequence of the industrial mindset, which dominates and exploits the environment as a means to economic gain. As such, these two entities are in many cases understood as being in a dynamic, and potentially antagonistic relationship with one another. 'Sustainable Development' (an imaginative discourse), however, proposes a rather different relationship between human, environmental and economic entities. As Dryzek summarises, 'The most important relationship [for the 'Sustainable Development' discourse]. . . is the positive-sum one: economic growth, environmental protection, distributive justice, and long-term sustainability are mutually reinforcing' (2005: p. 155). Meanwhile, critics (e.g. Walker, 2011; Mathews, 2006) argue that the seeming failure of 'Sustainable Development' suggests that these aspects are not mutually reinforcing.

Agency

All discourses construct narratives about how the world works (Dryzek, 2005: p. 18). When analysing a discourse, it can be helpful to keep track of not only who these central actors are within the discourse's narrative (i.e. the basic entities recognised or constructed), but also what their *motivations* are in the story (i.e. agency).

While there is general consensus across environmental discourses that the environment is 'good', there is no such consensus regarding the 'goodness' of humans. Some environmental discourses view individual humans as basically 'good', but with the capacity for collective evil (e.g. in the form of corrupt, disinterested, or immoral governments and/or organisations). Other discourses paint a picture of humans as 'rational egoists' (Drzyek, 2005: p. 135), i.e. motivated entirely by self-interest. This pair of conflicting frames has been described as:

Empathy[9] vs. *Self-Interest.*

These frames have implications for understanding the agency that might be attributed to the economy. Prosaic discourses tend to demonstrate a belief not only in the agency of the economy, but in its benevolence. This is a clear holdover from industrial philosophy, such as Adam Smith's notion of 'the invisible hand' (Smith, 1976[10]: pp. 447-8). Currently this manifests in environmental discourses as what Darnton & Kirk (2011) identify as the *Free Market* frame (p. 83). This frame presumes the *Rational Actor* and *Self-Interest* frames, and assumes that if everyone is seeking to maximise their benefit (i.e. profit), then 'the profit of all will be maximised' (p. 84). Markets, therefore, are seen as the natural means of ensuring this utilitarian outcome.

An alternative to the *Free Market* frame is the *Shared Prosperity* frame, which 'presumes that the world is filled with support systems... [that] serve as mechanisms for generating wealth' (ibid: p. 84). In other words, wealth is not guaranteed by the market; it can only be created through cooperation between individuals (Darnton & Kirk, 2011: p. 84). This kind of thinking is particularly evident in 'Ecological Modernization', which advocates cooperation between governments and businesses towards achieving the greatest societal benefit (Dryzek, 2005, p. 173).

Key metaphors and rhetorical devices

Prosaic discourses, which accept the basic premises of Industrialism, tend to employ Industrial-Age metaphors and rhetoric; whereas the challenge to these premises, in contrast, is reflected in the relative absence of Industrial language in imaginative discourses. For example, Dryzek argues that 'Promethean' rhetoric (the least imaginative environmental discourse) is highly 'mechanistic', e.g. approaching environmental problems as 'malfunctions' (2005: p. 60). In contrast, imaginative 'Green Radicalism' discourses are rich in natural or 'organic' metaphors — e.g. 'openness to the black bear' (Dobson, 1990; in Dryzek, 2005: p. 196), 'thinking like a mountain' (Dryzek, 2005: p. 196)[11].

[9] While the word 'empathy' may not seem the most obvious opposite to 'self-interest', this frame pairing is used by others (e.g. Lakoff, 2008) to reflect the difference between caring for one's own interests and wellbeing versus caring for other people's interests and wellbeing (i.e. as an extension of being able to empathise).

[10] Originally published in 1776.

[11] Schumacher provides another illustration of the use of organic metaphors:

> *Our ordinary mind always tries to persuade us that we are nothing but acorns and that our greatest happiness will be to become bigger, fatter, shinier acorns; but that is of interest only to pigs. Our faith gives us knowledge of something better: that we can become oak trees* (1978: p. 155).

Discourses also differ in terms of rhetorical style. Reformist discourses tend to be reassuring, communicating a faith that ingenuity will most certainly prevail in the face of environmental challenges, and downplaying the amount of discomfort that might result from 'sustainability' solutions. Radical discourses, by comparison, propose that more major changes are required. A common concern for these discourses is that the natural response to calls for major change is often to retreat into denial[12]. One rhetorical strategy, in these cases, is to appeal to people's sense of morality and to inspire people to be heroic.

Finally, imaginative/radical discourses are typically more optimistic than prosaic/radical discourses — the latter of which tend to articulate a 'Plan B' for a catastrophic contingency. (This will be explored further in Section 2.3.1.)

2.1.2 Appropriation of key terms

So far these different discourses have been referenced in quotations, indicating that while some recognise and define them in these ways, they are by no means universally accepted categorisations. These quotations are also intended here to acknowledge the degree to which these categories are in flux. Indeed, the reason these discourses are shifting is partly because certain key terms — such as 'green' and 'sustainable' — have been (mis)appropriated by discourses because of their fashionability or cachet, thus muddying the waters of once separate discourses. In order to regain some clarity, this section explores the evolution of the term 'sustainability', which as will be shown in Section 2.2, has profoundly influenced Green Computing research.

Sustainable Development

While the phrase 'sustainable development' existed in environmental discourses before the 1980s (Dryzek, 2005: p. 148; e.g. Schumacher, 1973), it was popularised by the 1987 Brundtland Report[13]. This report, sponsored by the United Nations, proffered 'a vision of the simultaneous and mutually reinforcing pursuit of economic growth, environmental improvement, population stabilization, peace, and

[12] For example, Berners-Lee & Clark conclude their book with:

> *It's often assumed that the world isn't ready for this kind of message — that it's too negative or scary or confrontational. But reality needs facing head on — and anyhow the truth may be more interesting and inspiring than the watered down version* (2013: p. 170).

[13] This report is largely responsible for turning 'Sustainable Development' into a proper noun.

global equity, which could be maintained in the long term' (Dryzek, 2005: p. 148). The most cited excerpt from the report is its definition of 'Sustainable Development': 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environmental Development, 1987). This formulation of 'Sustainable Development' has subsequently become associated with the so-called 'Triple Bottom Line of sustainability' (Elkington, 1999), which, as mentioned above, focuses on three interrelated concerns: environmental, social, and economic needs.

At its inception, the Brundtland Report embodied some of the mounting popular concerns regarding the impact of industrial and neo-colonial practices on nature and humankind. While it produced a critique of the ways in which contemporary development failed to meet the criteria for sustainable practices, it offered a) no plausible prescriptions for realising 'Sustainable Development', and b) no radical critique of the nature of the capitalistic system underpinning unsustainability. Indeed, the report presupposes the inextricability of contemporary society from Western-style capitalism and focuses on bridging the divide between 'economic and environmental objectives through fostering awareness of how humanity is united in sharing its common home' (Davison, 2001: p. 2).

Critics argue that the linking of 'growth' with 'sustainability' is paradoxical, and reduces 'sustainability' to an imperative to ensure economic growth as a means to overall societal wellbeing. Davison labels this interpretation of 'Sustainable Development' as 'Ecomodernism', characterised by the pursuit of 'sustained growth in the global marketplace' (ibid: p. 31) and 'unrestrained and inarticulate faith in the social progressiveness of modern techno-economic change' (ibid: p. 34). This linking of 'eco' to 'modernism' reflects the ways in which this notion of 'growth' is engendered by, and therefore compatible with, the modern (i.e. industrial, progressive, future-facing) worldview. And just as efficiency is a central pursuit within the modernist paradigm, so too efficiency finds a home in 'Ecomodernist' discourse. 'Ecoefficiency', therefore, is characterised by seeking maximally efficient use of environmental resources. As a result, Davison argues, ecoefficiency,

> *. . . shields the technological society from these questions [of virtue] by reinventing ecological crisis as a frontier of vast techno-economic opportunity, which we are urged to enter with profound techno-ethical optimism. The ecological crisis has been reinvented as an urgent imperative for the completion of the emancipatory promise of freeing its 'masters' from material scarcity and moral ignorance. More than anything else, the combination of the imperative of technological development and the ideal of sustainability, with its consequent linking of efficiency*

> *with ecology, has led to the emptying of environmental discourses of their cultural content* (2001: p. 38).

Reacting to this specific appropriation of what had once been seen as a deeply meaningful concept, a competing discourse has emerged re-*radicalised* — appropriating 'Green Consciousness' thinking (e.g. Schumacher, 1973) as a basis for more 'meaningful' concepts of 'sustainability'. This discourse, consisting of the works of Davison (2001), Orr (2003), Porritt (2002), Mathews (2006), Walker (2011, 2006) and others, is herein referred to as 'Radical Sustainability'[14]

'Radical Sustainability'

'Radical Sustainability' argues that 'Ecomodernism' works to reinforce the industrial premise and mindset, i.e. the root of our 'unsustainability'. The discourse, therefore, argues that we must somehow recover the *roots*[15] of 'sustainable' living. As Davison (2001) argues:

> *. . . I develop the claim that we are blindly building a deformed world. Our latemodern world is unsustaining because it is deformed. And the blindness of our technological agency is the cause of our world's deformation. Yet our blindness is not irreversible; it has not been inflicted upon us. Following Winner, I contend that it is the result of a dangerous cultural sleepwalking in our understanding and experience of technology. Understanding technology as world-building is first of all a matter of recovering our experience of technology, that is, our practices, from the philosophical strictures of instrumentalism* (p. 95).

Like 'Green Consciousness', 'Radical Sustainability' constructs a narrative that 'industrial society induces a warped conception of persons and their place in the world', requiring 'new kinds of human sensibilities' (Dryzek, 2005: p. 193). Specifically, the 'Radical Sustainability' narrative is that the industrial worldview has been deeply damaging to human meaning and corrupted our sense of purpose in the world, the result of which is the development of practices that are wildly out of kilter with our natural environment, i.e. 'unsustainable'. Taylor (2007) describes the

[14] While not a recognised environmental discourse, 'Radical Sustainability' is here proposed as the fitting title for this new branch of environmental discourse, as it advocates systemic change above incremental adjustments.

[15] Interestingly, the etymology of 'radical' is the Latin *radicalis*, meaning 'of or having roots', while 'reformist' originally meant 'change from roots' (`http://etymonline.com/?term=radical`). The irony of radical discourses is that modernity has become so distant from these roots (see page 24) that discourses that advocate a return to these roots have acquired an 'extreme' connotation.

post-industrial society as 'secularised', and describes an injustice inflicted on humanity, whereby the modern worldview has replaced rich spiritual understandings with a sense of meaninglessness: 'nothing but ennui, a cosmic yawn' (pp. 716–7). Orr (2003) argues that this 'spiritually impoverished world is not sustainable because meaninglessness, anomie, and despair will corrode the desire to be sustained and the belief that humanity is worth sustaining'[16]. Similarly, Hawken describes contemporary society as sick and unworthy of preservation (in Ausubel, 2004: p. 150), comparing it to the Buddhist concept of 'the hungry ghost' — 'depicted as a wretched figure with a huge protruding stomach, a pencil neck, and a tiny mouth, forever grasping for food, power, sex, or stimulation to feed an endless and insatiable appetite' (ibid: p. vii).

The difficulty, however, is that while consciousness change may be in order, humanity cannot simply *return* to understanding the world in pre-industrial ways, and would instead have to *advance* towards a new era . Therefore, 'Radical Sustainability' often places faith in 'spirituality' as a pathway towards a sustainable future. This *spiritual* orientation aligns with a recognised decline in religion and an increase in what people self-describe as 'spirituality', a trend referred to as the 'subjective turn' (Heelas et al., 2005), defined as 'a turn away from life lived in terms of external or "objective" roles, duties and obligations, and a turn towards a life lived by reference to one's own subjective experiences' (p. 2). In terms of 'Radical Sustainability' discourse, this 'subjective turn' reflects a rejection of pure ('cold') rationalism in favour of ostensibly 'deeper' (and perhaps 'warmer') ways of apprehending the world[17]. This rhetoric, a clear shift from *Rational Actor* to *Embodied Mind*, emphasises 'inner development' (e.g. 'living fully present', 'practicing compassion'), with inspiration from a myriad of religious and spiritual traditions.

Another concern of the 'Radical Sustainability' discourse is the importance of the establishment of a radically different economic system. Critical to this, 'Radical Sustainability' argues that much of the deformation of today's society, as evidenced by its 'unsustainability', is due to the influence of an amoral (or worse, *immoral*) economic model, and many have proposed reform of the social science of economics to accommodate ethical and/or spiritual values (e.g. Wijers, 1996). This reform ultimately consists of the following frame substitutions:

[16] Note the similarity with 'Eco-theological' discourse, which, 'diagnose[s] the root of the problem in spiritual terms, and if the root of the problem is spiritual, then so too must be the cure' (Dryzek, 2005: p. 190) (cf. Schumacher, 1973).

[17] e.g., Walker writes that sustainability 'requires that we conceive of our material goods, and especially those that rely on rapidly advancing technologies, in terms that include more than instrumental reason and rationalism' (2011: p. 208). He proposes that 'substantive values' and 'matters of ultimate concern' (ibid: p. 188) become central to the design process, thus generating new design criteria that ultimately result in human-to-object relationships that are *meaningful*, rather than superficial and based solely on utility.

Free Market $\Longrightarrow$ *Shared Prosperity*

Self-Interest $\Longrightarrow$ *Empathy*

Combining all of these elements, 'Radical Sustainability' discourse offers a new framework to replace the Triple Bottom Line of 'sustainability'. In this framework, 'spirituality' (Inayatullah, 2005) and/or 'personal meaning' (Walker, 2011, 2006) becomes a primary concern for a sustainable society, in addition to social justice and environmental stewardship (both of which are newly appreciated in often 'spiritual' ways). The economic concerns are fundamentally re-evaluated, being consciously demoted below what are understood to be more fundamental human needs, whether practical needs (e.g. those met by one's environment), social needs, or a need for personal meaning (spiritual or otherwise). In this context, economic needs are recognised as a 'pragmatic "lubricant" that enables the interrelationships among the other elements to be negotiated and realized' (Walker, 2011: p. 189). This configuration is often shorthanded as the 'Quadruple Bottom Line', as illustrated by Figure 2.1.

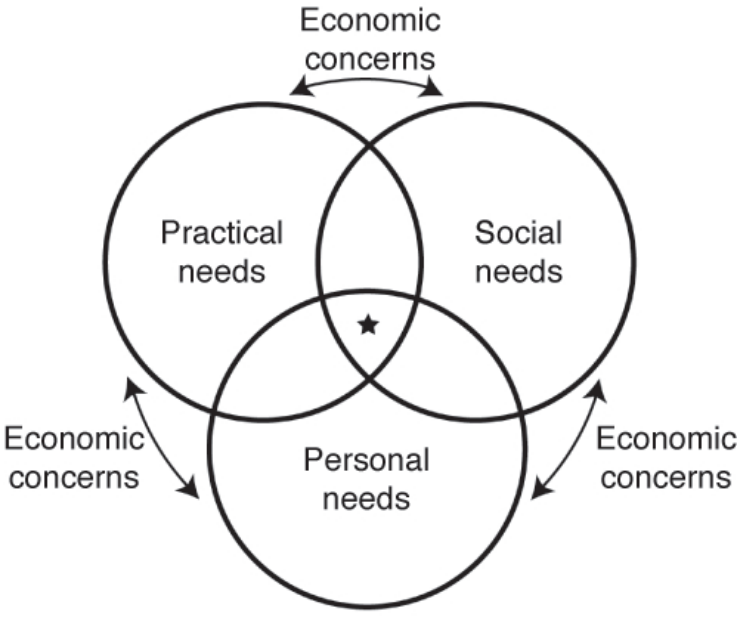


Figure 2.1: Quadruple Bottom Line framework 'sustainability', adapted from Walker (2011).

Table 2.1: Discourse analysis of Radical Sustainability

1. Basic entities recognised or constructed	• consciousness / worldview • the human soul • the environment, ecosystems • economies (plural) • spirituality (not religion)
2. Assumptions about natural relationships	• there is nothing 'natural' or 'predetermined' about economic systems; they can be changed • fundamental human needs (environmental, social, spiritual) are above created human needs (economic)
3. Agents and their motives	• people, guided by morality • industrialism, as oppressor
4. Key metaphors and other rhetorical devices	• spiritual malaise, despair, disenchantment, loss • collapse and renewal, return to roots • inner development, 'acorn' metaphor (cf. Schumacher, 1978) • divergent problem solving • spiritual concepts (e.g. 'compassion', 'wu wei', 'maya', etc.)
5. Key frames	• *Intrinsically Valuable Environment* • *Embodied Mind* • *Empathy* • *Shared Prosperity*

'Sustainability': clarity of terms

There is a danger that the term 'sustainable' is so variously defined as to approach meaninglessness. As Davison notes, 'people have paid homage to this catch-cry by defining it to suit their own needs, with over seventy definitions in print by 1992' (2001: p. 38). However, if we do not seek to define 'sustainability' as something more than 'Ecomodernism', a very powerful concept will be reduced to a very mundane one and consequently its potential will remain unfulfilled.

The solution seems to be to insist on clarity of terms. While it is certainly far easier to converse about 'sustainability' as if a shared meaning exists between all parties and all researchers, there are clearly foundational premises that differ between conceptions of the term. A lexicon for teasing out these differences seems to be required in order to debate these premises and make headway during discussions about what 'sustainability' is or ought to be. As a starting point, 'Sustainable Development' needs to be clearly differentiated from the faction that has evolved in

reaction it, i.e. 'Radical Sustainability', as well as from other competing discourses, summarised below.

Prometheanism denies the notion of a 'sustainability' problem altogether, often arguing that we will use our innate (historically verified and ostensibly infallible) ingenuity to overcome 'sustainability' problems as they arise, or economic forces will stabilise out-of-control consumption, or else we will 'evolve' to the new environmental realities that emerge as a result of our current practices (cf. Simon, 1981; Lomborg, 2001).

Survivalism denies the notion that our ingenuity will stave off environmentally-induced systemic breakdown, and prepares a 'Plan B' for adapting a very different (harsh) reality of our own making (cf. Hardin, 1993; Brown, 1978; Meadows et al., 1992).

Problem Solving argues that necessary 'sustainability' changes can be brought about through adjustments to existing systems, e.g. bureaucracy, democracy and markets.

- **Administrative Rationalism** emphasises the importance of experts in shaping 'sustainable' policies (e.g. resource management and pollution agencies).
- **Democratic Pragmatism** emphasises the voice of the people as an important contribution to effectively addressing 'sustainability' concerns, and rely on voluntary commitments to more 'sustainable' policies (e.g. Kyoto Protocol, 1997).
- **Economic Rationalism** emphasises the the power of market forces to affect 'sustainable' behaviour (e.g. privatisation).

Sustainability argues that global breakdown can be averted through strategic interventions that bring environmental, social and economic needs into greater alignment.

- **Sustainable Development** promotes a notion of environmentally- and socially-benign economic growth (cf. World Commission on Environmental Development, 1987).
- **Ecological Modernization** attempts to restructure the capitalist political economy in accordance with Triple Bottom Line sustainability, particularly by promoting collaboration between business and government on environmental and social issues (cf. Christoff, 1996).

- **Ecomodernism** embraces the 'sustainability' problem as an opportunity to profit and to excel through the application of modernist rationality (cf. Davison, 2001).

Green Radicalism argues that global breakdown can be averted through major psychological, cultural and/or societal transformations.

- **Green Politics** emphasises a route to change through affecting problematic social, economic and political structures. Examples include Green parties, Social Ecology (cf. Bookchin, 1990, 1982), Eco-socialism (cf. Kovel, 2007; O'Connor, 1988), Environmental Justice (e.g. Love Canal) and others.
- **Green Consciousness** emphasises a route to change through affecting worldview, in particular through changing how people understand the environment and their fellow humans. Examples include Deep Ecology (cf. Naess, 1973; Devall & Sessions, 1985), Ecofeminism (cf. Diamond, 1994), Bioregionalism (cf. McGinnis, 1998), Eco-Theology (cf. Schumacher, 1973), and others.
- **Radical Sustainability** re-orients the sustainability discussion around a strategy for ensuring human thriving along several dimensions of human need (cf. Walker, 2011; Walker, 2006; Orr, 2003). Admittedly idealistic, Radical Sustainability (like Green Consciousness) understands worldview change as the 'Plan A' for sustainability, and transcends the pragmatic solution space in an effort to develop deeper, more systemic solutions.

These discourses can be categorised according to the dimensions of prosaic/imaginative and reformist/radical (Table 2.2).

Table 2.2: Dimensions of Environmental Discourses (see Dryzek, 2005: p. 15)

	Reformist	**Radical**
Prosaic	Problem Solving • Administrative Rationalism • Democratic Pragmatism • Economic Rationalism	Survivalism
Imaginative	Sustainability • Sustainable Development • Ecological Modernization	Green Radicalism • Green Politics • Green Consciousness • Radical Sustainability

The next section moves on to explore the characteristics of the specific understanding(s) of 'sustainability' adopted by Green Computing, and explores the degree to which Green Computing discourse engages with (or fails to engage with) the broader debate between these diverse environmental discourses.

2.2 Green Computing

This section begins by analysing the Green Computing discourse as a whole, paying special attention to the differences between Green IT and Sustainable HCI within this larger discourse. This analysis represents a synthesis of all publications — including conference papers, journal publications, magazine articles and white papers — read by the author throughout the period of research reported in this dissertation[18]. It will be argued that although Green Computing appropriates aspects of 'Ecological Modernization' and 'Sustainable Development' discourses[19], it does so without assimilating any rich understanding of the evolution of the term 'sustainable'.

In Section 2.2.1, Green IT will be analysed as a discourse in relation to Dryzek's four discourse elements (as explored in Section 2.1). This analysis will then be compared with 'Ecological Modernization' and contrasted with related computing discourses (Section 2.2.2). The same will be done for Sustainable HCI (Section 2.2.3), compared with 'Sustainable Development' and contrasted with other related discourses (Section 2.2.4). These comparisons will then be used in Section 2.3 to explore the opportunities as well as limitations posed by these orientations to 'sustainability'.

2.2.1 Green IT discourse

While it is possible to identify differences between so-called Green IT (Information Technology) research and Sustainable HCI (Human-Computer Interaction) research, and therefore to analyse Green IT as a separate discourse, this discourse

[18] This is compared to the analysis in Chapter 3, which is bounded by specific parameters. However, given that the publications analysed in Chapter 3 were limited to include only those archived within the ACM Portal and IEEE Xplore, the analysis represents a specific expertise in publications from these venues.

[19] Both of which are 'Sustainability' discourses as Dryzek uses the term.

is markedly lacking in conformity. In order to say anything of the characteristics of this discourse, therefore, one must generalise it as being represented by its most pronounced (i.e. popular) trends. The inconsistencies within Green IT which differ from the greater discursive trends are temporarily ignored, but will be explored in detail in Section 2.3.

Recognition and construction of basic entities

Information Technology The name Green IT is indicative of a techno-centric orientation within this discourse — 'technology' is in the very title. The foremost entity of concern throughout Green IT is the technology itself (i.e. 'sustainability *in* design', or 'greening *of* IT'); secondarily (and more recently), Green IT considers the role of IT in catalysing business- and societal-level changes with environmental benefits (i.e. 'sustainability *through* design', or 'greening *by* IT')[20]. A wide range of approaches are explored within Green IT, sometimes summarised as comprising research into 'optimal use of information and communication technology (ICT) for managing environmental sustainability of enterprise operations and the supply chain, as well as that of its products, services and resources, throughout their life cycles' (Mingay, 2007). More specifically, these approaches include but are not limited to to the following:

- improving hardware efficiency (a.k.a. 'energy-aware hardware') (cf. Feng, 2007);
- improving operational and process efficiency (a.k.a. 'energy-aware software') (cf. Sabharwal et al., 2013);
- improving transportation and logistics efficiency (Davies et al., 2012; Webb, 2008);
- monitoring and management of resource usage (e.g. smart grids; Ipakchi & Albuyeh, 2009; Massoud Amin & Wollenberg, 2005);
- incorporation of renewable energies for powering IT (cf. Cowan & Harmon, 2007);
- impact assessment and optimisation of cloud services (cf. Chauhan & Saxena, 2013; Bash et al., 2011; Younge et al. 2010);

[20] Note that this represents a recent entry into what had formerly been 'Sustainable HCI' territory; recall Figure 1.1.

- dematerialisation and virtualisation (cf. Hilty et al., 2011; Beloglazov & Buyya, 2010; Webb et al., 2008);
- IT environmental (and economic) impact assessment (cf. Raju et al., 2013; Coroama & Hilty, 2009); and
- reducing toxicity of electronic waste (cf. Tulkoff & Breyer, 2006) and better managing this waste (cf. Murugesan, 2008)).

Importantly, the technology is recognised as a non-neutral entity, both in the sense that its byproducts are harmful to the environment, and that they can be leveraged for greater environmental wins (Mickoleit, 2010). Using one metric, the scale of IT's negative CO_2[21] impact is currently estimated at around 2–3% of the world's greenhouse gas emissions (Murugesan et al., 2013), and is predicted to continue rising, reaching 1.43 billion tonnes CO_2e annually by the year 2020 if business continues as usual[22] (Webb et al., 2008). Yet while Green IT researchers recognise the environmental problems caused by IT, they argue that 'it can also be part of the solution' (To et al., 2013), potentially leading to 'emissions reductions five times the size of the sector's own footprint' (Webb et al., 2008). As a result, the environmental challenge for Green IT is understood to be two-fold: optimising these environmental wins ('greening by IT') while minimising the losses ('greening of IT').

Business and government Other important entities within the discourse are 'business' and 'government', both of which are understood to comprise Green IT's target audience[23]. On the whole, both are assumed to be able to see sense in, and therefore become ambassadors for, Green IT — the former by setting industrial standards of practice and demonstrating to others the business value to be gleaned through adoption of Green IT (Raju et al., 2013); and the latter through legislative means and economic enticements to businesses (Chauhan & Saxena, 2013; Webb et al., 2008).

Economy and consumers To the extent that Green IT recognises the importance of businesses' economic bottom line, the discourse also recognises 'the

[21] The common terminology for indicating carbon footprints in Green Computing (both Green IT and Sustainable HCI) is CO_2, rather than CO_2e. For this reason, CO_2 will be used when discussing current Green Computing discourse.

[22] Note that this calculation assumes that current rates of energy efficiency improvements continue into the future.

[23] More explicit than most, though representative of this pervasive trend, Cowan & Harmon (2007) state, 'This paper will assume a target audience of business managers and policy makers who need common sense, plain-spoken recommendations on the energy choices they should make in the near future'.

economy' as an entity of significant influence in the uptake of Green IT. As part of this, Green IT understands the economic importance of being able to attract 'consumers'. While Green IT speaks of people-as-consumers, the discourse attributes a great deal of environmental savvy to these consumers, pointing out that they 'are beginning to demand more disclosures from companies with regard to their carbon footprint as well as their environmental initiatives and achievements' (Murugesan, 2008).

Environment Lastly, although the appropriation of the term 'green' for the title of the discourse invokes environmentalist connotations, the environment is a somewhat ambiguous character in the narrative of Green IT. There is variation in the community regarding the degree to which environmental concerns are explicitly mentioned as motivations for the research. When the environment is recognised, however, it is discussed largely in terms of its instrumental value — i.e. its diminishing supply of resources needed for IT, and the amount of pollution it can reasonably absorb. Green IT is described as a 'high priority' (Harmon et al., 2010) for businesses not because of any obvious worthiness of the cause of environmental protection, but because of the business costs typically associated with IT (Koomey et al., 2011; Cowan & Harmon, 2007)[24].

Natural relationships between entities

An unquestionably natural relationship is assumed to exist between technology and business — i.e. they are mutually beneficial to one another. Businesses need IT to stay competitive and prosper[25], and technology needs businesses as investors to ensure that technological progress can continue. But specifically, it is argued that a) Green IT increases business profits (by reducing business costs) (Webb et al., 2008), and b) businesses' drive for growth (Hilty et al., 2011), along with increased performance to meet consumer demands, leads (inevitably) to the development of 'greener' IT (Koomey et al., 2011). The discourse presents Green IT as the means by which economic prosperity and environmental protection attain alignment, and promises that businesses will ultimately benefit from societal pressures to 'green' their IT.

[24] Note that environmental wins tend to be listed as byproducts of business cost optimisation strategies, e.g. 'A primary objective of [Green IT] solutions has been to lower IT operational costs by reducing IT-related energy consumption, which also helps reduce carbon emissions' (Murugesan et al., 2013).

[25] e.g. IT is associated with an estimated £600 billion of energy efficiency savings globally (Webb et al., 2008), and cloud computing in particular has been shown to be particularly beneficial to emerging markets (Murugesan, 2011).

Although businesses are understood to play a significant role in greening society, Green IT also clearly recognises that, in addition to having to comply with governmental legislation (Pollard, 2013; Ruth, 2009) and appease non-governmental agencies such as Greenpeace (Mingay, 2007), businesses are greatly affected by market variables. Of particular concern are the expected rising costs of energy (Cowan & Harmon, 2007). Green IT also recognises the costs of the disruption that necessarily results when businesses upgrade their IT, noting that 'factory managers find it difficult to stop producing long enough to implement more efficient industrial processes because they risk losing revenue and competitiveness' (Webb et al., 2008), though it is argued that the long-term benefits of Green IT are worth the investment.

Agency

The key decision-makers in this narrative are businesses. New opportunities arise through Green IT, which businesses can rationally determine are in their economic self-interest, or not; but because environmental and economic interests align in this narrative, the market is trusted to guide businesses towards the environmentally beneficial decision (*Rational Actor, Self-Interest, Free Market*).

While there is a recognition in Green IT discourse that although adoption of greener technologies is currently a choice — and one that will only benefit businesses — there will be growing government and public pressure on businesses to become green (Raju et al., 2013). For example, Murugesan et al. (2013) write, 'Triggered by the imminent introduction of more taxes and regulations and the public's growing interest in green businesses, there will be a major increase in the demand for green IT products and solutions in the near future'. In other words, the agency of these entities should not be underestimated[26].

To some extent, technology is (optimistically) seen as having agency in the sense that what technology 'wants' is to improve human quality of life. Green IT is presented as the natural evolution of IT towards this purpose. The assumption is that if technological progress is allowed to continue (see Nordhaus, 2007), technology can clean up its own environmental mess; so the challenge for Green IT is to simply 'unleash ICT's potential to support sustainability' (Hilty et al., 2011) and 'unlock emissions reductions on a dramatic scale' (Webb et al., 2008).

[26] Mingay (2007) writes, 'The question for the enterprise has changed from 'Why should we bother?' to 'What risks do we face if we don't act and are not seen to act?"

Key metaphors and rhetorical devices

Efficiency More than any other word, 'efficiency' is invoked as an unquestionably worthy ambition for Green IT. This is, in part, because it is assumed to yield the greatest environmental wins (Webb et al., 2008), and in part because efficiency improvements are a seemingly inviolable trend in computing (cf. Koomey et al., 2011).

Strategies and 'smart' Another important characteristic of the Green IT rhetoric is the emphasis on 'strategies'. e.g. Green IT as a 'strategy which may lead to long-term competitive advantage' (Cowan & Harmon, 2007), and Green IT as a means of 'strategically position[ing] organisations to meet customers' future growth needs economically, environmentally, and socially' (Murugesan et al., 2013). Related to this, Green IT frequently employs the term 'smart' to describe its solutions: e.g. smart grids, smart energy, smart buildings, smart logistics, etc (Laitner, 2013; Mickoleit, 2010; Webb et al., 2008).

Opportunities Green IT is presented as an 'exciting opportunity' (Webb et al., 2008), not only allowing businesses to play a key role in contributing to this important cause, but also to make money (Mingay, 2007). The discourse suggests that this applies particularly to those that are first to adopt the technology, implicitly appealing to the recognised business concepts of 'first mover advantage' and 'industry leaders' (Raju et al., 2013; Webb et al., 2008). Rhetoric such as, 'Companies can benefit by taking these [environmental] challenges as strategic opportunities' (Murugesan, 2008), further entices businesses by emphasising the extrinsic rewards associated with 'greening' practices, and allows Green IT to present itself as worthwhile without having to justify its ambitions in terms of the intrinsic rewards of 'doing the right thing'.

Progress It is taken on faith — and therefore not really interrogated — that the 'right thing' for humanity is technological progress. Green IT paints a picture of technological progress as directly paralleling improvements in quality of life (cf. *ideology of progress*, Greer, 2008). For example, Murugesan states that 'Over the years, the use of IT has exploded in several areas, improving our lives and work and offering convenience along with several other benefits' (2008)[27]. Protecting the environment is offered up as a new frontier for Green IT, which will continue the tradition of

[27] Similarly, Webb et al. (2008) write,

> *The ICT sector has transformed the way we live, work, learn and play. From mobile phones and micro-computer chips to the internet, ICT has consistently delivered innovative products and services that are now an integral part of everyday life. ICT has system-*

improving the quality of human life. The solutions proposed by Green IT for solving the environmental 'problem', therefore, involve more technology, rather than less. In this sense, its rhetoric is greatly reassuring for techno-centric societies. Further, by continually emphasising the ways in which Green IT contributes to economic growth, its rhetoric works to incentivise industry to adopt 'greener' practices.

Quantification in terms of CO_2 and cost Finally, Green IT tends to articulate its potential impact in quantifiable terms, e.g. CO_2 emissions reductions, and cost savings (e.g. Raju et al., 2013), which are typical communication tools in business and in government.

2.2.2 Classifying Green IT

Turning again to Dryzek's (2005) discursive dimensions, it is now possible to classify Green IT:

Prosaic vs. Imaginative. Green IT is imaginative insofar as it challenges the 'rule' that economic growth is necessarily antagonistic to environmental protection. There are, however, prosaic elements to Green IT, such as the assumption that environmental protection needs to align with economic growth in order to be viable (see further discussion in Section 2.3); but Green IT can be described as more imaginative than it is prosaic.

Reformist vs. Radical. Green IT is reformist because it does not go so far as to advocate major overhaul of the dominant worldview as a route to 'sustainability'. Instead, Green IT looks for solutions that fit within familiar modes of technological production, e.g. efficiency improvements.

This assessment is corroborated by the similarities between Green IT and another imaginative/reformist discourse, namely 'Ecological Modernization' (see comparison, Table 2.3). Like Green IT, 'Ecological Modernization' is dominated by efforts to mitigate environmental damage through targeted efficiency improvements throughout society, and enthusiastically proclaims the economic benefits of 'greening' practices, including, for example, the business opportunity to be found in providing 'green' products and services.

atically increased productivity and supported economic growth across both developed and developing countries.

Table 2.3: Green IT vs. 'Ecological Modernization' discourse

	Green IT	'Ecological Modernization' [28]
1. Basic entities recognised or constructed	• Information Technology • Environment as resources and waste treatment plant • Businesses • Environmentally savvy consumers • Governments (with the capacity to legislate)	• Complex systems • Nature as waste treatment plant • Capitalist economy • The state
2. Assumptions about natural relationships	• Businesses, government, consumers, and researchers are mutually dependent on one another • Subordination of nature • Environmental protection and economic gain go hand in hand for businesses	• Partnerships encompassing government, business, environmentalists, scientists • Subordination of nature • Environmental protection and economic prosperity go together
3. Agents and their motives	• Businesses; motivated by economic bottom line • Environmentally-savvy consumers; motivated by intrinsic value of environment • Governments; motivated by pressure (from consumers) to protect the environment • Technology; moving society towards improved quality of life	• Partners; motivated by public good
4. Key metaphors and other rhetorical devices	• Efficiency • Strategy, smart • Opportunities • Quantification of benefits • Ideology of progress • Reassurance + incentivisation	• Tidy household • Connection to progress • Reassurance
5. Key frames	• *Instrumentally Valuable Environment* • *Rational Actor* • *Self-Interest* • *Free Market*	• *Instrumentally Valuable Environment* • *Rational Actor* • *Self-Interest* • *Free Market*

Both discourses also claim that certain strategic adjustments will ensure sufficient progress towards 'sustainability'. 'Ecological Modernization' advocates more systemic 'restructuring of the capitalist political economy along more environmentally sound lines' (Dryzek, 2005: p. 167), while Green IT on the whole assumes that market forces compel this restructuring naturally and attempts to educate businesses about the cost savings the Green IT can bring; but both discourses are fundamentally premised in corporatism, which assumes that businesses and governments can work together towards ends that benefit the state and its people.

Green IT also understands the relationship between the environmental and economic bottom lines very similarly to 'Ecological Modernization' (Table 2.4[29]).

Table 2.4: Relationship between environmental and economic bottom lines

Green IT	**'Ecological Modernization'**
• couches pollution reduction in terms of waste reduction and cost savings	• 'pollution prevention pays. . . . Less pollution means more efficient production'
• hints at future legislation that may force expensive changes that might otherwise be made more economically now • warns businesses about losing out to competitors who take advantage of Green IT	• 'if a problem is not solved in the present, solving it in the future may be vastly more expensive'
• highlights consumer demand for green businesses, and suggests Green IT as a way of appeasing these consumers	• 'there is money to be made in selling green goods and services'

It is worth noting that there is a recognised gradient within Ecological Modernization, ranging from 'weak' to 'strong' (Christoff, 1996). While Green IT seems to fit with the 'weak' variant of Ecological Modernization, an alternative discourse known as 'Sustainable IT' — a.k.a. the 'second wave' of Green IT (Harmon & Demirkan, 2011) — fits more closely with the 'strong' variant. Less singularly focused on solutions within the IT product itself (e.g. improving data centre efficiency), Sustainable IT is instead concerned with 'the application of IT knowledge and technologies for the benefit of customers and other stakeholders [i.e. society] that enhances long-

[28] With the exception of the Key Frames, the final column in Table 2.3 is taken directly from Dryzek (2005: p. 173).

[29] The 'Ecological Modernization' content in Table 2.4 is quoted from Dryzek (2005: p. 168).

term mutual economic, environmental, and social well being' (ibid: p. 6). The key driver of such an approach would be corporate social responsibility rather than business 'cost optimization' (ibid: p. 6). In other words, Sustainable IT is not only 'stronger' but also more imaginative than Green IT, and the strategic adjustments proposed as the next wave of Green IT serve to bring Green IT and Ecological Modernization in even closer alignment (Table 2.5).

Table 2.5: Classifying Green IT

	Reformist	**Radical**
Prosaic	——	——
Imaginative	• Green IT • Sustainable IT • cf. 'Ecological Modernization'	——

2.2.3 Sustainable HCI discourse

Compared to Green IT, Sustainable HCI is a more self-reflective discourse. As a result, several discourse analyses already exist (e.g. Goodman, 2009; also DiSalvo et al., 2010; Dourish, 2010; Brynjarsdóttir et al., 2012); but given that these analyses have motivated important changes in the discourse in recent years, an updated analysis is needed here to account for these changes.

Sustainable HCI is explored below in terms of broad discursive trends across the entire discourse (like Dourish, 2010), rather than in terms of specifics of, or differences between, discourses of sub-communities within Sustainable HCI (like Brynjarsdóttir et al., 2012, DiSalvo et al., 2010, and Goodman, 2009). The analysis is based on a large number of self-identified Sustainable HCI publications, with particular emphasis on programmatic statements from the community and the most heavily cited works. Because the discourse is in a transitionary phase, the analysis will distinguish between historical characteristics of the discourse and emerging changes.

Recognition and construction of basic entities

People and behaviour By its very nature, HCI is an anthropocentric discipline (Blevis, 2007), and in keeping with this tradition, Sustainable HCI focuses on the

relationship between people and technology, rather than on the technology itself. Historically, the discourse has constructed people as either 'consumers' or 'citizens' — the former dominating behaviour change research, and the latter dominating 'citizen sensing' (Goodman, 2009) or 'environmental informatics' (Hilty et al., 2011) research. Recent works have criticised the notion of people as consumers, and instead aim to construct people as multi-dimensional, social beings negotiating various roles in society[30]. In either case, however, the main interest lies in the ultimate *behaviour* of people, i.e. as it relates to environmental impact.

Systems of practice and societal macrostructures Although the behaviours of individuals are the key interest for the discourse, Sustainable HCI has come to embrace the sociological concept of 'practices' (Pierce et al., 2011; Strengers, 2011; Pierce et al., 2010; Dourish, 2010; cf. Shove, 2010). In contrast to its beginnings, the discourse now states that 'sustainability does *not* begin with the individual' (Hazas et al., 2012), and that 'Unsustainability arises from complex interactions among individuals, social groups, corporations, organizations, governments, etc.' (Brynjarsdóttir et al., 2012). For this reason, Sustainable HCI is beginning to ask questions such as 'how can HCI be embedded into societal macrostructures' (Busse et al., 2013b)? One such macrostructure is the Digital Economy, which couples business success with a) increased adoption of technologies, and b) continuous consumption of technological products by individual consumers (to be discussed further in Section 2.2.3, below).

Environment Compared with Green IT, Sustainable HCI much more explicitly identifies 'the environment' as an entity needing protection. Typically this need is articulated in instrumental terms — though rather than focusing on the instrumental value of environmental resources, Sustainable HCI focuses on mitigating environmental damage as a matter of public interest[31].

To signify the impact of behaviours, 'energy consumption' is frequently used as a proxy for 'carbon emissions', which is itself a proxy for overall environmental impact (e.g. Foster et al., 2010; Chetty et al., 2008). Although the discourse aims to reduce this consumption through various mechanisms of control, actual targets for these reductions are usually not linked to statistics about the limits that the environment

[30] For example, Neustaedter et al. (2013) explore sustainable behaviours in the context of family dynamics; Woodruff et al. (2008) explore sustainability within the role of 'household manager'.

[31] This construction of 'the environment' had been adopted without interrogation or debate within Sustainable HCI, and although Dourish's (2010) paper exposes the larger context of 'strategic essentialism' that Sustainable HCI has unwittingly appropriated (i.e. 'the discursive creation of 'the environment' as an object of mutual concern"), subsequent publications have not yet offered any challenge to this construction.

can absorb, or any limits to technological productivity needed to stretch these limits (Mankoff, 2012). Critiquing this failure specifically, Mankoff (2012) points out that,

> *. . . to replace 14 (of 16) TW [TeraWatts] of global energy use with alternative sources (which would be sufficient to reduce CO_2 emissions to a manageable level), we would need to build, in total, for the next 25 years: One 1250m^2 pool of algae per second; one 100m^2 solar cell per second; one 50m^2 thermal mirror per second; 12 wind turbines per hour; three geothermal turbines per day; and one nuclear plant per week. This paints a daunting picture of how big the effort required is to truly solve the problems we face (and suggests, once more, that the role of HCI may be something other than reducing home energy use).*

Designers The target audience of Sustainable HCI publications is other designers (e.g. hardware and software designers), or researchers interested in design. This is an important difference from Green IT, which is more outwardly facing, actively targeting businesses or government.

Natural relationships between entities

The most prominent dynamic between entities in Sustainable HCI discourse is that between designers and people (both 'consumers' and 'citizens'). Even in recent publications that expose the complexity of the design problem (i.e. practice theory; Shove, 2010), it is implicitly assumed that the designer can employ various techniques of the trade in influencing (or in some cases, monitoring or otherwise seeking to understand) people's behaviour. Interestingly, while Green IT subordinates nature itself to human experts, Sustainable HCI subordinates 'human nature' to expert designers.

Similarly, while it is accepted that the 'natural' dynamic of the Digital Economy is to enact 'progress' through obsolescence in ways that are ostensibly 'unsustainable', much Sustainable HCI research attempts to design a new relationship between the Digital Economy and the environment through interventions that moderate consumer demand (e.g. Gegenbauer & Huang, 2012; Turner & Turner, 2011; Huang & Truong, 2008; Odom, 2008; Blevis, 2007). Sustainable HCI also sees possibility for alignment between the Digital Economy, the environment and social justice (e.g. Nathan, 2008). Indeed, Sustainable HCI has recently embraced issues such as poverty (Le Dantec, 2008), peace (Hourcade et al., 2011), feminism (Bardzell,

2010), and international development (Wyche & Murphy, 2013; Kam et al., 2010; Sambasivan et al., 2009) as potentially being within its remit (cf. Busse et al., 2012).

Agency

Designers Sustainable HCI researchers have been described as being motivated by the 'feel good' factor that comes from doing a perceived 'good' in the world (Mankoff, 2012). Protecting the environment is, therefore, intrinsically rewarding for the designer. This, however, does not detract from the narrative of designers as benevolent experts, seeking the best interest of all. As Brynjarsdóttir et al. (2012) note, Sustainable HCI may, indeed, give undue credit to the expertise of the designer, who may not actually be in a better position than others to determine what is 'best' with respect to 'sustainability'.

Consumers In contrast, the great majority of Sustainable HCI research[32] promotes a vision of individual consumers as motivated by rational self-interest but being greatly under-informed, leading to seemingly 'poor' decision-making. Consequently, there is an emphasis on generating and communicating information regarding the impacts (both environmental and economic) of individual activity. Consumers are also described as having the power to impede 'sustainability' success by rejecting technological interventions, and therefore a large portion of Sustainable HCI research is devoted to understanding consumer resistance to design for greater uptake (e.g. Rodden et al., 2013) (see 'formative user studies' publications in DiSalvo et al., 2010).

Citizens The discourse tends to assume that citizens are engaged in environmental issues (cf. Burke, 2006), and in cases where they are not, they can be compelled to participate in citizen sensing activities through other enticements, both intrinsic and extrinsic (cf. Massung et al., 2013). This characterisation of people is specific to 'citizen sensing' and 'environmental informatics' approaches, which are considered part of Sustainable HCI despite some key distinctions, detailed by Goodman (2009).

People at various levels In this narrative, there can be agency at various dynamically interrelated levels, including the individual level, the group level and the

[32] i.e. historically, although this does appear to be changing as recent publications challenge this vision.

societal level (Mankoff et al., 2007). Although the designer is given the greatest responsibility, consumers are capable of making small changes, citizens are capable of helping out, businesses can consciously slow obsolescence cycles, and policy makers can potentially intervene if Sustainable HCI is able to engage them.

Digital Economy While Sustainable HCI proposes adjustments to the way the Digital Economy enacts 'progress' (e.g. through rapid obsolescence cycles), the discourse is still premised in market models that assume cost-benefit calculations on the part of rational consumers and rational businesses (Dourish, 2010) (see Chapter 4). In this narrative, therefore, there can be cooperation between agents towards 'sustainability' wins, but this cooperation is solidified by mutual self-interest, suggestive of an acceptance of free market logic (*Rational Actor, Self-Interest, Free Market*).

Key metaphors and rhetorical devices

Goodman (2009) proposes that Sustainable HCI discourse employs the metaphors 'footprint', 'probe' and 'exposure'. As in non-computing discourses on 'sustainability', the 'footprint' is used as a metaphor for individual impact that connotes a trace of an activity. The 'probe' is a metaphor for how designers should relate to the environmental 'problem', communicating caution in one's approach, i.e. seeking to understand the problem better before attempting to design solutions. 'Exposure', a metaphor typical of 'citizen sensing' research, emphasises both the degree to which individuals are exposed to pollution, and how 'citizen sensing' can aid in revealing data that exposes truths about the environment that are otherwise hidden.

Adding to and updating these, other key metaphors and rhetorical devices are identified below.

Living In recent years, Sustainable HCI has begun to reject mechanical rhetoric such as 'optimisation' in favour of a more organic, holistic notion of 'sustainable living' (cf. Håkansson & Sengers, 2013; also Nathan, 2008; Woodruff, 2008).

Action and Activism Because Sustainable HCI is guided by its conviction that it is doing important (and unquestionably good) work (cf. Mankoff, 2012). Consistent with this, an intentionally provocative special interest group explored the notion of researchers as 'activists' (Busse et al., 2013a) (cf. Hauser et al., 2013; Wakkary &

Stolterman, 2013). This echoes what Goodman (2009) identified as 'inspiring' and 'provoking', but specifically, this plays into that 'feel good' factor that is assumed to drive designers.

Reassurance + motivation Overall, while being motivating (above), the rhetoric of Sustainable HCI could be described as reassuring. The discourse clearly indicates that better decisions can be made, by designers as well as consumers, which will help fix this environmental 'problem'.

2.2.4 Classifying Sustainable HCI

Again, returning to Dryzek (2005), it is now possible to classify Sustainable HCI:

Prosaic vs. Imaginative. Sustainable HCI is imaginative because it challenges the 'rule' that economic growth is necessarily antagonistic to environmental protection. It goes further, and is more imaginative than Green IT, in that it also proposes that social justice can also go together with economic growth and environmental protection.

Reformist vs. Radical. Sustainable HCI is reformist because it does not critique its modernist underpinnings (cf. Dourish, 2010), explore alternatives, or propose worldview shift as a route to 'sustainability'.

Again, it helps to demonstrate this classification through determining which environmental discourse Sustainable HCI is most similar to. While Green IT was shown to be similar to 'Ecological Modernization', Sustainable HCI is most similar to (and seemingly draws inspiration directly from) 'Sustainable Development' (see comparison, Table 2.6).

According to Dryzek (2005), the basic narrative of 'Sustainable Development' is that 'economic growth should... be promoted, but guided in ways that are both environmentally benign and socially just' (p. 153). Despite initially being inspired by environmental concerns (Goodman, 2009), Sustainable HCI now embraces a Triple Bottom Line that includes social sustainability (Busse et al., 2012); and although Sustainable HCI does not adopt Sustainable Development's economically utopian stance that 'economic growth produced by free trade [is] the only hope for the world's poor' (Dryzek et al., 2005: p. 152), it does suggest that there is a role for digital technologies (and therefore growth of the Digital Economy) in fostering social justice around the world.

Table 2.6: Sustainable HCI vs. 'Sustainable Development' discourse

	Sustainable HCI	'Sustainable Development' [33]
1. Basic entities recognised or constructed	• Designers • Consumers and citizens, and their behaviour • Complex systems • Digital Economy • Idealised environment (detached from natural limits)	• Nested and networked social and ecological systems • Capitalist economy • Ambiguity concerning existence of limits
2. Assumptions about natural relationships	• Cooperation • Subordination of human nature • Economic growth, environmental protection and social justice can go together	• Cooperation • Nature subordinate • Economic growth, environmental protection, distributive justice, and long-term sustainability go together
3. Agents and their motives	• Agents at many levels • Designers; motivated by 'feeling good' and the best interest of all, better informed than other individuals • Consumers and Digital Economy; motivated by self-interest, under-informed • Citizens; motivated by environmental issues or rewards of participation	• Many agents at different levels, transnational and local as well as the state; motivated by public good
4. Key metaphors and other rhetorical devices	• Footprint • Probe • Exposure • Living • Motivating action and activism • Reassurance	• Organic growth • Nature as natural capital • Connection to progress • Reassurance
5. Key frames	• *Instrumentally Valuable Environment* • *Rational Actor* • *Self-Interest* • *Free Market*	• *Instrumentally Valuable Environment* • *Rational Actor* • *Self-Interest* • *Free Market*

One of the mottos of 'Sustainable Development' is 'from the global to the local' (ibid: p. 153). In 'Sustainable Development', this implies at the global level the involvement of governments in international cooperation; but government is not a central entity in Sustainable HCI discourse. For Sustainable HCI, 'global' cooperation takes place within international academia, while the 'local' is understood to be the role that individuals play in adopting more 'sustainable' behaviours or participating in gathering data to help generate 'more significant action and better understanding' (Goodman, 2009).

And finally, both discourses work rhetorically to 'reassure'. Dryzek claims that 'Sustainable Development' declares, 'We *can* have it all: economic growth, environmental conservation, social justice; and not just for the moment, but in perpetuity. No painful changes are necessary' (ibid: p. 157). Similarly, Sustainable HCI discourse does not often suggest that disengagement from technology is a necessary prerequisite of environmental sustainability[34]. With clever guidance from Sustainable HCI, it is proposed that digital technologies may not only be a part of a 'sustainable' future, but may also be part of a 'sustainable' solution.

Table 2.7: Classifying Sustainable HCI

	Reformist	**Radical**
Prosaic	——	——
Imaginative	• Sustainable HCI • cf. 'Sustainable Development'	——

2.3 Further classifications

Goodman (2009) argues that discourse analysis is an 'appealing tool' because 'it prioritizes not just what is said, but also the types of assumptions and gaps in attention that can suggest novel directions for research'. So far, the discourse analysis reported in this chapter has served to:

[34] Baumer & Silberman (2011) is a notable exception.

[34] With the exception of the Key Frames, the final column in Table 2.6 is taken directly from Dryzek (2005: p. 157).

(a) illuminate the assumptions underlying Green IT and Sustainable HCI, in order to clarify the similarities and differences between these discourses, helping to explain why proposed solutions differ between these sub-groups of Green Computing;

(b) enable a useful comparison between these discourses and other existing environmental discourses that helps anchor them within the wider context of debate[35];

It has been shown that both Green IT and Sustainable HCI can be classified as imaginative/reformist discourses, and a working analogy has been proposed as follows:

Working analogy for Green Computing's imaginative/reformist discourse
Green IT : Ecological Modernization ::
Sustainable HCI : Sustainable Development.

To the extent that this analogy reflects the commonalities (rather than variations) between publications within each discourse, this analogy is useful; though it is somewhat oversimplified. Further analysis (published in Knowles et al., 2013b) reveals a largely shared set of questions motivating Green IT and Sustainable HCI. These questions are named as follows (see Appendix C.1 page 221 for further details about these ten questions):

1. *How can we support more responsible disposal of electronic waste?*
2. *How can we reduce CO_2 emissions?*
3. *How can we better monitor the state of the natural environment?*
4. *How can we use technology to foster environmentally responsible behaviour?*
5. *How can we make better use of renewable resources?*
6. *How can we make more efficient use of resources?*
7. *How can we improve operational and process efficiency?*
8. *How can we use technology to make society more efficient?*
9. *What is the role of technology?*

[35] Until now, this discursive foundation has neither been articulated nor critiqued. This is a common critique of Green Computing (i.e. by academics in the field), that such omissions confuse the discourse while preventing constructive engagement with the ongoing environmental debates, thereby greatly impoverishing the discourse (DiSalvo et al., 2010).

10. *How can we promote less destructive and more satisfying patterns of consumption?*

These ten questions can be seen to span issues from each of the TBL dimensions, and further that they can be loosely grouped into areas that address pollution, resource management, and society & culture. Hence, the ten motivating questions can be visualised as in Figure 2.2[36]. Further analysis of the 100 most cited Green Computing publications (see Appendix C.2 for corpus formation details) demonstrates that within this broader discourse Green IT and Sustainable HCI tend to address different but overlapping pockets within this agenda (see Figure 2.3). In other words, they are not entirely distinct discourses.

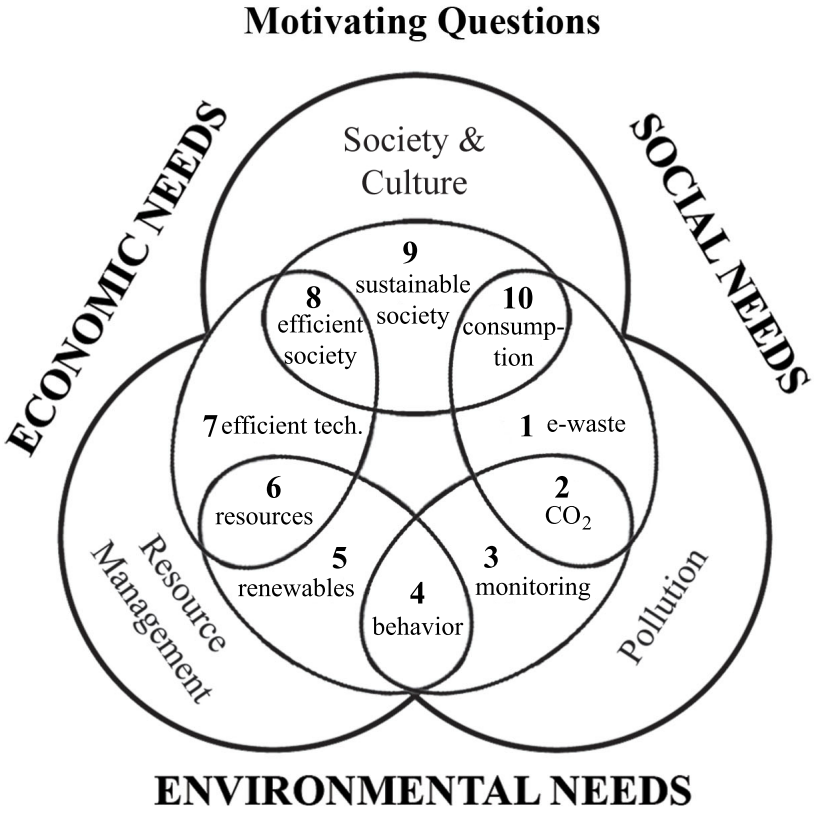


Figure 2.2: Framework of Green Computing's motivating questions.

The more detailed study that was undertaken in Knowles et al. (2013b) also reveals further subtleties within the proposed working analogy that identifies Green

[36] Details regarding the techniques used to create this map of Green Computing's motivating research questions are provided in Appendix D.2.3.

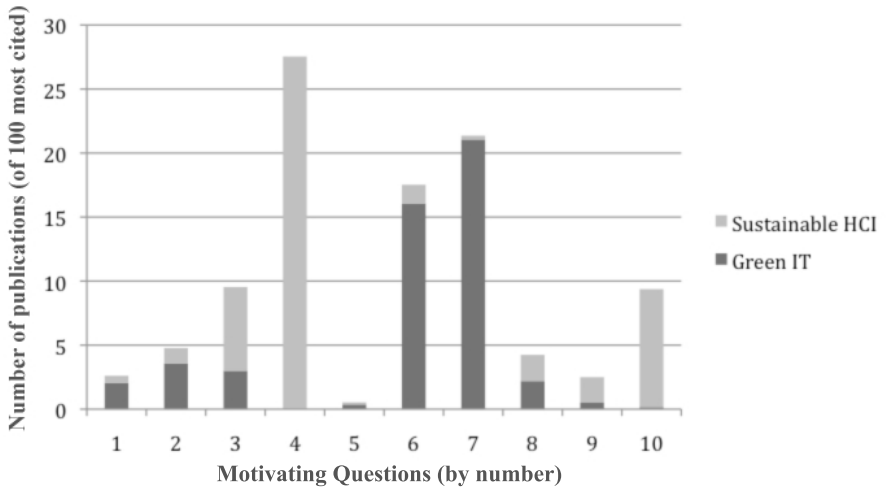


Figure 2.3: Research questions motivating the one hundred most cited Green Computing publications (see Appendix C.2 for corpus details).

Computing within an imaginative/reformist discursive quadrant. Some of the ten motivating questions — and some interpretations of these questions evidenced by specific publications — show similarities with prosaic/reformist discourses, specifically, 'Administrative Rationalism' and 'Economic Rationalism' (Dryzek, 2005), as follows.

Administrative Rationalism tendencies. Some approaches emphasise the role of the 'expert' in solving the sustainability problem. Particularly for Green IT research, rather than government figures playing the expert role, scientists and technologists are the experts. And to some extent, they must take up this mantle, given that their skill set is required for addressing questions like (7) *How can we improve operational and process efficiency?* But this expert role is also evident in some of the responses to (8) *How can we use technology to make society more efficient?*, specifically those that seek to develop smart grid solutions that can expertly coordinate resource consumption (cf. IBM's Smarter Planet).

Another feature of Administrative Rationalism is regulatory policy (Dryzek, 2005: pp. 80-1). The Waste Electrical and Electronic Equipment Directive (WEEE) implemented by the European Council in 2003 has implications for Green Computing's question (1) *How can we support more responsible disposal of electronic waste?*, and some Green Computing responses have been to prepare the industry for compliance with these regulations. Going further, some approaches to Green Computing claim a role for computing in

'work[ing] with public policy makers to ensure that the right regulatory and fiscal frameworks are in place to move us all in the right direction' (Webb et al., 2008: p. 6), though if this negotiation is taking place, it is taking place behind closed doors and not being published in academic journals.

Finally, Administrative Rationalism often relies on environmental impact assessments (ibid: pp. 80-1); and similarly, techniques such as Life Cycle Assessment (Hilty et al., 2011; Webb et al., 2008) and 'holistic' impact assessment (Raju et al., 2013) are popular within computing. The recent trend of disclosure of the environmental impact of some of the largest data centres (e.g. Vaughan, 2012; Clark, 2011), and the research efforts towards reducing their impacts (question 2, *How can we reduce CO_2 emissions?*), suggests a certain acceptance of Administrative Rationalism discourse. The degree to which businesses have been pressured into disclosing this information by environmental interest groups, however, is reflective of another prosaic/reformist discourse, i.e. Democratic Pragmatism.

Economic Rationalism tendencies. Green Computing discourses and Economic Rationalism assume that people are economically motivated, rational beings (see Section 4.3 for further discussion). While purist Economic Rationalism assumes that the Free Market will rectify any 'sustainability' problem, Green Computing appears to recognise a lack of transparency about the economic implications of certain consumer decisions, and therefore often seeks to make such relationships more visible to consumers (the dominant mode of addressing question 4, *How can we use technology to foster environmentally responsible behaviour?*). Another important similarity is the emphasis on consumer behaviour as a target for reform. It is worth noting, however, that the Brundtland Report itself advocated certain Economic Rationalism approaches towards addressing Sustainable Development (Dryzek, 2005: p. 122); and it appears that Green Computing also borrows some from 'Sustainable Development' discourse.

The fact that Green Computing appears on the one hand to embrace an imaginative understanding of 'sustainability' as a Triple Bottom Line issue, while adopting some of the tactics of prosaic discourses, may be indicative of the very problem this chapter seeks to address — namely that a lack of clear articulation of the assumptions underpinning Green IT and Sustainable HCI has made it difficult for communities of researchers to coalesce around a shared vision and agenda. It may also reflect, however, the fact that digital technology is often addressed within other, non-technical discourses, as evidenced by the WEEE Directive, for example. And it is worth noting that many of the examples of Administrative Rationalism within com-

puting come from industry, whereas contributions from academia tend to be more imaginative.

In order to be appropriately inclusive of the variety of computing responses to the environmental 'problem' and still retain what is meaningful about the category of Green Computing described in this chapter, the term 'Rationalistic Computing' is proposed as a tentative title for the prosaic/reformist activities described above (see Table 2.8).

2.3.1 Radical discourses

This begs the question, *are there any radical 'sustainability' discourses in computing?* It should be noted that the preceding analyses characterise the kinds of research being published in mainstream and high rated venues, and while it may represent the work that is generally accepted as comprising the Green Computing agenda, it may not account for more radical research that might struggle to be accepted for publication, or is published in venues not explored in this research[37].

Yet, as a notable exception to this trend, in 2012, a new radical discourse emerged from a mounting fear that Green Computing may not be doing enough to prevent major societal collapse that could result from continuation of ostensibly 'unsustainable' trends. In a paper entitled, 'What If Sustainability Doesn't Work Out?' (Tomlinson et al., 2012b), computing researchers began to outline a 'Plan B' that focuses on the potential role of computing in a 'collapse' or 'post-collapse' scenario. Recently, this new field of enquiry has been named 'Collapse Informatics'[38] (Tomlinson et al., 2012a; Preist et al., 2013; Busse et al., 2013b; Busse et al., 2012) and, like 'Survivalist' discourse, it focuses on 'adaptation' responses to crisis rather than crisis mitigation, and includes an eschatological narrative of (likely) resource depletion and looming tragedy[39].

2.3.2 Summary

In light of these additional pieces of the puzzle, the computing response to 'sustainability' can be summarised by the following discourse descriptions (paralleling

[37] e.g. Society for the Social Studies of Science.

[38] a.k.a. 'Adaptive Informatics'

[39] Undoubtedly, authors of Collapse Informatics would resist being labeled 'Survivalist'. Note, however, that these discursive quadrants are not meant to represent discrete differences, but rather two continuums. The point being made here is that in contrast to Green Computing, Collapse Informatics is clearly *more* radical, and *less* imaginative.

Section 2.1.2); and they are categorised according to their discursive dimensions in Table 2.8 (paralleling Table 2.2).

Promethean Computing: this mode is characterised by a denial of the very notion of a 'sustainability' problem and/or a denial of 'sustainability' as falling within the remit of computing.

Survivalist Computing: this mode is characterised by a concern about the possible futility of attempting to solve 'sustainability' (i.e. engineering 'sustainability' through computing or any other means), and a focus instead on the role of computing in mitigating the societal disruption that might result from organic, potentially crisis induced, evolution towards 'sustainability'.

- **Collapse Informatics** explores the role of computing in easing the process of adaptation in a 'collapse' or 'post-collapse' scenario (cf. Tomlinson et al., 2012a).

Rationalistic Computing: this mode is characterised by the belief that computing can be made 'sustainable' through adjustments (e.g. efficiency improvements) to everyday computing practice, rather than through specific 'sustainability' technological interventions (typically industry).

Green Computing: this mode is characterised by the belief that computing can bring environmental, social and economic needs into greater alignment through a) 'sustainability *in* design' and b) 'sustainability *through* design'.

- **Green IT** tends to interpret 'sustainability' as a mandate for efficiency improvements, seeking to enable more environmentally sound business operations that also benefit the *economic* bottom line (cf. Murugesan, 2008).
- **Sustainable IT** is a proposed 'stronger' mode of Green IT, which focuses less on 'sustainability *in* design', and more on the role of computing in promoting cooperation between businesses and government towards more significant, long-term change (cf. Harmon & Demirkan, 2011).
- **Sustainable HCI** targets individual consumption behaviours and seeks to understand the potential role of computing in enabling more sustainable living (cf. DiSalvo et al., 2010).

Table 2.8: Classifying 'Sustainability' Research in Computing

	Reformist	**Radical**
Prosaic	Rationalistic Computing	Survivalist Computing • Collapse Informatics
Imaginative	Green Computing • Green IT • Sustainable IT • Sustainable HCI	(none)

2.4 Conclusion

Although the term 'sustainability' is part of the public lexicon these days, there is no universally agreed understanding of what it means, much less what an agenda for 'sustainability' might entail. Green Computing clearly distinguishes itself from mainstream computing by aligning its research with 'sustainability', but appears to do so without adequately addressing the contested nature of the term. Recent Sustainable HCI critique makes precisely this point (most notably, Dourish, 2010), but this new awareness has yet to result in an articulation of a clear unifying vision (or several different, competing ones) for 'sustainability' around which the community might construct an agenda. Within Green IT discourse, meanwhile, the contested nature of 'sustainability' is not even acknowledged, much less debated.

The discourse analysis presented in this chapter goes some way towards enabling constructive debate as a result of the following contributions:

- **Exposing the assumptions (i.e. frames) that appear to shape Green Computing's understanding of 'sustainability'.** This is a necessary first step towards interrogating these assumptions. The salient question with regards to frames, to be investigated in subsequent chapters, is not whether these frames are valid, but rather *how they impact the success of Green Computing in realising its vision of 'sustainability'*[40].
- **Identifying the appropriation of a Triple Bottom Line notion of 'sustain-**

[40] As such, this dissertation presents an argument based on pragmatism, rather than essentialism (see Norhaus & Shellenberger, 2009: pp. 219–222).

ability'. Green Computing is an imaginative discourse because it proposes that a mutually beneficial relationship can be designed between environmental, social and economic concerns (TBL). It is interesting that Green Computing seems to be following a common trajectory of TBL-based discourses: while it emerged initially in response to environmental concerns, economic concerns now circumscribe environmental and social concerns. In the case of Green IT in particular, economic concerns have become central to the argument for greener technology, and environmental concerns are presented almost as an afterthought, and are generally conflated with social concerns. This may have important consequences for the impact that Green Computing has in society (to be explored in the next chapter). But another question this analysis raises is whether there are equally (or more) valid concerns that are not accounted for by the TBL that might be addressed within future 'sustainability' research in computing.

- **Classifying Green Computing discourse.** Given that Green Computing appears to be motivated by ten broad research questions, it is worth reflecting on whether these questions are sufficient, and whether addressing them is likely to yield a great enough impact for 'sustainability'. As this chapter has illustrated, however, answering these questions depends on one's understanding of 'sustainability' and one's assessment of the degree of change required for realising this notion of 'sustainability'. Currently, Green Computing seems to be suggesting that 'sustainability' can be achieved through minor changes — and that the role of computing is mostly to make incremental efficiency improvements in the technology itself, and to help consumers make incremental efficiency improvements in their personal energy consumption. While these ambitions may be desirable, if they are to guide a research agenda, there ought to be an evaluation of the degree of impact these interventions are likely to have, and a serious discussion about whether the scale of this impact is commensurate with the scale of change required in realising Green Computing's criteria for 'sustainability'.

- **Identifying a gap for computing research in 'sustainability'.** Locating Green Computing discourses within the imaginative/reformist quadrant helps to reveal the fact that there are not yet any imaginative/radical approaches to 'sustainability' within computing research. While a gap in research might be exploited as a new discourse and hive of activity, just because a research gap is located does not necessarily mean it is worth pursuing, or that research in this space would be 'better' than what people are currently working on. So how might computing justify pursuit of research in the imaginative/radical quadrant? As suggested by the first bullet, above, if it can be shown that

Green Computing is unlikely to succeed as a discourse — i.e. it is unlikely to realise the goals of 'sustainability' as defined by Green Computing — then it would suggest that alternative approaches ought to be explored. To this end, Chapter 3 explores the *values* that Green Computing reinforces, and whether these are aligned with the values that psychological research shows correlate with pro-social and pro-environmental behaviour change. Chapter 4 then delves deeper into the *frames* underpinning Green Computing to demonstrate some deep-seated limitations within the discourse, and proposes that an imaginative/*radical* discourse is more likely to be successful.

Chapter 3

Values Analysis

‘Negative spillover’ for sustainability fostered by Green Computing discourse

Introduction

The aim of this chapter is to report on the findings of a different kind of discourse analysis than that of Chapter 2. Here, discourse analysis is the application of an existing body of values research to the domain of Green Computing by coding publications according to interpretations of existing descriptors of values, and then comparing the prevalence of instances of these values as indicators of characteristics of the discourses of Green IT and Sustainable HCI, as described in Chapter 2.

This chapter makes several important contributions.

1. Firstly, and most notably, by operationalising an existing, robust values framework, it is demonstrated that Green Computing inadvertently reifies values that underpin ‘unsustainable’ behaviour, thereby undermining the discourse’s stated goals.
2. Secondly, discursive differences between Green IT and Sustainable HCI as identified in the previous chapter are enriched and corroborated by separate analyses of their values content.

3. And thirdly, broad implications for Green Computing discourse are discussed as they might relate to future research in Green IT and Sustainable HCI.

Within this chapter, Section 3.1 provides a brief overview of the relationship between values and 'sustainable' behaviour. Section 3.2 reports on the methodological details of undertaking the values analysis. Section 3.3 presents results of the analysis of the Green IT literature sub-corpus, and a discussion of implications of these results. Section 3.4 reports the results of the analysis of the Sustainable HCI literature sub-corpus, along with the analysis of another corpus within Sustainable HCI, namely persuasive technology literature. The chapter concludes (Section 3.5) with implications of this analysis and an evaluation of the likelihood of success for Green Computing's strategy to motivate pro-'sustainability' behaviour change.

3.1 Values research

Values are commonly discussed in computing, especially in publications contributing to ongoing research in so-called 'value-sensitive design'[1]. Having defined values as it pertains to this dissertation in Chapter 1, values-sensitive design work is acknowledged here to indicate an awareness of this established and ongoing research. The key inspiration of this dissertation, however, is the psychological research into human motivation that has been used to re-think the campaign strategies of prominent NGOs, such as WWF-UK and Oxfam, to more effectively engage the public in issues such as global poverty and sustainability in order to realise more significant pro-environmental and pro-social behaviour change. For the sake of consistency, throughout this dissertation, values are understood in accordance with this Common Cause research to reflect this source of inspiration.

This section reports on some of the findings of the significant body of research on by Common Cause (and those drawn upon by Common Cause) to explain what values are, how they 'work', and why they are important to understand when trying to motivate 'sustainable' behaviour. The case of the Make Poverty History campaign (analysed by Common Cause researchers) is discussed as a means of generating insight into some of the 'traps' that progressive campaigns commonly fall into that may also apply to Green Computing. And finally, this section provides a basic

[1] Select publications include Borning & Muller, 2012; Nathan et al., 2011; Woelfer et al., 2011; Friedman, 2008 ('Value Sensitive Design', in Schuler, 2008); Nathan et al., 2008; Miller et al., 2007.

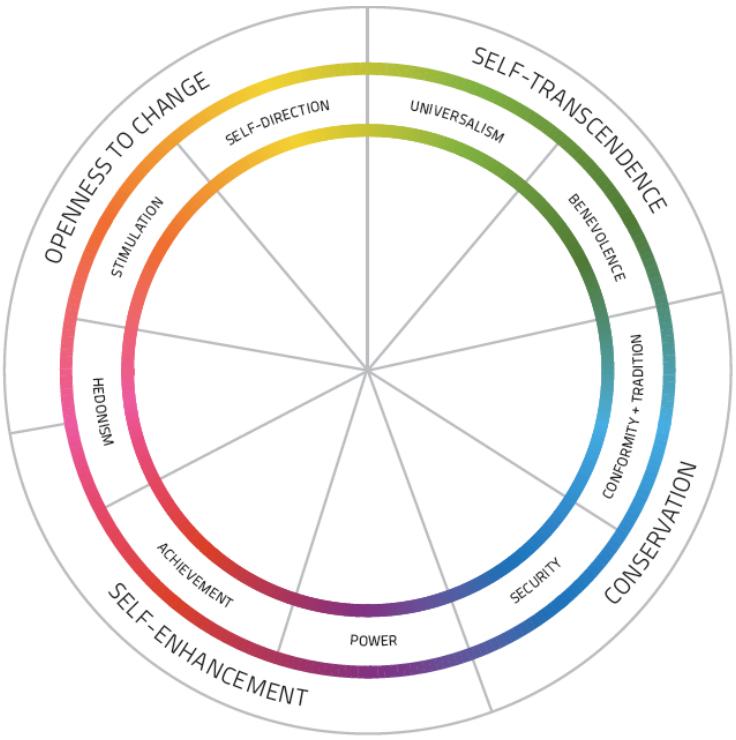


Figure 3.1: An updated version of the Schwartz Circumplex created by Holmes et al. (2011), showing values types (inner circle) and higher order value types (outer circle). (See Appendix D.3.2 for the list of values within these types.)

overview of how this values research is applied in this dissertation to the context of Green Computing.

3.1.1 The dynamics of values

Early values research (Rokeach, 1973; Allport et al., 1960) conceptualised values as being discrete types with identifiable characteristics, which individuals can recognise as being of greater or lesser importance to their lives. In a cross-cultural study (details in Appendix D.1) that asked people to rank the relative importance of these values, Schwartz (1992) found patterns in the data, which indicated that these seemingly discrete values are in fact dynamically inter-related (Maio, 2010: p. 4). Values were shown to cluster into identifiable groups — namely the value types Self-Direction, Stimulation, Hedonism, Achievement, Power, Security, Conformity, Tradition, Benevolence, and Universalism (see Appendix D.3.2 for definitions of these types) — and the dynamics between these values types are illustrated by the Schwartz Circumplex (Figure 3.1).

Neighbours and opposites The circumplex reflects *spatially* the empirical data of Schwartz's (1992) study — neighbouring values were found to be rated of similar levels of importance within a single individual, whereas values on opposite sides of the circumplex were found to be rated of different levels of importance within an individual. This finding is suggestive of cognitive compatibility between neighbouring values, and cognitive incompatibility between opposite values. Even though people appear to have inherent access to the full range of values (as indicated by Schwartz, 1992), the fact that certain values are in conflict requires that individuals prioritise certain values over others.

This accounts for differences in the self-reported importance of these values between individuals. Subsequent research has shown that these prioritisations are in flux and are constructed dynamically in response to stimuli. Priming experiments that make values temporarily salient (i.e. that 'activate' values) have demonstrated the following effects (cf. Holmes et al., 2011):

Dependent behaviour. When a value is activated, behaviours related to that value are increased (Maio et al., 2001; Bargh et al., 2001; Macrae & Johnston, 1998).

The 'see-saw effect'. When one value type is activated, its opposite is simultaneously de-activated and suppressed.

The 'bleedover effect'. When one value type is activated, its neighbouring value types are simultaneously activated.

Self-Enhancement vs. Self-Transcendence Reflecting the above effects, the ten value types have been grouped into four broader types (see again Figure 3.1). Openness to Change values, which include Self-Direction, Stimulation, and some of the Hedonism values, are opposite to Conservation values, including Security, Conformity and Tradition values. Likewise, Self-Enhancement values (Power, Achievement and some of the Hedonism values) are opposite to Self-Transcendence values (Universalism and Benevolence values).

Numerous studies independently suggest that Self-Transcendent[2] (ST) values are

[2]While Schwartz uses the terms 'Self-Enhancement' and 'Self-Transcendence', some researchers will use these terms interchangeably with 'extrinsic' and 'intrinsic', respectively. The latter terms are derived from the tradition started by Grouzet et al. (2005), which overlaps a great deal with Schwartz's findings. In the words of one of the co-authors of Grouzet et al. (2005), 'there's more overlap than there is difference [between the terms and models used to describe these terms], and that's why we've been comfortable combining it. And Schwartz hasn't objected, by the way' (Tim Kasser; Values and Frames Workshop, Lancaster University, 13/6/12). Nonetheless, for the sake of simplicity, this dissertation will not use these terms interchangeably, and will adopt the Schwartz terminology unless it is necessary to

correlated with pro-social and pro-environmental behaviour, and that Self-Enhancement (SE) values are negatively correlated with these behaviours (e.g. Good, 2007; Schwartz, 2006; Schultz et al., 2005; Saunders & Munro, 2000). Sheldon & McGregor (2000), for example, found that highly materialistic individuals (defined here as being high in SE values) more quickly destroyed a virtual forest in a resource dilemma game than did less materialistic individuals. This corroborates other studies suggesting that Self-Enhancement is predictive of environmentally 'unsustainable' behaviour. Significantly, these studies also show that even individuals who are exceptionally high in SE *initially*, can be primed to demonstrate higher Self-Transcendence (Chilton et al., 2012), suggesting that deliberate priming of ST values can be used as a technique to encourage people towards engaging in pro-social and pro-environmental behaviour.

'Positive' and 'negative' values Although no value can be said to be 'good' or 'bad', 'right' or 'wrong', since their 'goodness' and 'rightness' is somewhat context dependent, values can be said to be 'positive' or 'negative' with respect to target goals. Since studies show that Self-Transcendence values (e.g. Universalism and Benevolence values) tend to promote pro-environmental behaviour, they are 'positive' with respect to pro-environmental behaviour. 'Negative' values for pro-environmental behaviour, on the other hand, are Self-Enhancement values (e.g. Achievement and Power).

Given that studies have demonstrated the effectiveness of priming individuals' values with language (e.g. having them read a passage of text designed to prime a target value, answer a questionnaire biased towards a particular value, or perform a wordsearch or anagram task with words related to a value), this has important implications for the language that people use in trying to motivate a given behaviour. For example, when trying to encourage pro-environmental and/or pro-social behaviour, 'playing on people's concern for status and wealth... may encourage less environmentally-conscious behaviour and lower concern about other people' (Holmes et al., 2011: p. 30).

'Positive' and 'negative' values Because values and behaviour are linked (i.e. dependent behaviour, above), values can also be engaged (primed) through adoption of a given behaviour, with implications for subsequent behaviour:

use the Grouzet et al. (2005) terminology. The terms 'intrinsic' and 'extrinsic' will instead be used to describe goals (rather than values), as was the original usage of these terms in the Grouzet et al. (2005) study.

'Positive spillover.' This describes the phenomenon that when people adopt a behaviour that is linked to particular values, it increases the likelihood that they will later engage in the same or related behaviour. This would suggest, for example, that a person who recycles will later be more inclined to switch off the lights when leaving a room. A related phenomenon is known as the 'foot-in-the-door effect', whereby an individual who adopts a particular value-related behaviour is likely to adopt another, more ambitious related behaviour.

'Negative spillover.' On the other hand, sometimes the adoption of a behaviour — such as environmental gestures like switching off the lights — can work to decrease the likelihood of an individual adopting other related behaviours.

Crucially, *the difference between whether a behaviour leads to positive or negative spillover has been found to be the motivation behind doing that behaviour*. If a person is switching off the lights in order to save money on their electric bills, this will reinforce Self-Enhancement (Power) values, and in turn will likely lead to negative spillover and fewer subsequent pro-environmental behaviours (or at least fewer of these that are not linked with financial reward). Similarly, if the motivation to switch off lights is a desire to be regarded positively by others for appearing environmentally responsible, this makes it less likely that a person will act environmentally responsible when no one is looking[3]. On the other hand, if the motivation for switching off the lights is a feeling of obligation to the planet and to friends and family to be environmentally responsible, this is more likely to lead to positive spillover.

To illustrate these many principles in action, and to explore how these values relate to frames, the next section discusses implications from Common Cause's analysis of the Make Poverty History campaign.

3.1.2 Make Poverty History

In 2011, Oxfam sought the expertise of Common Cause to understand why, after decades of campaign work to help increase public engagement in the issue of global poverty, this level of engagement has remained low, and indeed seems to be declining (Darnton & Kirk, 2011: pp. 5-6). The subsequent analysis by Common Cause demonstrates that a significant contributor to these trends is likely that, in

[3]This may explain the 'moral licensing effect' that was noted in Mazar & Zhong's (2010) lab study, whereby the group of participants who bought green products online were subsequently more likely to behave in unethical behaviours as compared with the group who looked at green products but did not buy them.

an effort to garner support for their cause, Oxfam's Make Poverty History campaign directly appealed to Self-Enhancement values. As a result, the report concludes, people 'will only become more self-interested, and less likely to support pro-social campaigns in the longer term' (ibid: p. 7). So 'despite good intentions' (Holmes et al., 2011: p. 37), bypassing the Self-Transcendence motivations for supporting Oxfam's campaign to end global poverty and instead appealing to individuals who are (presumed to be) self-interested in order to increase measurable indicators of support (e.g. signatures, donations), has in the long term contributed to a significant decline in public engagement in global poverty as an important issue.

The report isolates several 'positive' values that align with the goals of the Make Poverty History campaign. The authors argue that the central strategy of the campaign should be to enhance Universalism values, which is required for people to feel concern for the effects of global poverty on those they may never meet. Of the Universalism values, Common Cause suggest that 'Equality', 'A world at peace' and 'Social justice' are of primary importance (Darnton & Kirk, 2011: pp. 53, 100). Because of the 'bleed-over effect', however, Make Poverty History is encouraged to also enhance other seemingly less relevant Universalism values, such as those related to protecting the environment (ibid: pp. 53, 100). Benevolence values might also be 'positive', as they are Self-Transcendence values and are therefore associated with 'bigger-than-self' issues (ibid: p. 57); yet empirical data suggests that Benevolence is not as strongly linked with concern about 'development issues' as Universalism (ibid: p. 54), perhaps in part because Benevolence tends to enhance in-group Affiliation (cf. Grouzet et al., 2005) more than (out-group) Community Feeling (Darnton & Kirk, 2011: p. 62). For this reason, the authors suggest that values such as 'Helpful', 'Responsible', 'True friendship' and 'Meaning in life' should 'only be activated for specific purposes as part of a longer-term strategy (especially in order to engage the previously unengaged and the outright sceptical)' (ibid: p. 100). Also, in light of evidence for the 'see-saw effect', the authors argue that an effective campaign would simultaneously work to de-emphasise problematic values, namely Power values (ibid: pp. 53, 100).

While the report recognises the importance of attracting individuals to the cause by appealing to what they care about, an obvious difficulty arises when people's 'immediate concerns do not coincide with those of development NGOs' (ibid: p. 63). In these instances, however, the strategy should be to try to 'strengthen positive values, and within this to bring Universalism values to the fore' (ibid: p. 63). In other words, attracting supporters is important, but it cannot be done at any cost. The authors warn:

> *If, for the short-term, NGOs choose to trade on extrinsic motivations, to earn revenue or engage new supporters, then they must do so, but all the time being mindful of the collateral damage these tactics will cause to the supporter base in the longer term. Such tactics should only be employed as part of a considered, longer-term strategy for building public engagement with development — a strategy founded on the positive values* (ibid: p. 64).

In conclusion, while appealing to Self-Enhancement values will likely generate more donations (at least in the short term), they will be generated from people who are as a result *less* inclined to take any further action on behalf of the cause (i.e. 'negative spillover'). Self-Enhancement appeal is, therefore, a case of one step forward, two steps back. To consistently make progress in a positive direction, the campaign needs to communicate a consistent, issues-based, Self-Transcendence focused message.

3.1.3 Application of values research

In light of these observations, the obvious question is whether Green Computing is falling into these same traps, in this case seeking to foster pro-'sustainability' behaviour by appealing to Self-Enhancement values. If so, the implication would be that Green Computing may inadvertently be fostering negative spillover for pro-'sustainability' behaviour, *at least as it relates to two of the three pillars of its Triple Bottom Line framing of 'sustainability'* (environmental and social needs). In short, if Green Computing discourse is characterised by strong activation of Self-Enhancement values over Self-Transcendence values, it would suggest that Green Computing's impact will at best be limited, or at worst do more harm than good in terms of its overall 'sustainability' impact.

To study this hypothesis, the 58 Common Cause values[4] (derived from the Schwartz circumplex) were operationalised and adapted for the purposes of discourse analysis. A large corpus of Green Computing literature was then coded with respect to these values to reveal in particular the proportional activation of Self-Enhancement versus Self-Transcendence values. The next section explicates the details of this study.

[4] The two additional values not found in Schwartz's 1992 list but are used by Common Cause include 'Privacy' and 'Self-indulgent'.

3.2 Green Computing values analysis

The purpose of this study was to analyse the values content of a representative slice of Green Computing literature in order to enable reflection on whether these values are conducive to pro-environmental and pro-social behaviour — i.e. values that are conducive to Green Computing success in at least 2 of the 3 pillars of its Triple Bottom Line-based research. This involved three main research activities as part of a mixed-methods approach: 1) systematically developing a literature corpus, 2) developing a coding system, and 3) coding the literature. An outline of this methodology is summarised in Figure 3.2, below (a more detailed summary is provided in Appendix D.2), and the sections to follow provide details of these stages.

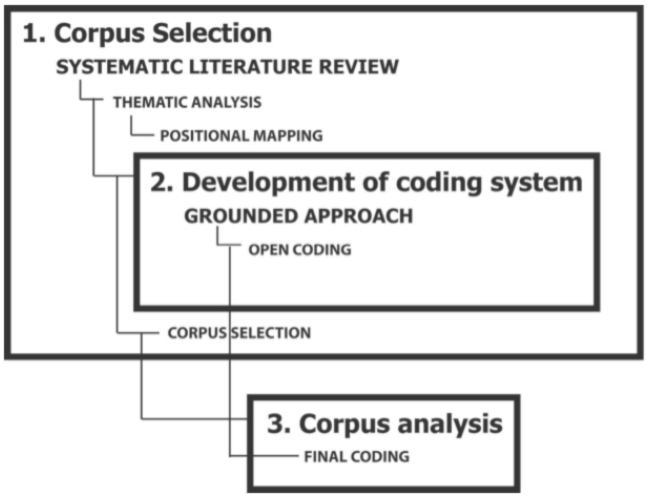


Figure 3.2: Overview of research methods for the Green Computing corpus values analysis.

3.2.1 Developing a corpus: Systematic Literature Review

A Systematic Literature Review (SLR) is a method of analysing an existing body of literature that pertains to one's research question, and it is specifically designed to a) minimise selection biases, b) eliminate omissions of pertinent data, and c) be repeatable by other researchers. Guidelines have been developed for undertaking a systematic literature review (Kitchenham, 2004), which have been adapted for the

purposes of this study. The key stages of this process are described briefly below.

Rationale

The reason for using SLR, rather than a regular literature review, was to enable a comprehensive overview of research in the domain of Green Computing. This overview was intended to be used to develop a framework for this research consisting of identifiable units within Green Computing, providing insight into how best to develop a representative corpus of Green Computing publications for values content analysis. See Appendix D.2.1 for further details about the rationale for using SLR.

Developing a review protocol

The difference between SLR and a regular literature review is the establishment of a strict review protocol in advance of doing the analysis. The elements of this review protocol are discussed in turn below.

Research question(s). Using Thematic Analysis (TA) (Braun & Clarke, 2006), and within this Positional Mapping techniques (Clarke, 2005), several research questions were identified as motivating Green Computing. These motivating questions were adopted as the research questions for the purposes of conducting the remainder of the SLR. Details of this process are published in Knowles et al. (2013b), and are included in Appendix D.2.2.

Search strategy. A search strategy was developed for each of the ten motivating questions identified in the previous step, along with each of the additional paper types identified along the way[5]. This involved the selection of ACM Portal and IEEE Xplore as the publication archives to be searched[6], and iterative development of specific search strings for each of the 13 categories (details in Appendix D.2.3).

[5] Three additional categories were created to account for pronounced differences in paper types — named reflective, legislative, and formative user studies. *Reflective* papers were those that discussed what Green Computing (or a sub-genre) is, could be, or should be, and often included a survey of research activity to date. *Legislative* papers were policy-focused, and explored potential pros and cons of implementation of green policy measures. And *formative user studies* is a term borrowed from DiSalvo et al. (2010), describing papers that undertake primary research as a means of better understanding a target group as inspiration for future design.

[6] The initial strategy was to include publications from only the top rated journals and conferences, but having surveyed publication venue ratings and finding that many of the top rated were sponsored by ACM (the Association of Computing Machinery) and IEEE (the Institute of Electrical and Electronics Engineers), the SLR scope was limited to publications that appeared in the ACM Portal and IEEE Xplore archives as a way of isolating top-rated journals and publications.

Selection criteria and quality assessment. General selection criteria were developed for the entire corpus. These include the following:

- Published in the last 10 years (2002 – 2012).
- Top 5 most cited papers from each sub-question category.
- Relevance to Green Computing and best fit for sub-question.

Specific details about the selection criteria for each sub-question and category are included in Appendix D.2.4, which also provides details about how the top 5 most cited papers were determined.

Data extraction strategy. The final stage of the SLR is to perform the desired analysis on the systematically selected corpus (or in this case, corpora). Because there is no existing means of coding values content from text, in order to determine which values are being activated by Green Computing research, a new coding system needed to be developed that operationalises values research. The development of this coding system is detailed in the next section.

3.2.2 Developing a coding system: grounded approach

Descriptors were developed for each of the values to be coded in the systematically selected corpus resulting from the process above. These descriptors (detailed in Appendix D.3.2) were used as guidelines for coding the values in the publication text. While the values being used in the study have been described and tested in other contexts (e.g. Holmes et al., 2011; Schwartz, 1992), applying them to this research domain involved a degree of interpretation. To ensure consistency in the coding, therefore, final descriptors were eventually set after a process of iteration. This iterative process was based on the grounded theory technique of 'constant comparison' (Dick, 2006; Glaser & Strauss, 1967), summarised by Figure 3.3 and detailed in Appendix D.3.1.

Strict coding procedures were developed for each of the selected papers (details documented in Appendix D.3.3). Coding the final corpus involved scoring each value for each paper — scoring the value either a 1 (meaning the value was present and 'activated') or 0 (meaning the value was absent)[7].

[7] Presence or absence of values was determined based on the values descriptors (Appendix D.3.2). When a passage of text contained an indicator (e.g. a keyword, a suggestion, an acknowledgment, etc) within a value's descriptor, it was coded a 1. While reading publications, potential values were flagged, and then checked against these descriptors for verification.

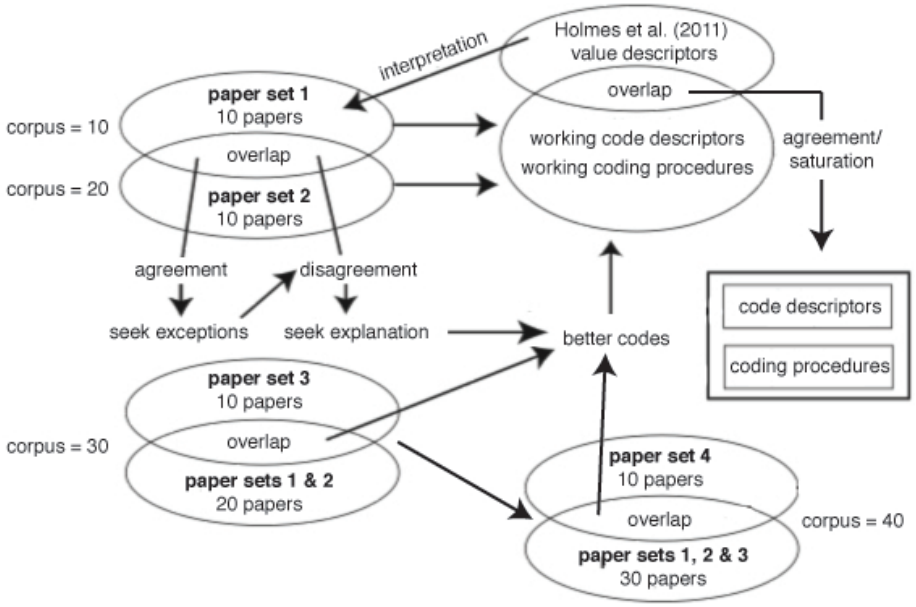


Figure 3.3: Model of constant comparison method used for creating values code descriptors and coding procedures (adapted from Dick, 2006).

3.3 Green IT values analysis

The system described above that was used for generating a Green Computing literature corpus resulted in many more Green IT papers being included than Sustainable HCI papers (respectively, 47 and 18 out of 65). This in itself is an interesting finding, suggesting that the most cited papers in each of the categories identified belong disproportionately to the Green IT research camp.

Had the contributions been approximately 50% from both Green IT and Sustainable HCI, then the results of the analysis could have been more easily combined, and any data visualisation would represent the approximate average between the two. However, because there were far more Green IT papers, it became necessary to differentiate the analyses. Below are the results of analysis of Green IT papers[8]. Note, however, that Green IT is used in a broad sense, encapsulating sub-genres such as Green IS, Green ICT, ICT for Green and Sustainable IT[9].

[8]Whether publications were classified as Green IT or Sustainable HCI was determined based on assessment of publication venue, author affiliation, and content.

[9]As was the case for the discourse analysis performed in Chapter 2.

3.3.1 Results

The most commonly activated value (94% of the corpus) was 'Capable', which was indicated most often by claiming that Green IT enabled greater efficiency. 'Wealth' was the next most commonly activated value (85%), e.g. suggesting that Green IT (usually because of the efficiency it enabled) led to financial savings. Following behind with 72% was 'Intelligent', which was activated here when authors advocated a highly rational, logical route to 'sustainability' (as Green IT defines it) wins, e.g. greater information or analysing capabilities. 'Protecting the environment' came in as low as fourth, with 66%, despite having been coded, generously, in all instances when the environmental benefits of Green IT were mentioned at all.

Several other Self-Enhancement values were also commonly activated. 'Successful' was indicated in 49% of the corpus, either when authors suggested means to evaluate whether goals had been met, or mentioning the accuracy of the technology (e.g. in monitoring environmental data). 'Social power' was also activated (40%) by authors suggesting that adoption of technology would be competitively advantageous for business. Related to this, 'Social recognition' and 'Preserving my public image' were both found in 23% of the corpus (though interestingly only with a 45% overlap in papers), and were coded, respectively, in instances when Green IT was advocated as a means of garnering popularity among consumers, and suggested as a deterrent of the wrath of environmentally savvy consumers. 'Ambitious' was activated in 27% of the corpus, usually by glorifying the aspirations of Green IT. And 'Influential' (21%) was coded in instances when the technology was rhetorically 'sold' as being somehow important in making a change in society, or when authors asserted that purchasing (and/or developing) Green IT would make a positive 'difference'.

Also heavily activated was 'Obedient', a Conservation (Conformity) value, found in 40% of the corpus. 'Obedient' was indicated by authors mentioning legislation (current or anticipated) as motivation for adopting Green IT — usually with implicit or explicit financial reward for early adopters. The only other highly activated Conservation value was 'Healthy' (a Security value), with 21%, which was coded when authors mentioned 'toxicity' of non-Green IT, or mentioning associated health risks, as a motivator for adoption and justification of its endeavour.

The types of values most frequently appealed to were Self-Enhancement (SE) values, together totaling 205 incidents in the corpus of 47 papers[10]. In contrast, Self-Transcendence (ST) values accounted for a mere 46 incidents, of which 82% of the

[10]Hedonism, which appears somewhere between Self-Enhancement and Openness to Change was not included in the SE totals.

Universalism values were accounted for by 'Protecting the environment', and 75% of the Benevolence values were accounted for by 'Responsible'. In total, the ST values activated in this corpus were only just higher than Conservation values (39 incidents). The results of the analysis are visualised in Table 3.1 and Figure 3.4.

Table 3.1: Results of values coding (selective list), Green IT corpus

Value	**%**	**SE**	**ST**
Capable	94	X	
Wealth	85	X	
Intelligent	72	X	
Protecting the environment	66		X
Successful	49	X	
Social power	40	X	
Obedient	40		
Ambitious	27	X	
Social recognition	23	X	
Preserving my public image	23	X	
Influential	21	X	
Healthy	21		

3.3.2 Discussion

This values analysis validates and enhances the discourse analysis presented in Chapter 2. Below, the values analysis is discussed in terms of some of the discursive characteristics of Green IT (as summarised in Table 2.2.2).

Businesses motivated by economic bottom line The predominant function of the discourse isolated here is to 'sell' the concept of Green IT to businesses — in short, to increase demand for Green IT products, as opposed to advocating blanket reductions in usage. Because Green IT understands businesses as the key decision makers and agents of change, Green IT presents a rational business case for Green IT adoption, as evidenced by the overwhelming focus on 'Wealth' and 'Capable'.

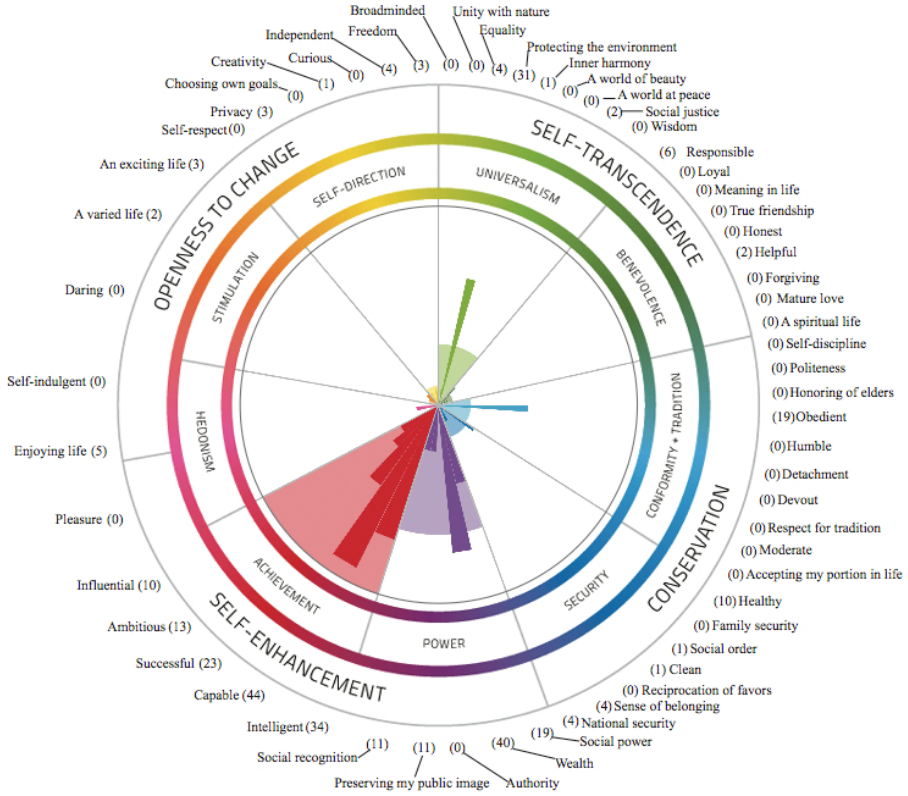


Figure 3.4: Relative weightings of values found in the Green IT corpus, overlaid onto the Schwartz Circumplex as adapted in Holmes et al. (2011). Darker segments indicate the percentage of papers in the corpus in which a particular value was activated; lighter segments represent the total incidents for a particular value type on a scale of 124 (the highest total found).

Environmentally savvy consumers Not only is the efficiency of Green IT 'sold' to businesses as a means of increasing profits, but it is also sold in what might be described as 'cosmetic' terms; i.e. greening one's business will make it more 'attractive' to environmentally savvy consumers. This is indicated by the high activation of 'Social power', 'Social recognition' and 'Preserving my public image'.

Governments (with capacity to legislate) Even the high activation of 'Obedient' is indicative of the belief that businesses are purely *Self-Interested* — that businesses will be financially better off preparing for upcoming green legislation before their practices become too deeply ingrained.

Subordination of nature, ideology of progress, and reassurance 'Capable' was often activated in more than one form in these papers, though for simplicity of the coding system, was only ever coded once per paper. Sometimes, in addition to being activated by mentioning efficiency benefits, it was also activated by emphasising the ingenuity of Green IT researchers on the whole — that they, as a group, were highly capable, and by extension, the human race was capable of overcoming environmental challenges. For this reason, the high activation of 'Capable' might also be interpreted as reinforcing the *ideology of progress*. Furthermore, the fact that this activation of 'Capable' serves to reassure businesses that solutions will be found — coupled with the fact that environmental problems are downgraded — potentially undermines motivation to make significant and possibly difficult changes on the part of businesses to achieve environmental wins.

Efficiency, and environmental protection fits with economic growth The fact that instances of 'Protecting the environment' are outweighed 31 to 84 by the combined activation of 'Wealth' and 'Capable' indicates the Green IT's emphasis on efficiency is primarily economically (rather than environmentally) motivated. Even though 'Protecting the environment' was coded in 66% of papers, in most cases, the activation of this value was made weaker by the fact that it either appeared at the end of a long list of SE-based reasons for Green IT, or was mentioned in the abstract or introduction of a paper which was otherwise SE-focused.

Mutual dependence between entities By selling Green IT in terms of 'Wealth', its success is linked to its continued ability to deliver a return on investment, rather than being linked to its success in delivering significant 'sustainability' wins. It is possible that mentioning the environment in such a 'throw-away' manner (above) subtly communicates that 'Protecting the environment' is less important than ensuring economic growth.

3.3.3 Green IT values analysis conclusions

In assessing the impact of this strong activation of Self-Enhancement values, it is worth considering how the discourse here might function as both an *advertising campaign* and as a *political campaign*. As an advertising campaign, Green IT might be highly successful, in that businesses are likely to purchase Green IT because of the all the extrinsic motivations for doing so (cf. Crompton & Thøgersen, 2009). In this way, the strong emphasis on 'Wealth' (and wealth-related values)

makes sense — it is a salient value for businesses, and its activation is likely to stimulate economically-motivated consumption. On the other hand, the emphasis on 'Wealth' is problematic for Green IT as a political campaign, if the purpose of which is to convince businesses that causes such as protecting the environment and ensuring social justice are important and that these are the reasons to adopt Green IT. If the main argument is that Green IT saves money, this does nothing to persuade businesses that the 'sustainability' benefits of Green IT are inherently worthwhile. Without presenting a strong environmentally- and socially-based argument for Green IT, in situations when financial incentives for Green IT are minimal or in conflict with environmental and social incentives, Green IT is going to be viewed as an impractical and undesirable add-on. Indeed, this will remain the critical limitation of Green IT if it does not evolve towards Sustainable IT (Harmon et al., 2010), which elevates corporate social responsibility above cost-optimisation (see Section 2.2.1).

3.4 Sustainable HCI values analysis

Of the 65 Green Computing papers selected using the Systematic Literature Review process, only 18 were categorised as belonging to the Sustainable HCI camp. Note, however, that as with the Green IT heading, Sustainable HCI is used in a broad sense, encapsulating sub-genres such as Sustainable Interaction Design, Re-visioning Consumption, Citizen Sensing, Pervasive and Participatory Sensing, Formative User Studies, Persuasive Technology and Ambient Awareness[11]. Important distinctions are made between Green IT and Sustainable HCI, both in terms of a) the proportional values activations and b) the ways in which these values are activated.

3.4.1 Results

In the Sustainable HCI corpus, the most commonly activated value was 'Protecting the environment' (89% of the corpus). Interestingly, 'Protecting the environment' here — in contrast to the Green IT corpus — accounts for only two-thirds of the Universalism values activated. Universalism is more broadly activated, including

[11] And again, this is consistent with how Sustainable HCI was analysed in Chapter 2.

activation of ‘Social justice’ and ‘Equality’, both in 16.5% of the corpus (representing 12.5% of the Universalism activations). The most popular Benevolence value was ‘Responsible’ (33%), demonstrating a strong concern for protecting the environment out of a sense of duty to others.

After ‘Protecting the environment’, the next most commonly activated values were largely Power and Achievement values (SE). ‘Wealth’ was indicated in 50% of the papers, usually by acknowledging the overriding financial imperatives of Sustainable HCI. Next most popular, ‘Capable’ was activated in 44% of the papers; though instead of being indicated primarily by mentioning ‘efficiency’, it was often indicated by leveraging the audience’s desire to manage and demonstrate mastery over a problem. ‘Intelligent’ was also present in high numbers (39%); though somewhat differently from Green IT, this was indicated most often by advocating the facilitation of increased information as a route to environmental wins. ‘Ambitious’ (33%) was found when authors emphasised the difficultly of the ‘sustainability’ problem it seeks to address. In 27%, ‘Successful’ was activated, usually by emphasising the achievement of environmental goals, and by seeking to spark competitive spirit (see Persuasive Technology discussion, Section 3.4.2). Within this corpus, ‘Social recognition’ (positive reinforcement) was activated more often than ‘Preserving my public image’ (negative reinforcement), with 22% and 11% respectively. And while ‘Influential’ was activated in 22% of the corpus, it was here indicated most often by asserting the ability of individuals and designers (rather than businesses) to make a positive change for the environment. Notably, in contrast with the Green IT corpus, there was only a single activation of ‘Social Power’.

Another noteworthy difference between sub-corpora is the fact that this corpus demonstrated no instances of ‘Obedient’ as a motivation (in contrast with 40% of the Green IT corpus). There were, however, other more popular Conservation (Conformity, Tradition and Security) values in the Sustainable HCI corpus. For example, ‘Healthy’ was found in 44%, though importantly this was coded here not only when physically harmful effects of technology were mentioned, but also when issues of general ‘wellbeing’ were discussed. ‘A sense of belonging’, which was not found in any of the Green IT papers, was activated in as much as one-third of this corpus. This was indicated when authors activated an awareness in the audience (i.e. the reader or user of a technology) of being part of a larger group, and leveraging a sense of responsibility towards the group as a means of fostering change (e.g. adoption of Sustainable HCI technology, attracting researchers to the field of Sustainable HCI). ‘Accepting my portion in life’, ‘Self-discipline’ and ‘Moderate’, all of which address consumption behaviour, were also found in the Sustainable HCI corpus but not in the Green IT corpus. Together, this demonstrates a concern for — or at least awareness of — the social aspects of the human condition in the

Table 3.2: Results of values coding (selective list), Sustainable HCI corpus

Value	**%**	**SE**	**ST**
Protecting the environment	89		X
Wealth	50	X	
Capable	44	X	
Healthy	44		
Intelligent	39	X	
Responsible	33		X
Ambitious	33	X	
A sense of belonging	33		
Successful	27	X	
Social recognition	22	X	
Influential	22	X	
Social justice	16.5		X
Equality	16.5		X
Preserving my public image	11	X	

Sustainable HCI literature, as might be expected from the 'H' in HCI.

Perhaps related to this, another important difference between the two corpora is the amount of activation of Openness to Change values (e.g. Hedonism[12], Stimulation and Self-Direction). 'A varied life' and 'Curious' were both found in 22% of the papers; 'Choosing own goals', 'Creativity' and 'Privacy' were found in 17%; and 'Pleasure', 'Enjoying life' and 'Freedom' were found in 11% — many of which were not activated at all in the Green IT corpus.

The types of values most frequently appealed to were Self-Enhancement values, together totaling 46 incidents in the corpus of 18 papers. In contrast, Self-Transcendence values accounted for 34 incidents, making the difference between the two much less significant than compared to the Green IT corpus. And much more so than the Green IT corpus, Openness to Change and Conservation values were well-represented and fairly balanced, with 26 and 20 incidents respectively. The results of the analysis are visualised in Table 3.2 and Figure 3.5.

[12] As with the Green IT corpus, Hedonism was lumped with Openness to Change rather than with Self-Enhancement, to avoid biasing results towards those expected from the hypothesis.

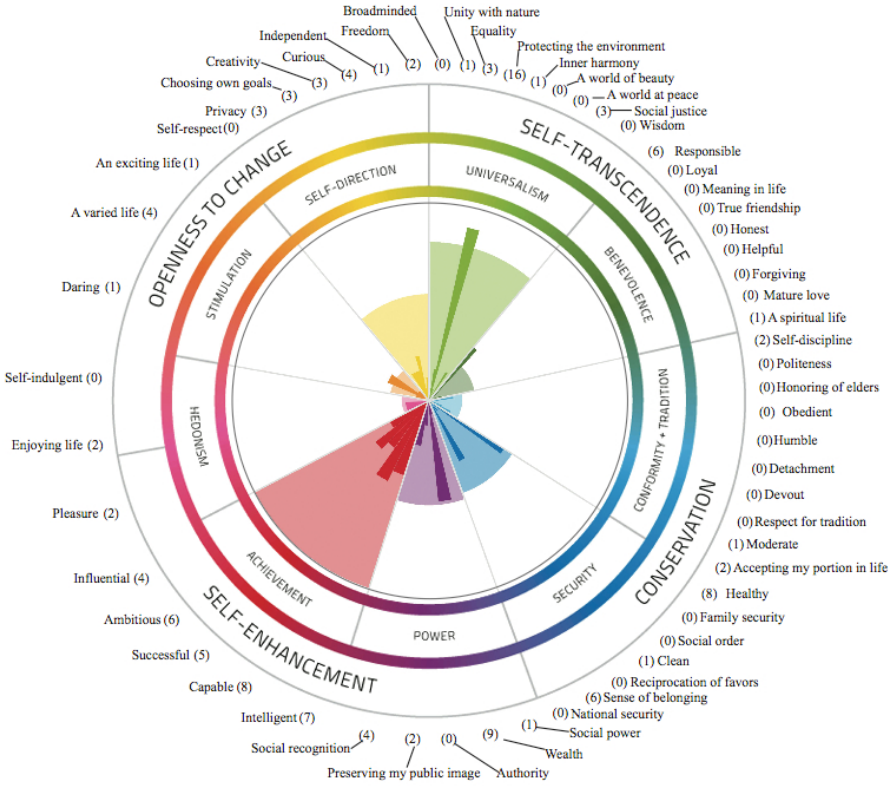


Figure 3.5: Relative weightings of values found in the Sustainable HCI corpus, overlaid onto the Schwartz Circumplex as adapted in Holmes et al. (2011). Darker segments indicate the percentage of papers in the corpus in which a particular value was activated; lighter segments represent the total incidents for a particular value type on a scale of 30 (the highest total found).

3.4.2 Persuasive Technology analysis

In part to address concerns regarding the small sample size of the Sustainable HCI corpus, additional analysis was conducted on a specific subset of Sustainable HCI research, namely Persuasive Technology research. It has been determined by others that Persuasive Technology research accounts for 44–45% (Brynjarsdóttir et al., 2011 and DiSalvo et al., 2010, respectively) of all Sustainable HCI research, making it by far the dominant research area. More importantly, however, Persuasive Technology research specifically aims to motivate behaviour change, making it particularly interesting for values analysis. Described below are the methodological details of this mini-study and the results of the analysis.

Corpus selection and coding procedures

A similar, though far less complicated Systematic Literature Review was undertaken here. The key differences that simplified the process were 1) papers were only drawn from within a single motivating research question (i.e. *Q4: How can we use technology to foster environmentally responsible behaviour?*; see Figure 2.2), and 2) the scope was narrowed to include only CHI Conference publications. The justification for this narrowing was to twofold: 1) this mini study was the foundation of a publication submitted to CHI, so was tailored for that audience; 2) CHI papers tend to be relatively high impact compared with other venues. Search criteria included the following: a) published between 2007 and 2012; b) must be a CHI publication; c) matching the search string (persuasive + technology + environment); d) must focus on fostering environmentally responsible behaviour and propose design criteria.

For this corpus, *only the values that the authors explicitly designed for were coded positively*, the rationale being that these represented the values that the authors aimed to 'activate' in the user of the technology. This meant that any values that the authors may have demonstrated themselves but did not appeal to in the user were excluded from the analysis. This difference in coding rules is significant, because it means that the results of the two analyses (Figures 3.5 and 3.6) cannot be compared side-by-side. Nonetheless, this somewhat different analysis contributes important information for understanding the nature of Sustainable HCI on the whole, as different from Green IT.

Results of the Persuasive Technology sub-corpus analysis

The analysis showed that the most commonly activated value was 'Successful', found in 71% of the corpus. Usually this manifested in the technology incorporating some element of competition or facilitating a sense of having 'won' or 'improved'. The next most commonly activated values were 'Wealth' and 'Intelligent', both in 54% of the corpus (though not always the same papers). 'Wealth' was activated in most cases by displaying energy savings in the form of financial savings to the user; 'Intelligent' was activated when designs aimed to provide the user with more information with which they could make more 'rational' and presumably more environmentally sound decisions. Following closely behind these with 50% was 'Protecting the environment', which was coded in instances when the designer tried to communicate to the user through the technological intervention that protecting the environment is important and worth doing. Other values strongly appealed to

Table 3.3: Results of values coding (selective list), Persuasive Technology corpus

Value	**%**	**SE**	**ST**
Successful	71	X	
Wealth	54	X	
Intelligent	54	X	
Protecting the environment	50		X
Preserving my public image	42	X	
Social recognition	42	X	
Enjoying life	29		
A varied life	25		
Responsible	25		X
A sense of belonging	25		

include 'Preserving my public image' and 'Social recognition' (42% each, with 90% overlap in papers) — which are both to do with extrinsic rewards and praise, and were coded, respectively, when designs enabled social judgment as a deterrent for environmentally irresponsible behaviour, and when environmentally responsible behaviour was made visible to user's peers as a means of motivating and rewarding that behaviour. Another 29% of papers activated 'Enjoying life', aiming to make the persuasive technology fun as a means of engaging users; and related to this, 25% activated 'A varied life' by seeking to maximise the technology's novelty in order to entice users. And 25% activated 'Responsible' — by seeking to enable accountability — and 'A sense of belonging' — often by enabling connections between other users of the system.

By far, the types of values most frequently appealed to were Self-Enhancement values, namely Achievement and Power values, which collectively were indicated 76 times in the corpus of 24 papers. In contrast, Self-Transcendence values (Universalism and Benevolence) were indicated a mere 22 times, i.e. less than once per paper. The results of the analysis are visualised in Table 3.3 and Figure 3.6.

3.4.3 Discussion of Persuasive Technology sub-corpus

Th Sustainable HCI values analysis validates and enhances the discourse analysis presented in Chapter 2. Below, the values analysis is discussed in terms of some of the discursive characteristics of Sustainable HCI (as summarised in Table 2.2.4).

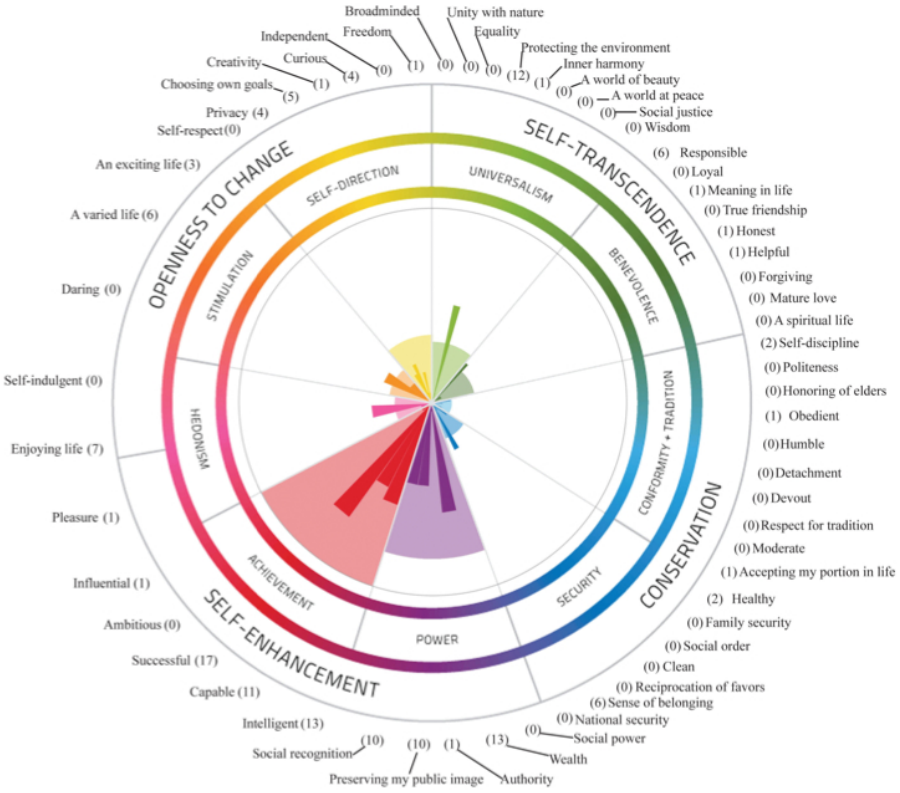


Figure 3.6: Relative weightings of values found in the Persuasive Technology corpus, overlaid onto the Schwartz Circumplex as adapted in Holmes et al. (2011). Darker segments indicate the percentage of papers in the corpus in which a particular value was activated; lighter segments represent the total incidents for a particular value type on a scale of 42 (the highest total found).

Designers motivated by 'feel good' factor and best interest of all In contrast to the discourse isolated in the Green IT analysis, Sustainable HCI discourse speaks more directly to fellow academics and designers. The analysis of the Sustainable HCI corpus demonstrates how Sustainable HCI is discussed amongst peers in the community. The nearly ubiquitous activation of 'Protecting the environment' (89%) indicates that the researchers view environmental concerns as a powerful motivator of their work; and the relatively high activation of 'Responsible' indicates that this work is seen as the fulfilment of a sense of duty. The noticeable lack of 'Obedience' activation indicates the fact that government is not an important entity within the discourse.

Consumers motivated by self-interest, under-informed The Persuasive Technology sub-corpus demonstrates how Sustainable HCI is implemented and 'sold' to

the public. Crucially, *these publications contain rather different values content* than those seeking to articulate or contribute to a Sustainable HCI agenda. Amongst Persuasive Technology publications, a range of SE and Openness to Change values are appealed to — 'Wealth', 'Preserving my public image', 'Social recognition', 'Enjoying life' and 'A varied life' — in order to entice consumers to engage in less environmentally damaging activities by finding some other personal benefit of doing so (e.g. money, status, fun). The high activation of 'Intelligent' demonstrates the assumption that these ostensibly rational consumers would be better able to determine their own self-interest if given more information.

Subordination of human nature The activation of 'Influential' and 'Capable' within the larger Sustainable HCI corpus serves to reinforce the belief that designers of technology have the power to influence human behaviour, and the activation of 'Ambitious' and 'Successful' serves to inspire these designers (and researchers exploring such designs) to use these techniques for the good the society.

Digital Economy Despite the explicit concern that the Digital Economy is complicit in driving 'unsustainable' patterns of consumption, there is no real challenge to these profit-driven foundations, as Sustainable HCI still legitimises its academic quest in financial terms (50% activate 'Wealth').

Instrumentally Valuable Environment Although 'Protecting the environment' is highly activated in Sustainable HCI, most often it is linked with self-preservation, as evidenced by the high activation of 'Health'. In other words, the message is that 'protecting the environment is good because if we don't protect it, our health is threatened.' Environmental protection is also strongly linked with another Security value, 'A sense of belonging', which functions to make that argument that 'protecting the environment is good because I am responsible for the security of others in my group, who might be threatened by environmental destruction.' This is closely linked with the activation of 'Responsibility', 'Equality' and 'Social justice', which effectively extend the circle of compassion further afield: 'protecting the environment is good because people around the world will suffer from environmental destruction.' Notably, this is a very different argument than 'protecting the environment is good because the environment is intrinsically valuable.'

Reassurance and motivation What these arguments serve to do, however, is to motivate protection of the environment *by making an environmentally based argu-*

ment — something that Green IT generally does not attempt — and imbues the mission with a sense of urgency.

3.4.4 Sustainable HCI values analysis conclusions

At a first glance, the data gleaned from the Sustainable HCI corpus (Figure 3.5) is significantly better balanced than that from the Green IT corpus, with Self-Transcendence values strongly activated, if only somewhat less than Self-Enhancement values. And while values researchers disagree about the effects of Self-Direction (type) values on pro-environmental and pro-social behaviours, because of their proximity to Universalism values on the circumplex, there is some possibility that their activation might have positive bleedover effects for these desired behaviours. At the very least, it cannot be argued that the strong emphasis on Self-Direction values undermines the 'sustainability' aims of Sustainable HCI. What it does indicate, instead, along with the more broad activation of both Universalism and Benevolence values, is a stronger focus on the many facets of human nature — which is, historically, a particular strength of HCI research.

It is certainly important how Sustainable HCI researchers justify their work, but what is most interesting of all is how these ideas manifest in design, for example, in the development of persuasive technologies. But, in fact, the significant differences in the shapes of Figures 3.5 and 3.6 indicates that Persuasive Technology does not 'sell' itself in terms of the same motivators as Sustainable HCI, making it problematic for the larger Sustainable HCI discourse in which is has historically found a home. While the aim of these persuasive technologies is to motivate users to adopt more pro-environmental behaviours, the central design challenge is understood to be *how to engage people in pro-environmental behaviour when they do not really care about the environment*. The strategy is to appeal to people as *consumers*, and use extrinsic rewards as incentives (*Self-Interest* frame) to adopt behaviour that the 'consumer' need not embrace as inherently worthwhile in order to still have the desired behaviour change effect. To accomplish this, researchers adopt a strategy of matching the technology's feedback to users' inherent or baseline motivations[13]. Most often this means presenting financial savings alongside some measurable proxy for environmental impact (e.g. Watts, CO_2 emissions). There is some evidence to suggest that providing people with multiple motivations increases the likelihood that individuals will adopt a particular target behaviour (Crompton &

[13] For example, for people who care about saving money, the design implication is to provide feedback in financial terms; for people who care about their fitness, provide them feedback about how many calories they burn by bicycling rather than driving to work (cf. He et al., 2010).

Thøgersen, 2009), and indeed many of these Persuasive Technology studies reveal evidence of positive behaviour change, at least in the short-term.

But if the larger ambition of persuasive technology is to encourage *lifestyle change* — in other words, 'positive spillover' — research shows that *offering mixed motivations is unlikely to lead people to spontaneously adopt other pro-environmental behaviours* (Evans et al., 2012; Crompton & Thøgersen, 2009). The implication for Persuasive Technology, therefore, is to consider whether promoting the increased adoption of a target behaviour through appealing to Self-Enhancement values can be said to be an overall environmental 'win' if the effects of doing so may in fact be 'negative spillover', i.e. a decrease in pro-environmental sentiment that leads to fewer spontaneous pro-environmental behaviours.

This really comes down to a question of the long-term goals of Persuasive Technology (and as long as it is embraced by Sustainable HCI[14], this includes the long-term goals of Sustainable HCI more broadly), which are not adequately addressed in the literature. Is the goal to manipulate people into doing what is best for the environment despite any apathy? Or is the ultimate goal to change the values and attitudes that lead to environmental destruction? If the goal is the former, Persuasive Technology is resigned to forever chasing its own tail, as each SE-based intervention reifies the motivations that produce the environmentally destructive behaviours in the first place. Instead, persuasive technologies could address the *cause* of unsustainable behaviour by seeking to make Self-Transcendent values such as protecting the environment (and social justice) more salient. The persuasion challenge then is not *how to engage people in pro-environmental behaviour when they do not care strongly about the environment*, but rather *how to get people to really care about the environment and their fellow humans so that they willingly choose to engage in pro-environmental behaviour*. In other words, the goal would be to facilitate a shift in values, rather than a shift in behaviour. Notice then that the challenge of how to keep users engaged is no longer relevant.

It is worth noting that a small number of the Persuasive Technology publications challenged the idea of presenting users with positive feedback as a means of incentivising behaviour change. Two alternative approaches include aversive feedback (Foster et al., 2011; Kirman et al., 2010) and indirect persuasion (Aleahmad et al., 2008). Neither of these, however, adopt a Self-Transcendence-based approach. In the case of Foster et al. (2011), the aversive feedback was in the form of negative social judgments by peers — i.e. 'Saving public face', a Self-Enhancement value. And the proposal by Kirman et al. (2010) to motivate behaviour change

[14] Note that Sustainable HCI is increasingly arguing for a need to move beyond Persuasive Technology research.

through punishment is merely a twist on Self-Enhancement (or in this case, more accurately 'extrinsic') motivation — i.e. people are motivated *not* to receive the *opposite* of rewards and praise. The approach taken by Aleahmad et al. (2008), in contrast, is to conceal the underlying environmental motivations of the persuasive technology, the logic being that individuals are resistant to direct persuasion.

The key point is that these aversive and indirect approaches to persuasion adopt the same overarching tactic of persuasive technology, namely *to avoid environmentally based motivation* — notably the opposite of the larger Sustainable HCI discourse. As a result, the users of these persuasive technologies are not engaged in environmentally-based behaviour change, but rather are engaged in Self-Enhancement-based behaviour change. This means, therefore, that there is not only tremendous opportunity but also *very real need* for radically different persuasive technologies that are environmentally and socially (i.e. *intrinsically*) grounded.

3.5 Implications for Green Computing

So far in this chapter, Green IT and Sustainable HCI have been analysed separately to determine the differences between these discourses as they relate to the analysis in Chapter 2. But given that the line between the two is blurred, and that this dissertation aims to understand the breadth of current Green Computing research on the whole, it is also important to analyse the values of Green Computing as indicated by the values content of the entire corpus of 65 systematically selected papers[15]. It has already been noted that there are many more Green IT papers in the corpus than Sustainable HCI papers, so the shape of the model is skewed heavily towards Green IT values activations. Importantly, however, while researchers may see the distinction between Green IT and Sustainable HCI as significant, the people at whom these discourses are aimed may not recognise these subtleties. The values people (at least those in the research community) associate with Green Computing, therefore, are going to be the values activated by the highest impact (e.g. the most cited) research, as depicted in Figure 3.7.

Overall, this analysis affirms what Common Cause researchers have been arguing in the context of NGOs: that well-meaning organisations that are trying to find

[15] As previously noted, due to methodological differences, the Persuasive Technology sub-corpus analysis cannot be combined with the rest of the analysis.

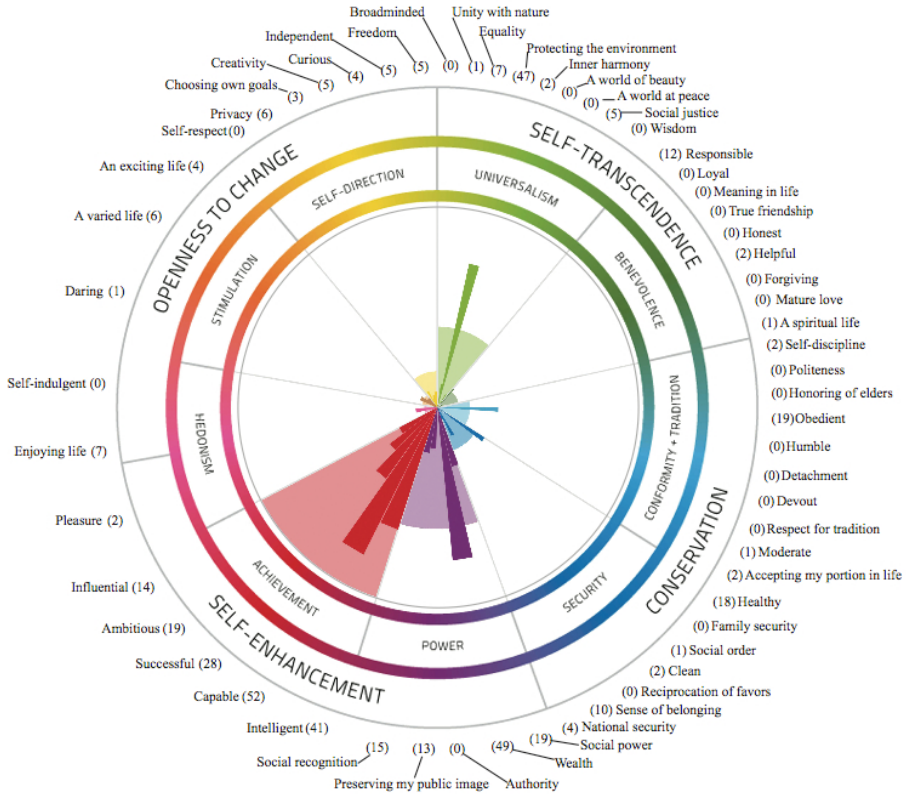


Figure 3.7: Relative weightings of values found in the Green Computing corpus (Green IT and Sustainable HCI corpora combined), overlaid onto the Schwartz Circumplex as adapted in Holmes et al. (2011). Darker segments indicate the percentage of papers in the corpus in which a particular value was activated; lighter segments represent the total incidents for a particular value type on a scale of 154 (the highest total found).

solutions for sustainability borrow assumptions from marketing that focus on Self-Enhancement values (cf. Crompton, 2008). The marketing strategy of *matching* to consumer (i.e. generally SE) values might work in instances where the target behaviour is itself motivated by SE values — such as selling shoes, for example; but this strategy does not make sense when the target behaviour is motivated by Self-Transcendence values, as is the case with protecting the environment, because it tends to lead to negative, rather than positive, spillover into other necessary pro-environmental behaviour change. Indeed, *this highlights a critical tension within the Triple Bottom Line construction of 'sustainability' underpinning Green Computing* — namely that economic aspects of sustainability tend to be motivated by Self-Enhancement values, whereas environmental and social aspects tend to be motivated by Self-Transcendence values. Given that values research suggests that mixed-motivation (ST *and* SE) appeals are far less successful than single-

motivation (ST *or* SE) appeals at producing desired behaviour (see again Evans et al., 2012), Green Computing may have to consider the degree to which the economic bottom line ambitions contradict and ultimately hamper its ability to make a positive impact for the environment and for social justice.

Furthermore, the kinds of pro-environmental behaviours Green Computing discourse is likely to encourage are the easy and relatively insignificant ones. If there is a strong political message to be gleaned from Green Computing discourse, it is the assertion that small changes by a lot of people amounts to big change — that the key to realising a sustainable future is for everyone to adopt slightly more efficient technology and to use technology to encourage small behaviour changes. But to quote Crompton & Thøgersen (2009):

> *The comfortable perception that global environmental challenges can be met through marginal lifestyle changes no longer bears scrutiny. The cumulative impact of large numbers of individuals making marginal improvements in their environmental impact will be a marginal collective improvement in environmental impact. Yet we live at a time when we need urgent and ambitious change* (p. 6).

Persuasive technologies typically target behaviours that contribute only very minimally to any CO_2 footprint (e.g. Kuznetsov & Paulos, 2010; Miller et al., 2009; Pace et al., 2007). Even household electricity monitoring interventions (Kjeldskov et al., 2012; Patel et al., 2010; Foster et al., 2010; Petersen et al., 2009) are likely to yield only small reductions in energy usage — though notably, no instances were found where specific energy targets were explicated. One of the problems of the Green Computing discourse, then, is that in trying to 'sell' itself, it appears to greatly overestimate (and overstate) the potential impact it will have on the environment. Even ignoring the effects of negative spillover (and ignoring other rebounds; see 'rebound effect' in Glossary, Appendix A), Green Computing would certainly not be sufficient for producing a truly 'sustainable' society[16]. But the discourse effectively commoditises 'sustainability' — making it purchasable in the form of Green ICT, persuasive apps, etc — and in the process both 1) reifies consumerist tendencies that have driven much of the environmental destruction to date, and 2) absolves individuals from having to make more significant behaviour changes.

The takeaway message of the values research referenced in this chapter is that it is essential to insist on making environmentally based (and perhaps also socially based) arguments for behaviour change in order to produce positive spillover

[16] 'Sustainable' environmentally or otherwise.

towards additional and greater behaviour changes. In addition to *matching*, the major strategic error by Green Computing is what might be called 'designing to the barrier'[17]. This values analysis reveals that Green Computing demonstrates a concern that certain factors act as barriers to realising pro-environmental behaviour. Identifiable barriers include 1) overpowering financial motivations, 2) low boredom threshold, 3) the ease of behaving unsustainably, and 4) environmental apathy. In the case of the first 3 of these, Green Computing researchers have tailored their 'sales pitch' to appeal to — and hence minimise — these barriers to behaviour change. Meanwhile, environmental apathy is presumed unchangeable and is not even addressed.

This suggests that a strategic adjustment needs to be made, whereby environmental apathy becomes the central target of Green Computing. This entails a shift from problem-led design — i.e. 'designing to the barrier' — to *issue-led* design, the issue being the detrimental effects of environmental apathy. This alternative approach might be called 'designing to the value', and while this may be done with an *awareness* of the barriers, these barriers should not become the super-ordinate factors.

What this means in terms of discourse as well is that researchers need to strongly communicate the reasons why protecting the environment is inherently worthwhile, and to make this the rhetorical focus. In practice, this means researchers not being constrained by what they think they should be saying (particularly because these assumptions are incorrect from a values perspective). After all, if protecting the environment is important for the researcher, chances are it will be important for others. And if protecting the environment is worth doing — if Green Computing is in fact worth doing — researchers ought to make it clear to others precisely why this is so.

In summary, this argument does not imply that Green Computing researchers are not trying to protect the environment. Instead, the argument is that despite the best of intentions, current Green Computing research may be counter-productive. What is missing in Green Computing is an understanding of the importance of values. In short, Green Computing is 'missing the point' — that significant pro-'sustainability' behaviour will only be fostered by linking this behaviour with values that are proven to lead to subsequent pro-environmental *and pro-social* behaviour. Manipulating people into performing supposedly 'positive' behaviours by enticing them with extrinsic rewards may result in short-term environmental wins — though usually making an exceptionally minimal impact — but in the long-term makes it

[17] This phrase is borrowed from Greg Maio, in a discussion at the Values and Frames Workshop, Lancaster University, 13/6/12.

less likely that they will engage in subsequent pro-environmental behaviours (and does nothing to engender pro-social behaviour). A more effective strategy, according to values research, would be to engage people in the Self-Transcendence motivations for 'sustainability' in order to foster positive spillover to many subsequent pro-'sustainability' behaviours, the effects of which cumulate over time.

3.6 Conclusion

The careful analysis of Green Computing discourse in Chapter 2 might have seemed largely academic, but this chapter shows that discourse — the language used and the messages conveyed — has real consequences for the eventual impact of research. It is important, therefore, that Green Computing craft a discourse that will be effective. This means, for example, if Green Computing seeks to foster pro-environmental behaviour change, that the discourse helps serves this purpose.

This analysis shows that the values being activated by the majority of Green Computing research may be counter-productive to fulfillment of the discourse's environmental and social aims of 'sustainability'. In the case of Sustainable HCI, although the motivations for research tend to be approximately equally Self-Enhancement and Self-Transcendence when discussed amongst researchers, the motivations presented to the public about why they ought to adopt pro-environmental behaviour are almost exclusively Self-Enhancement values. Somewhat ironically, although Green IT has an even stronger emphasis on Self-Enhancement, this may be less detrimental to Green IT's aims than it is to Sustainable HCI's aims, because Green IT aims (in part) to sell a product, and activation of Self-Enhancement values is generally a fairly effective means of marketing. That said, Green IT contributes to Green Computing's problematic emphasis on Self-Enhancement as a justification for what is fundamentally a Self-Transcendence cause. In other words, what Green Computing appears to be trying to convey is *Do what is good for others, but do it because it is good for you.* Of course, people *could* adopt pro-environmental and pro-social behaviour because it is personally beneficial; but this reinforces an attitude of *I will do what is good for others* only *when it is good for me* — which is precisely why Self-Enhancement based arguments for Self-Transcendence causes (the environment, social justice) lead to negative spillover. At a minimum, the call to *Do what is good for others, but do it because it is good for you* is hardly inspirational.

It is worth reflecting, therefore, on the kinds of messages that have historically inspired people to make a commitment to significant and long-term change. It seems that such a message would need to communicate that protecting the environment and pursuing social justice are the unquestionably *right* things to do, above and beyond any calculable economic benefit to consumers — in which case economic concerns ought to be demoted within any notion of 'sustainability', and environmental and social justifications for Green Computing ought to be stated proudly and unequivocally. Such a message would also need to appeal to the best in people — to emphasise how people can be caring and decent, and can unite to overcome enormous challenges[18], rather than how they can be apathetic, cruel, and ineffectual. As this chapter indicates, assuming that people are fundamentally selfish and apathetic has led to the design of persuasive technologies that reify exactly those negative qualities. What would happen, instead, if Green Computing assumes that people are basically well intentioned and want to make the world a better place? This is to be explored further in the Part II.

So far (Chapters 2 and 3), frames and values have been used a) to clarify 'sustainability' ambitions of Green Computing, b) to understand specific areas of Green Computing that need improvement, and c) to envision practical steps that may be taken towards improvement. Throughout, Green Computing has been evaluated on its own terms (i.e. with respect to its own particular orientation to 'sustainability'). In the next chapter, however, this orientation to 'sustainability' is fundamentally challenged, and it is argued that the frames underpinning Green Computing serve to limit its potential to make a significant, positive impact on 'sustainability' issues such as protecting the environment and ensuring social justice.

[18] cf. Norhaus & Shellenberger, 2009.

Chapter 4

Framing ‘Sustainability’

Understanding the worldview underpinning Green Computing

Introduction

In Chapter 2, key frames were identified within competing ‘sustainability’ discourses generally and within Green IT and Sustainable HCI discourses specifically. So far, these frames have served descriptive purposes, enabling the classification of Green Computing discourses as predominately imaginative/reformist. As this chapter will show, however, there are important implications of these frames, both in terms of the solution space they prescribe and in terms of associated values they either reinforce or diminish.

The first part of this chapter (4.1) argues that these frames — *Rational Actor, Self-Interest* and *Free Market* — are manifestations of a particular mode of thinking emerging in Modernity and carried over into Post-modernity, and therefore can be critiqued within the wider critique of these worldviews. The subsequent section (4.2) applies these same critiques to Green Computing specifically, showing that its Modernist understandings of ‘humans’ and ‘sustainability’ serve to narrow the types of Green Computing solutions and limit the perception of viable points of intervention for ‘sustainability’. It is shown (4.3) that the frames themselves, which underpin Green Computing, not only contribute to these limitations, but also appear

to reinforce the logic behind the Self-Enhancement based strategy that Chapter 3 showed was hindering Green Computing's success with respect to the stated goals of the discourse.

4.1 Limitation of a modernist approach to 'sustainability'

Modernity is a term used to describe a particular historical era and the worldview that dominated during that era[1], and to describe something as 'modernist' is to suggest that it fits within this worldview[2]. The discussion here serves to contextualise Green Computing's key frames within a broader Modernist critique, and explore how Green Computing's understanding of the 'sustainability' problem and its modes of addressing this problem (e.g. efficiency improvements and behaviour change) are intertwined with the (potentially problematic) Modernist worldview carried over into our Post-modern age. The notion of 'reification' is introduced to contextualise the dominance of the *Rational Actor* and *Self-Interest* frames, and critiques are presented regarding the ways in which Modernist approaches tend to narrow and limit 'sustainability' solutions.

4.1.1 An economic lens on the world

Within the *Rational Actor/Self-Interest* framing of 'the human' identified as underpinning Green Computing, 'rationality' is understood as the mental process by which a person arrives at an optimal decision. There are two modernist assumptions at the heart of this definition, namely that a) an optimal decision exists (as a 'truth') external to the individual (Rational Choice Theory; see Coleman, 1993), that is waiting to be discovered through 'rational' processes, and b) 'optimal' is understood as meaning the maximisation of personal benefits and minimisation of

[1] The term also applies to holdovers from this era that are observable in its supposed successor, Post-modernity.

[2] There are numerous facets of modernity that one can discuss, such as: a) the prevailing economic model of Western capitalism (cf. Weber, 2004), b) the industrialisation of modes of production (cf. Thoreau and others), c) the emphasis on individualism (cf. Heidegger, 1977), d) the dominance of a materialistic interpretation of 'reality' (cf. Husserl, 1931), and e) the rejection of traditional (including religious) ways of knowing and the secularisation of society (cf. Fackenheim, 1967; Walker, 2011).

personal costs (Darnton & Kirk, 2011: p. 83). This latter assumption, which presupposes the *Self-Interest* frame as integral to human rationality, is evidence of what Lukács and others have called 'reification' of the capitalist system:

> *Just as the capitalist system continuously produces and reproduces itself economically on higher and higher levels, the structure of reification progressively sinks more deeply, more fatefully and more definitively into the consciousness of man* (Lukács, 1971: p. 93).

In other words, economic models have so permeated society (cf. Michaels, 2011) that we have eventually come to understand all things, including people, in terms of these models. As Dourish (2010) notes, this reification works, in part, by obscuring the truth that these frames — which are taken for granted as 'natural facts' — are socially constructed, and therefore, contestable. Three salient points regarding this reification are described below.

1. *Rational Actor* and *Self-Interest* frames are themselves framed by the *Free Market* frame. The dominant model of modern (Western) capitalism is that of the free market[3], which holds that the economic system functions to generate benefits to all through the mechanism of individuals' drive for rational maximisation of self-interest. This is captured, for example, by Adam Smith's famous statement, 'It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their own interest' (Smith, 1976: Book I, Chapter II). As Mill famously argues, capitalist society, 'is concerned with [man] solely as a being who desires to possess wealth, and who is capable of judging the comparative efficacy of means of obtaining that end' (Persky, 1995: p. 223). He concludes, therefore, that the ideal human for capitalistic societies, the one who will produce the greatest wealth, is the Economic Man[4] who 'rationally' pursues his interests of accumulation, leisure, luxury and procreation (ibid).

This characterisation of Economic Man demonstrates the way in which the *Free Market* frame serves to contextualise — and, indeed, *frame* — our Modernist understanding of the nature of humans (Figure 4.1). This becomes a self-fulfilling

[3] To distinguish the economic model from the frame, free market is lower-case and non-italicised when describing the economic model.

[4] Note:

> *While John Stuart Mill is generally identified as the creator of economic man, he never actually used this designation in his own writings. But the term did emerge in reaction to Mill's work. In its first appearances in the late nineteenth century, 'economic man' carried a pejorative connotation reflecting the widespread hostility of the historical school towards Mill's theoretical abstractions. Economic man also raised the indignation of Victorian moralists shocked at the postulation of such blatant selfishness* (Persky, 1995: p. 222).

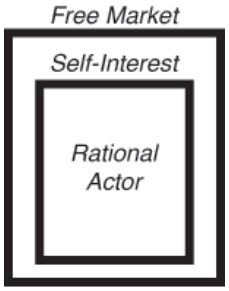


Figure 4.1: The Modernist framing of human rationality within an economic logic.

prophesy in two respects. Firstly, in a society that functions (according to the *Free Market* frame) when people are rationally self-interested, the fact that our economic system continues to function affirms the *Rational Actor/Self-Interest* framing of humans. Secondly, such a society would ostensibly reward such tendencies, meaning that the *Free Market* in turn helps shape people into Economic Man.

2. The economic bottom line frames the environmental and social bottom lines. Neo-liberalism, the brand of economic thinking that came into prominence in the 1980's, takes the self-interest-based *Free Market* model to its logical conclusion, and 'places economic prosperity ahead of other political goals (such as equality or social justice), arguing that, in the presence of an unfettered market as a regulative regime, these other issues will be outcomes of market forces that ensure "the greatest good for the greatest number of people"' (Dourish, 2010). This helps explain why the Triple Bottom Line of 'sustainability' has come to be dominated by economic concerns, as criticised by Davison (2001) and others (see Section 2.1.2). In values terms, the cultural influence of this reification is constantly working to foster Self-Enhancement values and undermine Self-Transcendence values. Together, this reinforces the importance of economic concerns, which Section 3.5 showed are linked with SE values; meanwhile, environmental and social concerns, which would be reinforced by ST values, are not amplified by this cultural influence (Figure 4.2). In other words, just as we come to view one another in economic terms, we come to view 'sustainability' through an economic lens, such that what we mean by 'sustainability' is understood with respect to a functioning (growing) economy — i.e. a 'sustainable' contribution that benefits the environment or social justice is only viable when it also contributes to economic growth.

3. This all functions to narrow one's 'vision'. On the one hand, Modernist approaches function by constraining one's solution space to reveal manageable

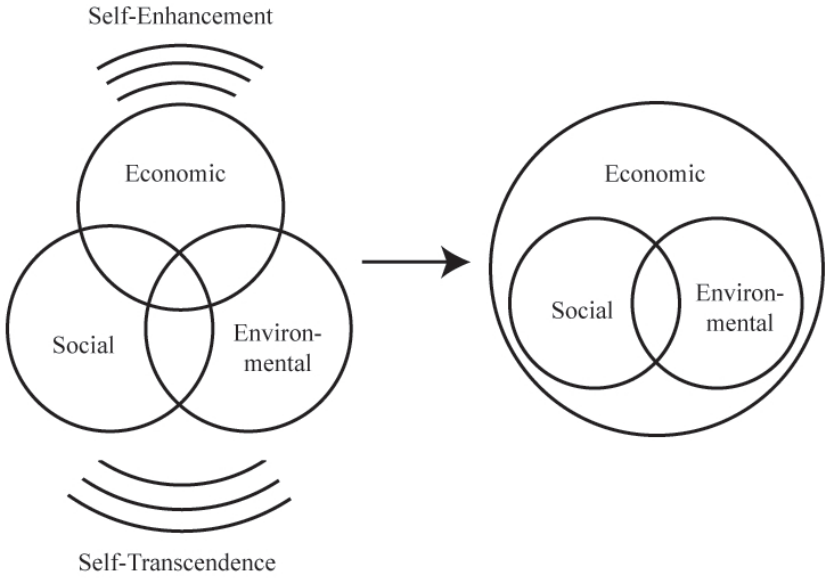


Figure 4.2: The values dynamics within the Triple Bottom Line. Environmental and social aspects of ‘sustainability’ align with and can be made more salient by activation of Self-Transcendent values, while economic aspects of ‘sustainability’ align with and can be made more salient by activation of Self-Enhancement values; meanwhile capitalist society disproportionately reinforces and rewards Self-Enhancement values, causing economic concerns to eventually subsume environmental and social concerns.

problems, giving researchers a clear target for intervention (cf. Scott, 1998). Yet as practical as this narrowing may be for making initial progress, ‘those solutions tend to break down in the face of ecological issues outside of the “selective reality” constructed through the problem framing’ (Brynjarsdóttir et al., 2012).

As the previous points illustrate, reification of the free market model narrows our understanding of ‘the human’, to account for only those qualities that fit with the *Free Market* (i.e. people as rational and self-interested), and also narrows our understanding of ‘sustainability’, to entertain only those solutions that contribute to, or are consistent with, economic growth. As a result, any intervention for ‘sustainability’, such as those that the discipline of computing might contribute, are premised in a narrow and necessarily *incomplete* understanding of a) the people who use these technologies, b) the ‘sustainability’ problem to be addressed, and c) which elements of society are changeable as part of a ‘sustainability’ solution.

The sections to follow will elaborate the ways in which this narrowing influences Green Computing specifically, and how it commits researchers to a program of intervention that is unlikely to make a significant change towards realising their

'sustainability' goals.

4.2 Limitations of Green Computing

Within Sustainable HCI, Brynjarsdóttir et al. (2012) identify the ways in which persuasive technology embodies four key modernist values (*calculability, efficiency, predictability* and *control*). They also identify three modernist axioms to which persuasive technology ostensibly adheres:

> *(1) trust in technoscientific reasoning and top-down, expert knowledge as a way to organize our lives; (2) orientation around means-end thinking, maximizing efficiency, and exerting control as ground principles to optimize everyday practices; and (3) trust that formal, rational methods capture essentially everything that matters about a given situation* (ibid: p. 950).

Dourish (2010) makes a similar observation about Sustainable HCI more broadly, arguing that while it may be a product of a Post-modernist age, it retains characteristically modernist tendencies such as, 'faith in technoscience — both in the authority of sciences such as botany and Earth systems science to analyze and understand the environment, and the transformative potential of new technology to change both the environment and our place within it'. As much as Sustainable HCI is a modernist discourse, however, Green IT is even more recognisably — and less reflectively — modernist, most evident by its clear focus on efficiency.

Below, several new critiques are posited regarding the influence of this modernist orientation on the ultimate success of Green Computing. It is argued that the dominant approaches, i.e. consuming more efficiently and consuming less, fail to take into account various factors that work to limit the impact of proposed solutions.

4.2.1 Consuming efficiently

The logic of efficiency is so embedded into modern society as to make it seem unquestionably correct: it makes sense to use the least amount of resources necessary for any given task. This logic, however, is an emergent property of what

Weber (2004[5]) described as 'the spirit of capitalism', which understood the '[w]aste of time [as] the first and in principle the deadliest of sins' (p. 104). Such productivity is embodied best by the Taylorism of the late 19th Century, which sought to improve the efficiency of labour. Given that more and more machines are doing our labour for us, it makes business sense, too, to ensure that these machines are working as efficiently as possible.

The question is, does efficiency make *environmental* sense? Specifically, does more efficient use of environmental resources lead to overall reductions in the usage of these resources? Berners-Lee & Clark (2013) argue that history has shown the opposite, that efficiency improvements invariably lead to an approximate average 1.8% *increase* in resource usage[6]. Their explanation of this apparent paradox is as follows:

> *When we improve energy efficiency, we make energy more productive, because each drop of oil or lump of coal can do more work. As a rule, making something more productive make it more valuable and that in turn means we use more of it. Think of it this way: if it took a tonne of coal to keep a household warm for a night, or a barrel of oil to drive to the shops, we probably wouldn't bother with fossil fuel at all* (p. 48).

In other words, the notion that efficiency necessarily leads to reduction in environmental impact only makes sense if economic drivers of consumption are ignored. To the extent that efficiency makes fossil fuels more valuable, this contributes to the fear that serious regulation to avert climate change would be economically catastrophic, making it less likely that policy makers will be willing to take necessary steps to protect the environment (ibid: p. 63).

Similarly, this externalisation of economic factors obscures the important fact that 'every penny or cent saved on energy becomes available for spending on something else — and that spending also has an energy impact' (ibid: p. 52). This rebound effect relates to the 'positive' and 'negative spillover' of Chapter 3: 'If they saved the energy as part of a conscious effort to be green, they'll be far more likely to use the savings in a low-carbon way. If they did it purely for financial gain they might spend the savings on something energy-intense' (ibid: p. 52).

The most damning of all critiques of Green Computing efficiency improvement efforts, however, is the fact that efficiency savings by a single individual or business

[5] Originally published 1905.

[6] According to a personal email correspondence with Mike Berners-Lee (24 June 2013), 'One way of putting it is that the sum total of the rebound effects from all technological developments is 101.8% per year'.

(or even country) do not have a direct effect on the environment. As Berners-Lee & Clark explain,

> *Across the EU, emissions of power plants, steel mils and other big industries are capped as part of the European Trading Scheme (ETS). Because the total carbon output is fixed in advance, it doesn't necessarily cut any carbon when we save electricity in our homes and offices. Instead, any permits saved by the local power station can be sold for use in a car factory or steel plant elsewhere in the continent and total emissions remain unchanged. But even if the ETS was well designed and ambitious (which it isn't), a regional carbon cap wouldn't deal with the carbon flows between nations in the form of fuels and goods. To work, we need the cap to apply globally* (ibid: p. 62).

In conclusion, selling more Green IT is not sufficient. In order for Green Computing's efficiency efforts to make a positive environmental impact — i.e. rather than contributing to rebound effects — it would be necessary to use these savings 'as an enabler for tightening up global regulation on fossil fuel use' (ibid: p. 62). Specifically, this means that for Green Computing to be successful, *it must become involved in the politics of climate change*, working with governments to increase efficiency *alongside* stronger emissions regulations. But as argued in Section 3.3.3, while Green Computing's strategy of appealing to Self-Enhancement values may work as an advertising campaign, it fails as a political campaign, reinforcing values that erode concern for 'sustainability' issues. As part of becoming politically involved, therefore, Green Computing needs to contribute to the activation of Self-Transcendent values that will build political will to make difficult global policy changes.

4.2.2 Consuming less

The above approach assumes that current levels of consumption are likely to continue, or even increase, in the future, and that therefore it is necessary to make consumption activity less 'costly'. In contrast, the primary strategy of Sustainable HCI is to develop tools that motivate and enable consumers to consume less — less energy, less IT, and in some cases, less of other resources and commodities. As Dourish (2010) notes, this approach reveals an underlying acceptance of market models for human behaviour, whereby 'sustainability' is framed 'as an issue of personal choice for rational actors — an instance of an economic rationality of costs and benefits'.

According to this framing, the brain is analogous to an input/output machine, whereby the brain interprets data input by running it through all of the possible actions one could take, locates the most beneficial and cost-effective action out of these choices, and then outputs that optimal behaviour (Figure 4.3). Persuasive technology interventions attempt to modify consumers' behavioural outputs by intervening at the point of informational input, specifically by providing consumers with greater information (assumed previously inaccessible) about how their consumption impacts the environment and other people, and/or how 'greener' consumption would be personally beneficial to them. This explains why most persuasive technologies serve both of these purposes simultaneously, by displaying information about the environmental impact of various behaviours, expressed in terms of how much money this costs the consumer.

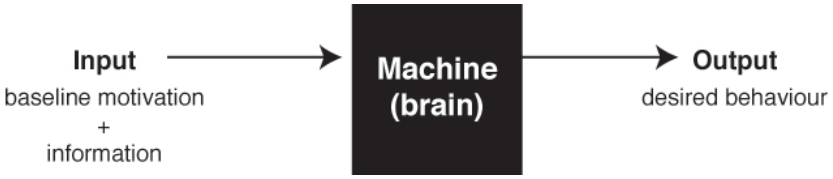


Figure 4.3: Input/output machine metaphor underpinning Green Computing behaviour change strategies.

While this input/output model of the brain fits with modernist framings, it does not fit cognitive psychology research. This research (Lakoff, 2008; Westen, 2007) shows that rationality is inherently 'irrational', in the sense that so-called 'rational' decision-making a) is only possible due to emotions, values and metaphors, and b) does not necessarily serve to maximise personal benefits[7]. Understanding people to be rationally self-interested, when in reality they are not, consistently limits the effectiveness of progressive political campaigns (ibid), and may similarly reduce the impact of Green Computing. As long as people are understood to be rationally self-interested consumers in a free market, Self-Enhancement based strategies will appear justified. Fostering 'positive' (Self-Transcendence) values, therefore — and indeed, even *recognising* that activating these values would be beneficial for realising behaviour change wins — would require fundamental re-framing within Green Computing. In other words, this narrow conception of the brain as an input/output machine obscures the important influence of values on behaviour, and seemingly justifies Green Computing's Self-Enhancement based motivational strategy for behaviour change.

Furthermore, as important as consumer behaviour is to the health of the environ-

[7] For example, polling studies repeatedly show that self-interest is a poor predictor of voting behaviour (Westen, 2007: p. 120).

ment, it is only one aspect of a more complicated feedback mechanism for increased carbon emissions. 'What is too often missed,' write Berners-Lee & Clark (2013), 'is the need to put downward pressure on supply as well as demand' (p. 54). This criticism is shared by Dourish (2010) who argues that focusing at the level of consumption and consumer choice 'may obscure the broader political and regulatory questions that attend significant change'. This also excludes considerations such as the economic incentives to design for obsolescence, the incessant barrage of advertisements that produce dissatisfaction as a means of spurring consumption, and the societal pressures that make consumption appear to be a necessity of modern life.

In conclusion, in narrowing Green Computing to a problem of consumption, the discourse has devoted itself to making only a very limited impact. Even the most optimistic assessments of the potential impact of behaviour change *combined with* efficiency improvements estimate a final impact of 0.6% reduction in global energy emissions[8] (Mankoff, 2012). Given that the average emissions growth has been around 1.8% per year for the last 160 years (Jarvis et al., 2012), and higher recently (2.3% per year from 2000 to 2010 (Berners-Lee & Clark, 2013: p. 13)), not only is Green Computing grossly insufficient for reducing carbon emissions to the levels required to stave off the potential devastation that might occur from a global warming of two degrees Celcius (i.e. 3-4% reductions per year for several decades (ibid: p. 27)), it cannot even stop the rate of carbon emissions from increasing.

4.3 Intervening at the level of frames

The previous sections show that Green Computing's two forms of intervention — intervening after behaviour (consuming efficiently) and intervening just before behaviour (consuming less) — cannot make a significant impact for 'sustainability' if 'sustainability' is understood in large part to mean reducing carbon emissions[9]. This suggests that if Green Computing is going to make a significant environmental impact, a new point of intervention must be identified.

Values and frames research provides some insight here. Behaviour is influenced

[8] Mankoff (2012) notes that the timeframe for these improvement is not known, so this 0.6% emissions reduction may occur in the next ten years, or over a much longer period of time. These figures also appear to externalise embodied carbon footprints related to upgrading to more efficient machines.

[9] While clearly this does not cover all aspects of 'sustainability' for Green IT or Sustainable HCI, carbon emissions play a central role in both discourses.

by and in turn reinforces frames; values are influenced by and in turn reinforce frames; and, as Section 4.1 argued, frames are influenced by and in turn reinforce worldview (Figure 4.4). This means that tying to affect behaviour without affecting the underlying motivations for this behaviour (e.g. values, frames, worldview) is a Sisyphean task: no matter now much progress is made, there will continue to be powerful forces working against 'sustainability' success.

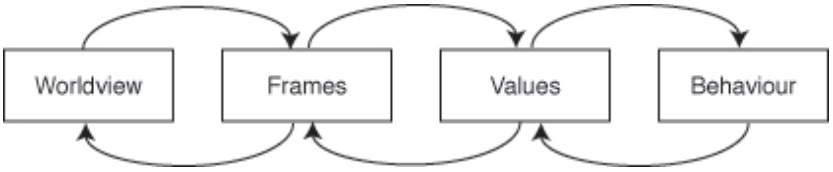


Figure 4.4: Feedback relationships between worldview, frames, values and behaviour.

Imagine these different components as carriages of a train, and that train is currently moving in the direction of 'unsustainability'[10] (Figure 4.5). The current Green Computing strategy for reversing that train is to put brakes on behaviour, while accelerating the (Self-Enhancement) values currently pushing it forward. In this scenario, the best result that one can hope for is that the brakes and acceleration cancel each other out, and that the train continues to move towards 'unsustainability' at the same speed.

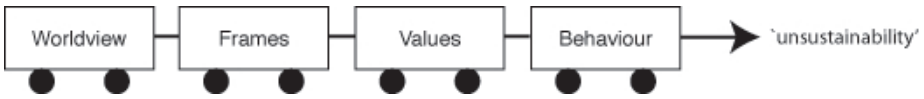


Figure 4.5: The factors propelling 'unsustainability'.

If, on the other hand, Green Computing attempts to slow the train by putting brakes on behaviour while also putting the values car in reverse (i.e. accelerating on *Self-Transcendence* values), the train will still move towards 'unsustainability' due to the force of the frames and worldview cars, but would progress more slowly. But if an intervention occurred further back, could the direction of travel of this train be reversed? In order to answer this question, it is necessary to understand the current contribution of frames towards 'unsustainability', specifically *if and how frames are reinforcing negative values and/or contributing to Green Computing's Self-Enhancement based strategy.*

A new technique has been developed as part of this dissertation (see Appendix E.1) for determining whether a frame is 'positive' or 'negative'. Recall that 'positive'

[10] This analogy is borrowed from Berners-Lee & Clark (2013: p. 54), who use it in a somewhat different context, i.e. in relation to the driving force of extraction, combustion and consumption.

values are conducive to desired behavioural outcomes — in this case pro-'sustainability' (or at least pro-environmental and pro-social) behaviours, and 'negative' values are not shown to contribute to these desired behaviours, and are indeed correlated with 'unsustainable' behaviours. Similarly, 'positive' frames are defined here as specific orientations to the world that are consistent with activation and reinforcement of 'positive' values. 'Negative' frames, on the other hand, are consistent with activation and reinforcement of 'negative' values.

This analysis reveals that the *Rational Actor* and *Self-Interest* frames (when understood in the context of *Free Market*), not only reinforce 'negative' values, but also undermine 'positive' values (see Table 4.1).

Table 4.1: Values related to the Modernist frames

	Consistent (Reinforced?)	**Inconsistent (Diminished?)**
'Positive' values	• **Universalism values:** Protecting the environment	• **Universalism values:** Broadminded, Equality, Social justice, Wisdom • **Benevolence values:** Helpful, A spiritual life
'Neutral' values	• **Hedonism values:** Pleasure, Enjoying life • **Self-direction values:** Privacy, Freedom • **Security values:** Healthy, National security • **Conformity values:** Obedient	• **Tradition values:** Respect for tradition, Devout, Detachment, Accepting my portion in life
'Negative' values	• **Achievement values:** Capable, Intelligent, Influential • **Power values:** Social power, Wealth, Preserving my public image, Social recognition	(none)

The influence of these frames is evident in the values activated by Green IT and Sustainable HCI (Table 4.2). The table shows show strong activation of the ('negative') values that are consistent with this modernist framing, along with very low activation of the ('positive') values that oppose this framing[11]. This suggests that the Self-Enhancement based motivational strategy exposed in Chapter 3 *makes sense* with respect to the frames underlying the discourse; i.e. since researchers assume that people are rational and self-interested, their 'sustainability' solutions accom-

[11] 'Protecting the environment' is a 'positive' value which is reinforced by this framing, and this reinforcement is also evident in the high activation of this value in the Green Computing corpora.

modate — and, indeed, try to make use of — people's rational/selfish tendencies. This, in turn, works to strengthen these tendencies, making people less inclined to act for the benefit of others by adopting 'sustainable' behaviours. In other words, the strategic approach criticised in Chapter 3 is the result of this specific framing of humans, which *evokes values that are dissonant with the values that tend to promote pro-environmental (and pro-social) behaviour*[12]. Correcting the problematic emphasis on Self-Enhancement values in Green Computing, therefore, requires more than a rhetorical or design shift; it requires, instead, a significant shift in thinking about the nature of humans and the aims of 'sustainability' research in computing.

Returning again to the train metaphor, this frames analysis suggests that society will continue to head in the direction of 'unsustainability' unless the momentum of the frames car is interrupted or reversed.

Because frames have the potential to feed back to worldview (see Figure 4.4), intervening to affect these frames — for example, by designing with the assumption that people are not rationally self-interested — has the potential to begin to change the cultural narrative that dominates Post-modern, capitalist, *unsustainable* society.

While it appears that careful framing may offer a powerful means of shifting values, which in turn would shape new, 'positive' behaviour, it is important to point out that this may not end up being the ultimate goal of 'sustainability' research premised on different frames. This is because intervening at the level of frames necessarily alters the Green Computing definition of 'sustainability'. As this chapter has shown, the *Rational Actor, Self-Interest* and *Free Market* frames *themselves* have shaped the meaning of 'sustainability' to be understood as a problem of consumption[13]. So while intervening at the level of frames is arguably necessary to enable Green Computing to realise its 'sustainability' goals — i.e. as it relates to significant pro-'sustainability' behaviour change in the form of 'green' consumption and/or decreased consumption — changing these frames necessarily moves the goalposts for 'sustainability', and these modes of intervention may no longer seem relevant. As the next chapter will show, a new discourse premised in different, 'positive' frames opens up a whole new vision of the 'sustainability' problem and a whole new problem space for computing to explore, which is currently excluded from consideration as a result of the 'narrowing' effects of reification of Modernist frames.

[12] Phrase borrowed from Chilton, 'Finding Frames for Nature', pre-publication copy, courtesy of Paul Chilton.

[13] Along with this, these frames have contributed to an understanding of protection of the environment in instrumental terms (i.e. *Instrumentally Valuable Environment*).

Table 4.2: Green Computing values linked with Modernist frames

	Green IT	**Sustainable HCI**
'Positive' values consistent with the Modernist frames	• **Universalism values:** Protecting the environment (66%)	• **Universalism values:** Protecting the environment (89%)
'Neutral' values consistent with the Modernist frames	• **Hedonism values:** Enjoying life (11%), Pleasure (0%) • **Self-direction values:** Privacy (6%), Freedom (6%) • **Security values:** Healthy (21%), National security (9%) • **Conformity values:** Obedient (40%)	• **Hedonism values:** Enjoying life (11%), Pleasure (11%) • **Self-direction values:** Privacy (17%), Freedom (11%) • **Security values:** Healthy (44%), National security (0%) • **Conformity values:** Obedient (40%)
'Negative' values consistent with the Modernist frames	• **Achievement values:** Capable (94%), Intelligent (72%), Influential (21%) • **Power values:** Wealth (85%), Social power (40%), Preserving my public image (23%), Social recognition (23%)	• **Achievement values:** Capable (44%), Intelligent (39%), Influential (22%) • **Power values:** Wealth (50%), Social recognition (22%), Preserving my public image (11%), Social power (6%)
'Positive' values inconsistent with the Modernist frames	• **Universalism values:** Broadminded (0%), Wisdom (0%), Social justice (4%), Equality (9%) • **Benevolence values:** A spiritual life (0%), Helpful (4%)	• **Universalism values:** Broadminded (0%), Wisdom (0%), Social justice (17%), Equality (17%) • **Benevolence values:** Meaning in life (0%), Helpful (0%), A spiritual life (6%)
'Neutral' values inconsistent with the Modernist frames	• **Tradition values:** Respect for tradition (0%), Devout (0%), Detachment (0%), Accepting my portion in life (0%)	• **Tradition values:** Respect for tradition (0%), Devout (0%), Detachment (0%), Accepting my portion in life (11%)
'Negative' values inconsistent with the Modernist frames	(none)	(none)

4.4 Conclusion

Key issues raised in Chapter 1 (page 4) have been addressed, namely Green Computing's apparent naïveté regarding:

- the rebound effects of proposed solutions;
- the scale of change required to mitigate climate change; and
- the long-term consequences of targeting marginal behaviour change through self-interested consumer enticements.

Two inter-related critiques have been put forward regarding the limitations of Green Computing. The first is that the modernist characteristics of Green Computing obscure:

(a) the socially constructed nature of assumed 'natural facts' (Dourish, 2010), such as the frames that underpin the discourse, shielding them from interrogation; and

(b) the degree to which this framing serves to 'narrow' the solution space for 'sustainability', ultimately preventing researchers from recognising the limited impact this research can have.

Secondly, the modernist framing of individuals as being motivated by rational self-interest strongly biases the activation of 'negative' values and deactivation of 'positive' values. So while Chapter 3 proposed that Green Computing strategically target the activation of 'positive' values and deactivation of 'negative' values in order to increase the long-term impacts of its research, doing so would require the abandonment of deep-seated frames that shape Green Computing as it manifests today.

This discussion also helps explain the findings presented in Chapter 2 (Figure 2.3), i.e. the pronounced emphasis on *Question 7: How can we improve operational and process efficiency?* by Green IT, and on *Question 4: How can we use technology to foster environmentally responsible behaviour?* by Sustainable HCI. Unfortunately, what this chapter also indicates is that both of these questions are fundamentally flawed, so while there is clearly significant interest in them, they may be the wrong

questions to ask. Asking the *right* questions is essential to developing effective solutions; so how might computing begin to identify new questions?

Fortunately, the first step in breaking out of this rut is exposing the assumptions that have gotten Green Computing stuck there in the first place, which have already been examined in this dissertation. If these assumptions (these frames) are not valid (which is not to say they are *incorrect* from an essentialist perspective, but rather that they *undermine* the ambitions of Green Computing from a pragmatic perspective), what alternative frames might be more valid as a foundation for a new 'sustainability' discourse in computing? In other words, the critique offered in this chapter not only opens the door for an entirely new 'sustainability' discourse to emerge in computing, but provides a compelling case for why researchers *ought to walk through that door*. What lies on the other side is the subject of the remainder of the dissertation.

Part I Contributions

This first part of the dissertation has explored in depth the current manifestations of Green Computing, while for the first time to the author's knowledge, providing a clear articulation of the differences and similarities between its two leading discourses, Green IT and Sustainable HCI. These chapters show that Green Computing has on the whole adopted an imaginative/reformist understanding of 'sustainability' which closely parallels that of 'Ecological Modernization', in the case of Green IT, and 'Sustainable Development', in the case of Sustainable HCI. All of these discourses share a Triple Bottom Line construction of 'sustainability' concerns — namely environmental, social and economic concerns — and although this three-fold construction has gained significant traction in popular culture, these chapters show that the Triple Bottom Line is problematic. Specifically, the values that are compatible with fostering concern for environmental and social issues are directly in conflict with those that are compatible with fostering concern for economic issues, *and vice versa*. As others have pointed out, the economic bottom line has come to dominate 'sustainability' discussions, so that environmental and social contributions to 'sustainability' must simultaneously support economic growth. As evidence of this influence, Green Computing tends to couch 'sustainability' wins in terms of the economic benefits they entail. Practically, this has led to Green Computing's strategy to entice pro-environmental and pro-social behaviours with information about how these behaviours are in consumers' economic self-interest. While this strategy appears intuitive, since it is the familiar strategy used in marketing goods to consumers, values research suggests that such a strategy is unlikely to result in significant and/or long-term pro-environmental and pro-social behaviour change. In other words, while Green Computing distinguishes itself from the remainder of computing research by its resolute commitment to protecting the environment (and, indeed, seems to suggest that technological interventions are sufficient for resolving what they recognise to be a looming environmental crisis), its strategy for motivating environmentally beneficial behaviour change will *at best* lead to minor, short-term environmental 'wins'.

Given that Green Computing is unlikely to be successful in making a significant contribution to 'sustainability' (as understood by the discourse), one option for increasing its impact is to make a strategic adjustment — specifically, to appeal to Self-Transcendence values, which have been shown to promote pro-environmental and pro-social behaviour. But as Chapter 4 shows, the current Self-Enhancement based strategy is a product of deep-seated and culturally reinforced beliefs about human nature. This means that Green Computing's impact cannot be increased through superficial changes in discourse and design outputs; rather, Green Computing would need to accept major changes to the very premises upon which it is built before it is possible to a) recognise the reasons why its current strategy is unlikely to succeed, and b) craft a new strategy that is consistent with the values that promote desired behaviour change for 'sustainability'. In particular, these chapters argue that the frames underpinning both Green IT and Sustainable HCI naturally reinforce a Self-Enhancement based strategy for motivating consumption behaviour change, while narrowing the solution space to strategies to make consumption more efficient, which may end up equally self-defeating.

This suggests that if Green Computing researchers want to make a 'sustainability' impact —- particularly if they want to do so on the scale that is required to prevent or even reverse climate change — they will have to adopt alternatives that replace these problematic frames. The difficulty, as Chapter 4 demonstrates, is that these frames are the cognitive legacy of Modernity, which has so permeated society over the last several centuries that they are often assumed to represent 'natural facts' about the world. Furthermore, these frames comprise the fundamental assumptions embedded in the various institutions that influence research, namely funding bodies[14], including those that host various conference and journal venues. In this sense, in addition to provoking researchers to undertake more radical research, Part I makes an *institutional* argument, questioning the norms in the field within which Green Computing researchers are and will be able to work. Currently, this norm constrains Green Computing to explore within the solution space these Modernist premises prescribe in order to envision interventions that can affect threefold 'sustainability' improvements. Indeed, this is why Green Computing can be classified as a reformist discourse — it seeks solutions within familiar modes of (Modernist) rational management, rather than moving away from industrial modes of living and being (radical). Given that these chapters suggest, however, that a prerequisite of pro-environmental (and pro-social) success for Green Computing is the rejection of these Modernist frames, adopting alternative frames would fundamentally alter the very nature of the discourse, *necessarily making it radical*.

[14] Many of which have industrial ties, including ties to industries whose interests may conflict with a 'sustainability' agenda, e.g the fossil fuel industry, or those that profit from product obsolescence.

So while Chapter 2 shows that there is a *gap* for 'sustainability'-related research in computing that accommodates an alternative imaginative/radical discourse on 'sustainability', the remainder of Part I serves to demonstrate that there is a *reason* to explore this imaginative/radical space.

Table 4.3: Gap for 'Sustainability' Research in Computing

	Reformist	**Radical**
Prosaic	Rationalistic Computing	Survivalist Computing
Imaginative	Green Computing	**?**

While an initial starting point is implied for the basic characteristics of the imaginative/radical alternative to Green Computing — i.e. it would be founded on alternatives to the *Rational Actor*, *Self-Interest* and *Free Market* frames — precisely how 'sustainability' would be defined within this space requires elaboration. As will be demonstrated in Part II, redefining 'sustainability' has profound implications for the kinds of interventions that computing can contribute, which necessarily goes beyond behaviour change. To be clear, while exposing the opportunity to be found in a radical 'sustainability' approach would potentially contribute to new areas of research that can be explored by those currently working in Green Computing (assuming they embrace this radical alternative), the purpose of this investigation is not to 'improve' Green Computing research; rather it is to develop a separate discourse and research agenda that can make a more significant, and indeed quite different, 'sustainability' contribution. As the remainder of the dissertation will show, stripping away the Modernist premises critiqued in Part I, and building an understanding of what Green Computing would entail if premised in non-Modernist assumptions, enables an entirely new path for computing research.

Cyber-Sustainability

Part II Overview

So far, the impact of Green Computing research to date is underwhelming:

- Despite the tremendous efficiency improvement efforts, net carbon emissions are continuing to *increase* year on year at a time when these emissions must drastically decrease to avert climate change disaster.
- Despite efforts to slow obsolescence cycles, electronic waste remains the world's fastest growing waste stream (Lundgren, 2012). And despite the efforts to develop various tracking technologies to ensure it ends up in recycling facilities, up to 80% of this e-waste continues to be shipped to developing countries, many of which do not have such facilities (ibid).
- Even with the effort devoted to raising awareness of the environmental impacts of technology use, studies show that this produces less than 10% change in consumption activity (Hazas et al., 2012).

To paraphrase Mankoff (2012), *it seems that none of the most obvious motivations for doing Green Computing justify the time being put in.* The cynical question, in this case, is are we better off doing nothing than doing Green Computing? There is a real, though rarely discussed, environmental consequence of this research, which in itself may not be justified by its minimal impact. For example, the production of more efficient IT entails consumption of natural resources, such as precious metals, and the disposal of redundant machines; and any electricity-powered 'solution' entails further resource usage during the life of the technology. It could be argued that the longer we spend working towards solutions that are bound to fail, the less time we have[15] to develop and implement solutions that *might work.* Is funding for this research, therefore, better spent on alternative energy or carbon capture research?

[15] e.g. before we pass a climate change tipping point

While it is important to expose these limitations, nothing is gained by dwelling on the possible futility of these efforts. Instead, it is important that alternatives to Green Computing are put forward for consideration. The purpose of this part of the dissertation is to demonstrate that an alternative future for sustainability research in computing is possible, and to articulate what this alternative might look like in discourse as well as in practice. Chapter 5 begins by elaborating an imaginative/radical understanding of 'sustainability' not yet considered within 'sustainability' research in computing. Chapter 6 then develops several propositional solutions, in the form of patterns, that would be compatible with such an understanding of sustainability in the context of alternative designs for the Internet and Web. Chapter 6 concludes by integrating the ideas developed in Chapter 5 and the insights gained from these patterns.

Chapter 5

Cyber-Sustainability

Developing a Radical Understanding of 'Sustainability' for Computing

Introduction

Motivated by Part I's critique of Green Computing's conception of 'sustainability', this chapter develops an alternative notion of sustainability[1] that might guide computing research towards making a more significant and more *meaningful* contribution towards sustainability. To this end, the Modernist premises that guided Green Computing's definition of 'sustainability' are suspended, and a fresh notion of sustainability is developed for computing.

The chapter begins (5.1) by adopting the Quadruple Bottom Line (QBL) of 'Radical Sustainability' (briefly outlined in Chapter 2) (Walker, 2013; Walker, 2012; Walker, 2011), and explores the implications of this framework for a radical discourse in computing. The QBL, which redefines sustainability in terms of fulfilment of human meaning, is one way of disentangling 'sustainability' from Modern frames that have typically shaped colloquial and academic (e.g. Green Computing) usages of the term. Although there may be other ways to achieve this same end, the QBL provides a new lens with which to evaluate the frames that have been used in building

[1] Note again (see Chapter 2), sustainability without quotes refers to the radical notion of sustainability underpinning 'Radical Sustainability' discourse, which is borrowed as the foundation of this new discourse in computing.

Green Computing's understanding of 'sustainability', and to justify the alternatives to these frames.

The second half of this chapter (5.2) describes the key concerns around which a new discourse in sustainability in computing might orient, specifically as it relates to the sustainability of Internet and Web technologies. Key terms are defined and prominent trends are explored as they relate to the understanding of sustainability for computing developed in the first part of the chapter.

5.1 'Sustainability' reconsidered

In this section, the four components of the QBL — practical, social, personal and economic — are discussed in terms of how they relate, or do not relate, to current 'sustainability' research in computing, and how they may be incorporated into a meaningful understanding of sustainability that might serve as the basis of an alternative discourse.

Practical meaning: This level of meaning recognises our physical, biological nature and the needs that come as a condition of this material reality, along with the impacts of supplying those needs on the environment.

Existing 'sustainability' research in computing is principally motivated by a recognition of a threat to practical needs. This threat stems from the fact that human survival requires certain environmental resources, which need to be protected from damage or depletion by human activity. The *instrumental modality* (Mathews, 2006) — i.e. mastery and control over nature — is employed as a means of insuring the continuance of our ability to satisfy these needs. This instrumental modality manifests in Modernity through scientific investigations and technological progress. It is not surprising, therefore, that computing instrumentalises the 'sustainability problem', because it is such a key contributor to this technological progress. The development of an environmental consciousness within computing over the last three decades is certainly commendable; but while the current understanding of 'sustainability' in computing helps researchers formulate instrumental goals for the continuance of our current standard of living, it does not adequately address questions about why we might *want* to sustain the world as is, or what *ought* to be sustained

to make our continued existence meaningful and fulfilling. This suggests a need to move beyond so-called objective, value-free approaches, and include considerations of other levels of meaning. In short, it suggests that *a focus on practical needs (i.e. the environment alone) is a necessary but insufficient basis for a guiding notion of sustainability in computing.*

Social meaning: This level of meaning recognises our social nature and the need to negotiate relationships with respect to an awareness of what is socially acceptable and morally right (Walker, 2012).

To attend to these social needs, sustainability would necessarily involve consideration of ethics and morality, equity, and our responsibility to one another; but it also must involve consideration of the ways in which our society accommodates or does not accommodate socially satisfying engagements and practices, and how it fosters or erodes empathy and compassion. Furthermore, it requires that we take an interest in and act in accordance not only with our own needs, but also those of others.

It is important to note that ‘sustainability’ makes little sense in terms of pure self-interest, partly because protecting the environment lacks immediacy and is, therefore, difficult to envisage in terms of personal gain. For example, saving a kilowatt of energy today makes no perceivable difference to life tomorrow. Furthermore, most of the consequences of environmental destruction by Industrialised nations are felt by individuals in less Industrialised nations — people whom a citizen of the United Kingdom, for example, is unlikely to ever meet (and who cannot, practically, return the favour).

While the *Self-Interest* frame accommodates beyond-the-self concern as far as it extends to close family — particularly insofar as one can envision an evolutionary argument for preserving one’s genes (cf. Dawkins, 2006, *The Selfish Gene*) — it denies the reality that humans experience concern for friends and acquaintances *as well as* other humans around the world. The *Empathy* frame, on the other hand, recognises that we are motivated by care for others ‘based on feelings of commonality and compassion’ (Darnton & Kirk, 2011: p. 116) (cf. de Waal, 2009). This suggests that sustainability is only meaningful when seen within a larger notion of reality — one that includes fulfilment of reasonable wants alongside environmental stewardship (practical meaning), as well as concerns for and a sense of duty towards others (social meaning). A meaningful definition of sustainability must therefore be rooted in frames that accommodate a notion of rationality inclusive of ethical and moral reasoning — frames such as *Embodied Mind* and *Empathy*.

Personal meaning: This level of meaning recognises humans as meaning making creatures, with an inherent need to find some higher order and significance to our existence (Walker, 2012).

Attending to personal needs would include consideration of inner values, conscience and personal ethics, and spiritual development (Walker, 2013). It also relates to notions of wellbeing (ibid), particularly given our inherent psychological need to find meaning in committing to societal values in order to avoid 'spiritual malaise' (Parsons, 1960). As Orr points out (2003), this wellbeing is essential for preservation of the desire to sustain humanity and the will to work towards this goal.

Traditionally, humanity's primary avenue towards satisfying these inherent meaning-seeking inclinations was religious, i.e. recognition of a theistic or non-theistic path to questions of profound meaning and ultimate value. Taylor (2007: pp. 715–6) has argued that during the Post-Enlightenment period, as these modes declined, 'progress' became our primary avenue to meaning, and from then on, meaningful actions were driven by notions of progress and its associated implications[2]. Today progress is articulated through scientific, but especially technological activity; so a contribution to progress, via technological change, is interpreted as an inherently meaningful activity. Green Computing's ostensibly meaningful contribution to progress has been the stepwise reduction of both human and machine inefficiencies through the application of various mechanisms of control.

One of the weaknesses of this conception of progress as a contemporary foundation for meaning is that it offers a route to human satisfaction through extrinsic fulfilment, indicating a 'deficiency in the ability to find intrinsic fulfilment' (Darnton & Kirk, 2011: p. 72; cf. Kasser, 2002). This begs the question whether Green Computing's efficiency targets are inherently meaningful, particularly given their seeming failure to deliver results. An alternative discourse would need to offer a route towards greater intrinsic fulfilment, perhaps in part by acknowledging protection of the environment as worthwhile beyond its instrumental value and its contribution to Modern progress. Rather, sustainability would aim to protect the environment because *in addition* to being instrumentally valuable, it is also *intrinsically* valuable to the human experience. But beyond this, sustainability would necessarily encompass a broad range of issues pertaining to human fulfilment and wellbeing, including fulfilment of our inclination towards more profound notions of meaning-seeking that ultimately contribute to a world worth sustaining.

[2] As Taylor (2007) notes, however, this has from the start been accompanied by a feeling that it may, in fact, be 'meaningless'.

Economic means: This pertains to the ability to satisfy practical, social and personal meaning through the acquisition of necessary financial resources, which today are typically circumscribed by Western capitalism (Walker, 2012).

Economic means is of a different order than practical, social and personal meaning, because it lacks an inherent basis of meaning, and is instead a means to other ends. That said, economic means are frequently mistaken as worthwhile in and of themselves, particularly as it relates to the goal of ‘profitability’ which is bound within Industrial notions of ‘progress’.

Current computing research justifies its efforts on the basis that they contribute to economic means while contributing to environmental (and sometimes social) needs, as if these are equally important concerns. In addition to this, computing mistakenly relocates government responsibilities to businesses, which are not principally ‘moral bodies’[3]. As Lakoff notes, ‘The first responsibility of business is to make money; the first responsibility of government is to protect and empower its citizens’ (2008: p. 48). Asking businesses to be environmental leaders makes government ‘unaccountable and take[s] away its moral mission’ (ibid: p. 63). So while economic means cannot be ignored with respect to any proposed sustainability solution, it is governments, not businesses, who should be entrusted to shape policy in ways that build support systems for economic means (i.e. *Shared Prosperity*), while pursuing strategies for addressing practical, social and personal meaning. Clearly this should not exclude participation of businesses towards sustainability — particularly since there are examples of businesses that prioritise larger societal needs above profit (e.g. the office flooring company, Interface); but a sustainability agenda ought to be pursued irrespective of any buy-in from businesses.

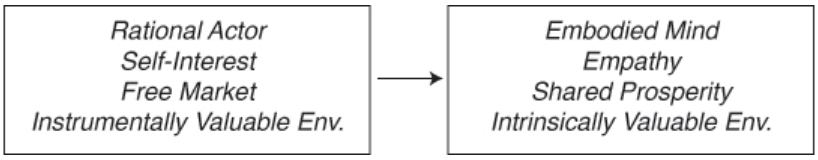
5.1.1 Sustainability redefined

The above discussion serves to demonstrate that reassessing our needs with respect to inherent aspects of our human condition, and using this as a basis for determining what we mean to ‘sustain’ when we speak of sustainability, calls into question many of the premises common to imaginative/reformist discourses. This goes beyond suggesting that a frame is strategically advantageous (i.e. instrumentally beneficial) with respect to realising sustainability goals[4]. In seeking to move away from the conditions created by and supporting Industrialism, it is an attempt to re-align a notion of technological ‘progress’ with satisfaction of inherent (rather

[3] Even if they are run by moral people, the business as an organisation is not principally moral.

[4] The frames proposed do, however, seem better aligned with Self-Transcendent values, and therefore are more likely to promote pro-environmental and pro-social behaviour.

than manufactured or distorted) needs, which appears to be a pre-requisite of a society that is both sustainable and worth being sustained[5]. Specifically, this radical understanding of sustainability entails rather different frames than those central to Modernity:



(To be clear, while stated in binary terms to help differentiate Green Computing's understanding of 'sustainability' from a new understanding being defined here, these frames should not be understood as opposites. For example, the difference between *Instrumentally* and *Intrinsically Valuable Environment* is that while the former tends to reduce the environment to its instrumental value alone, the latter understands the environment as both instrumentally and intrinsically valuable. Similarly, *Embodied Mind* does not state that humans are non-rational, but rather that rational decisions are informed by values, frames, metaphor, etc. Finally, while *Self-Interest* includes an understanding that humans can have concern for others, the *Empathy* frame simply widens the circle of human compassion further, including concern for people beyond our social group[6].)

Basing a definition of sustainability on human meaning suggests that there are three aspects that must be considered as part of this radical understanding, namely needs associated with practical, social and personal meaning. Economic needs, meanwhile, undeniably mediate our ability to satisfy these inherent human needs[7], and therefore ought to be considered as part of sustainability; though it should remain clear that any compromise in needs fulfilment should focus on adjustments to how we have understood and designed our economic needs, rather than sacrificing fulfilment of environmental, social, or personal needs which we have not designed. The Quadruple Bottom Line proposed to replace the familiar Triple Bottom Line of Green Computing is depicted in Figure 5.1. The star at the centre of this diagram represents the intersection of the different concerns, indicating that QBL sustainability must be investigated holistically as it relates to these four concerns.

For the remainder of this dissertation, the term sustainability (without quotes) will be used to refer to the QBL understanding of sustainability and the frames that fit with

[5]This assessment is consistent with other imaginative/radical discourses, which diagnose the sustainability problem as one of deformation caused by Industrialism (see Section 2.1.2).

[6]Note that this extension of compassion is referred to as Universalism, as compared with Benevolence, which pertains to concern for people in one's social group.

[7]Michaels (2011) argues that, in addition to mediating these needs, Western capitalism changes the nature of virtually everything we do.

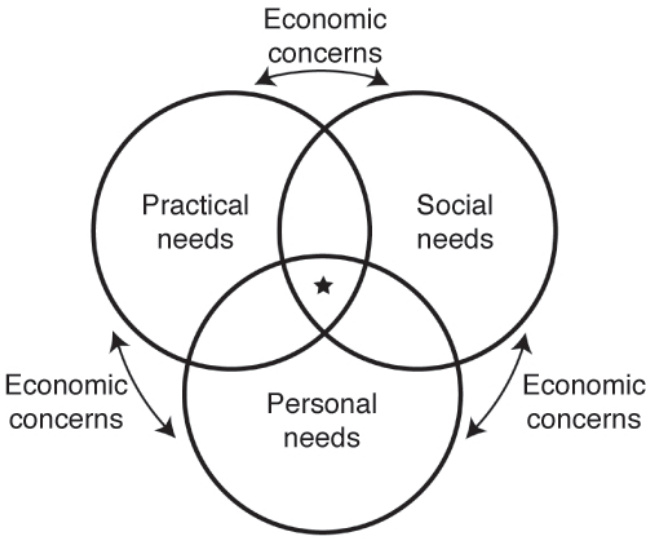


Figure 5.1: Quadruple Bottom Line framework for alternative sustainability questions in computing (adapted from Walker, 2011).

that understanding, as elaborated in this chapter. According to this, sustainability is rooted in an understanding of the importance of meaning as central to the human experience, and relates in this respect to the problem of enabling human fulfilment — what ought to be 'sustained' is that which fulfils us; and what is unsustainable is that which erodes or hinders this fulfilment.

5.2 Defining Cyber-Sustainability

A range of sustainability discourses could be developed to be in keeping with an imaginative/radical approach, just as Green IT and Sustainable HCI represent competing imaginative/reformist discourses. Some of the discourses in this space could conceivably articulate sustainability differently than has been detailed in the previous section. The purpose of this section, however, is to develop one potential imaginative/radical discourse as an alternative to other computing efforts, in order to show how this particular understanding of sustainability might manifest itself in computing, and how this differs from the current direction for computing research.

To provide some scope to this endeavour, this particular discourse will focus on

sustainability as it relates to Internet and Web technologies — an angle which has received little research attention to date, so can also offer new insights of interest to the Green Computing community. To the extent that it has been investigated by Green Computing, research has focused almost entirely on a) mitigating the environmental impacts of data centres that store our Web content, and to a lesser extent, b) the obsolescence cycles of the products that enable us to access the Web. While these are valid concerns, they do not capture the full range of concerns that pertain to the understanding of sustainability elaborated in the previous chapter (e.g. social and personal needs).

To begin, the concept of 'cyberspace' is clarified with respect to related terms. This is followed by the exploration of several digital trends as a means of isolating key areas of concern for this new discourse. The section concludes with a working framework for this new discourse.

5.2.1 Disambiguating cyberspace

The word 'cyberspace' is often used as a poetic synonym for the 'Internet' or the 'World Wide Web'. The distinction between these terms is, however, significant[8]:

Internet refers to a standardised mechanism of 'packet switching' and 'hierarchical routing' — a means of sharing data over a global network of linked computers — which was initially developed for defensive purposes as ARPANET in 1969. This has evolved over time into the Transmission Control Protocol (TCP) and Internet Protocol (IP) (a.k.a. TCP/IP) that today's computers use to connect to the global computer network (Comer, 2007).

World Wide Web (a.k.a. the Web) is a system of connected hypertext documents, using the hypertext protocol (HTTP), and supported by Internet servers. We use 'browsers' (e.g. Internet Explorer, Firefox, etc) as interfaces for viewing and searching these documents (Web 1.0). But often when we speak of the 'Web' today, we are referring to Web 2.0, a recent tendency of Web applications to support participation ('user-generated content'), communication, and collaboration, e.g. 'social media' such as Facebook, Blogger, and YouTube.

Cyberspace. The fact that the Internet enabled the sending of data between computers inadvertently facilitated our consideration of a dimension lying between these computers through which the data travels; and thus the concept of 'cyberspace' emerged. Gibson (1984) first popularised this term in

[8] This section is published in Knowles et al. (2013a).

> his science fiction novel, Neuromancer, where he famously describes it as 'A consensual hallucination experienced daily by billions of legitimate operators' (p. 69). Insofar as our ability to understand and experience cyberspace involves a shift in perception — one facilitated by the technological apparatus of the Internet — it is aptly characterised as an hallucination; and insofar as we can 'enter' this space via the Web, and experience the sensation of being 'online', the hallucination is indeed consensual and realistic.

Because 'cyberspace' is conceived of as a space qualitatively distinct from our physical existence, this makes it easy to forget that cyberspace is mediated through material technology, and therefore our digital activity can have significant implications in the physical world. Ironically, while we often imagine cyberspace as non-physical, we also tend to assume that it is a fixed 'thing', like the Internet or the Web, which are fixed in the sense that there are physical wires and established protocols for connecting computers and sharing information. Instead, cyberspace represents potential, and although we have exploited one particular use of cyberspace, there are any number of alternative uses that have not yet been considered — some of which could, potentially, contribute significantly towards satisfaction of our social and personal needs, and do so without threatening our 'real' lives (i.e. our practical needs).

5.2.2 Emerging trends

In the sections to follow, broad issues for the sustainability of cyberspace are introduced as they relate to prominent digital trends.

Rapid growth

Perhaps the most conspicuous trend for the Web is growth in digital content. The amount of data appears to be 'more than doubling every two years' (Gantz, 2011), and while much of this attributable to user-generated content (a.k.a. digital footprints; e.g. creating webpages, blogging, uploading photos and videos), the greater proportion of this content is produced *about* users (a.k.a. digital shadows). Not only is data being created by and about people, but the so-called Internet of Things (see Glossary) is creating an explosion of data by and about objects, the ultimate aim being to enable direct connection to any object in the world through the Web. An additional category of data is also being created *about data* (a.k.a metadata),

which is 'growing twice as fast' as the data itself (ibid). This latter category is necessary for several purposes, including a) the Semantic Web (see Glossary) and b) data analytics, which enables businesses to extract economic value from this data (see Information Asymmetry and Exploitation, below).

All of this data must be stored on servers, and despite the continuous growth in storage capacity per server, the number of servers worldwide is expected to increase tenfold in coming years (2011 to 2021) (ibid). The trend towards cloud computing, however, means that data is increasingly being managed through data centres, which are expected to manage 50 times more information during this same period (ibid). In 2010, the carbon footprint of the world's data centres was estimated at 130 million tonnes CO_2e (Berners-Lee, 2010: p. 161), and although it is difficult to estimate how this growth in information will translate into carbon emissions (because of potential advances in efficiency), it is inconceivable that such growth comes without a cost to the environment[9].

Finally, a related but frequently externalised component of this growth in data is the growth in consumption of IT equipment and mobile devices 'to enable us to access and interact with the Web. . . , [which] consume virgin materials, emit CO_2 during their production and use and contribute to ewaste' (Richards et al., 2011).

One area of concern for this new discourse, therefore, must relate to the various sustainability issues surrounding this growth.

Size Data should be created and stored with due consideration of its value and its costs. It is often (mistakenly) assumed that cyberspace is infinitely large, fostering a tendency to act as packrats, holding on to data not because it is useful now, but because it *might be* useful in the future. And while it may be wise to retain a backup copy of exceptionally valuable information, the current Web design (and culture of openness) enables non-essential and non-pragmatic multiplication of data[10]. This ultimately translates into real environmental consequences; and because data continues to accrue a carbon footprint over its lifetime of storage, it is important to consider strategies for deletion of redundant data.

[9] It is important to note that cloud computing may contribute to rebound effects, helping to encourage even greater rates of content generation (Berners-Lee, 2010: p. 162).

[10] An estimated 75% of data on the Internet is a copy (Gantz et al., 2010).

Free labour, Exploitation and Information Asymmetry

Web 2.0 has enabled a new form of labour — specifically 'immaterial labour 2.0' (Coté and Pybus, 2007) — where people actively and freely participate in the creation of digital content, and in so doing, 'become subjects' and commodify details pertaining to their identities (ibid). Behind the scenes, powerful computers are capturing this user-generated data and analysing it in an effort to extract value that businesses can trade between one another. These collections of aggregate data have been described as functioning 'like a fine modern art':

> *It is a new kind of security that the rich trade in, and the value is naturally driven up. It becomes a giant-scale levee inaccessible to ordinary people* (Lanier, 2013: p. 99).

This is an apparent reality of our so-called information economy: 'information is money. . . [so the] trick is to generate value by extracting the right information from the digital universe' (Gantz, 2011). To capitalise on this opportunity, therefore, one of the digital trends is increased investment in 'big data' technologies[11].

At the same time, recent whistle-blowing has revealed the extent to which governments monitor citizen activity through the Internet (e.g. America's NSA surveillance). Several large Internet businesses have granted government access to their data without informing the public. Even now that this has been made public, people being monitored cannot see who is monitoring them, what data is being collected, or for what purposes. This raises ethical questions about people's right to privacy versus issues of national security in an age of terrorism and cyber-attacks.

Empowerment Contrary to the trends described above, a sustainable use of cyberspace would involve empowering individuals as full beneficiaries in the information economy[12]. This may not mean that individuals directly benefit from their data production (as proposed by Lanier, 2013), but rather that the overall impact of digital developments works to increase people's quality of life, potentially through the funnelling of wealth (measured in money and/or time) from digital activities towards popular needs. At the same time, digital technologies ought to foster increased efficacy and social justice (Wallerstein, 1992), and protect against the misuse of information by governments to oppress its citizens.

[11] According to Gantz (2011), 'Big data technologies describe a new generation of technologies and architectures, designed to economically extract value from very large volumes of a wide variety of data, by enabling high-velocity capture, discovery, and/or analysis' (underlining in original text removed). The growth in business investment in 'big data' is estimated at approximate 50% from 2005 to 2011 (ibid).

[12] Lerner (1991) argues that disempowerment can result in economic disenfranchisement.

Dependence and inter-dependence

Another key feature of digital society which may become an even bigger concern is our dependence on Web technologies. There are two key ways in which this dependence manifests. Firstly, the Web has become a social necessity — opting out of Web-enabled communication (particularly mobile computing) is competitively disadvantageous[13]. Secondly, we have become reliant on the Web as our outboard brain[14], so to disconnect is to lose our memories and information. Even as Internet addiction skyrockets (Niemz et al., 2005), signalling an already unhealthy dependence on the Web, Web 3.0 enthusiasts embrace the inevitability of the final 'McLuhan Reversal', where we are entirely dependent on the Internet (Kelly, 2007)[15]. The danger with this dependence is that it is a hinderance to our ability to function without it in the face of some disruption in service, or in instances when individuals' wellbeing depends on being able to disconnect.

Current thinking in computing proposes that in addition to supposed environmental wins, technologies such as cloud services and smart grids enable localised or individual resilience — i.e. one's personal IT can 'go down' without disastrous results. The flip side of this, however, is that the technological inter-dependence required simultaneously decreases large-scale, societal resilience, as it is increasingly difficult to a) disentangle functional (and vitally important) capabilities of the Web from others which may have broken or otherwise failed (e.g. in the case of cyber-attacks), and b) 'unplug' from the Web were it to become too costly (environmentally or otherwise) to support[16].

Resilience Resilience is defined as 'the ability of a system, from individual people to whole economies, to hold together and maintain their ability to function in the face of change and shocks from outside' (Hopkins, 2008: p. 12). It is considered a key component of certain definitions of 'sustainability' (e.g. Holmgren, 2002), and relates to various levels of empowerment, e.g. individual-, community- and society-level. A sustainable cyberspace would, therefore, include consideration of strategies for maintaining (and in come cases, reclaiming) a healthy degree of independence from digital technologies, as well as strategies for eliminating inter-dependencies between services and systems that

[13] Lanier (2013) describes this as the 'punishing network effects' (pp. 161–5) of digital society.

[14] Consider Socrates' objection to the technology of writing, that people 'will rely on writing to bring things to their remembrance by external signs instead of by their own internal resources' (in Postman, 1993). Exuberant proponents of the Web now claim that it is comparatively inefficient to use our brains to store information when it is so easy to ask the Web (e.g. Google) to do our remembering for us (Kelly, 2007; Peter Suderman, in Carr, 2010: p. 181).

[15] Published in Richards, et al. (2011).

[16] Much of this was published in Knowles et al., 2013a; see also Richards et al., 2013.

currently reduce societal resilience.

Informationism

The Web is poised to shift to its latest iteration, Web 3.0, which includes the Semantic Web. The philosophical premise of the Semantic Web is the belief that we need more information and to be able to access it more easily. Even in its current state, the Web fosters the notion that our most serious problems will be solved by inventing technology that provides 'fast access to information otherwise unavailable' (Postman, 1993, p. 119); and in turn, we have adopted information 'as both the means and the end of human creativity' (Postman, 1993, p. 61). This has been criticised as *informationism*, i.e. 'a non-discerning, vacuous faith in the collection and dissemination of information as a route to social progress and personal happiness' (Schultze, 2002: p. 26). The consequences of informationism is that it contributes to addiction-like dependence (see Resilience), and 'derails any quest for moral wisdom by emphasising the *is* over the *ought*, *observation* over *intimacy*, and *measurement* over *meaning*' (ibid: p. 21). So while Web 3.0 calls for more information still (or at least more data) in an effort to address the lack of context for much of the information online, it does not address what we truly lack: 'We forget that improved knowing is also a matter of being a wiser person in a better society' (Schultze, 2002: p. 33).

Quality The term quality here refers to the *meaningfulness* of the functions the Internet and Web serve, as it relates to human meaning (see Section 5.1). A sustainable cyberspace would not simply provide information, but would continuously reinvent its purpose to align with genuine human needs. Examples of such purposes might include: a) fostering depth of thinking and wisdom; b) engaging and strengthening human cognitive processes that are associated with personal and spiritual development; and c) supporting creative expression and the cultivation of a world of beauty.

The 'Singularity'

Digital futurists (e.g. Kurzweil, 2005; Kaku, 2012; Kelly, 2007) predict that eventually our technologies will become so powerful that humans will willingly merge with technology. This human-machine symbiosis is presumed to usher in a new age in which people can transcend the 'limitations of our biological bodies and brain'

(Kurzweil, 2005: p. 9). In this age, we will be super-intelligent, able to download the entirety of human knowledge directly from the Web into our brains (Kaku, 2012).

These visions are symptomatic of what Fromm (1997) and Lanier (2010) describe as 'idolisation' of technology. The problem with this idolatry from a sustainability perspective is two-fold: 1) it compels us to accelerate our production and waste of technologies as we continue to move towards this goal; and 2) the more we become 'enamoured of technical gadgets,' the less we may be able to be human and experience life (Fromm, 1997: p. 36).

Computers are fantastically good at certain things, and indeed are 'intellectually superior' to us if measured in terms of speed of retrieval, quantity of retention, and accuracy of recall and calculation. There are, however, natural human competencies that are often overlooked, such as depth of contemplation, quality of retention (the layered and multimodal complexity of our memories), creativity, and comprehension, not to mention the importance of forgetting (Harper et al., 2008). By conceding our inferiority to machines — i.e. by designing to augment ourselves with technological capabilities — we tacitly accept that what technology can do well is what people need in order to be better people. And in mistaking technological 'aims' as our own, we subject ourselves to domination by an entity which is 'indifferen[t] to empirical, real human projects and happiness' (Ellul, in Szerszynski, 2005, p. 62). As a result of this misjudgment, we see the diminution of the qualities that ethical and spiritual traditions have long cherished as pathways to human flourishing (Carr, 2010; Turkle, 2011; Zaleski, 1997), which correlates (unsurprisingly) to negative effects on wellbeing.

Nourishment A notion of technological progress that seeks to replace human characteristics with machine characteristics is fundamentally unsustainable because it erodes the very meaning of our existence and compels us to develop new technologies simply because it is possible. Development of a sustainable cyberspace would, in contrast, be guided by what is 'good, true, or beautiful,' and thereby serve 'the unfolding and growth of man' (Fromm, 1997: p. 48). Sustainable digital technologies would, therefore, provide necessary nourishment and support not for 'productive man, not for the homo consumens or the homo technicus, or gadget man' (ibid: p. 37), but for *the human*.

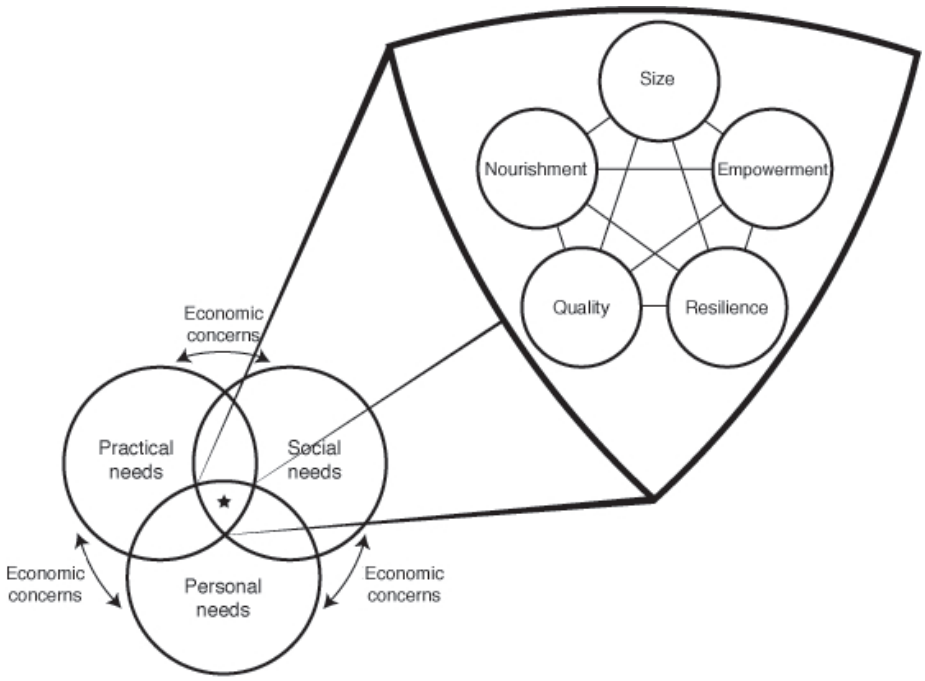


Figure 5.2: Framework for Cyber-Sustainability.

5.2.3 A working framework

These above trends have served to enable reflection on the key emergent areas of concern for a new discourse in sustainability, which shall be referred to as 'Cyber-Sustainability'. These areas of concern are derived from the imaginative/radical understanding of sustainability outlined in Section 5.1, and inter-relate, many touching on more than one of the four bottom lines. A working framework for Cyber-Sustainability is summarised in Figure 5.2.

Based on this understanding, Cyber-Sustainability as a discourse is concerned not just with the environmental impact of Internet and Web technologies, but also how well they satisfy our innate human needs, enabling us to flourish and achieve our human potential. As part of this, therefore, web-based activities should enable the development of meaningful social relationships as well as offering conditions and ways of interaction that are conducive to inner development and environmental stewardship.

Technologies that do not meet these standards are unsustainable because they erode a world worth sustaining. It should be noted that such technologies would not be unsustainable because they cannot be *continued*. Our history with digital technologies so far suggests that people tend not to reject technology because they fail

to meet their needs (Lanier, 2013 and 2010; Turkle, 2011; Carr, 2010; Carr, 2008), but continue to use them to the detriment of their wellbeing. Cyber-Sustainability, in contrast to Triple Bottom Line notions that tend to equate 'sustainability' with continuance, is concerned precisely with the fact that digital development may continue in its current direction, and that we will fail to recognise what we are losing as we march steadily to the dream of so-called 'progress'. For this reason, continuance of the Internet and Web *as we know them today* is not a necessary condition of Cyber-Sustainability. If there is a role for Internet and Web technologies in a sustainable future[17], or other uses of cyberspace yet to be imagined, they must contribute to the fostering of conditions necessary for human thriving.

The new narrative offered by Cyber-Sustainability discourse is that if we deliberately address human meaning as the inspiration for development in cyberspace, we are more likely to contribute a design that satisfies our practical, social, and personal needs, thereby maximising human potential and flourishing. The five areas of concern outlined in this chapter help guide a vision of Cyber-Sustainability, but so far no practical design solutions are proposed for realising this vision. This is the aim of Chapter 6, which explores the implications of Cyber-Sustainability in terms of radically different Internet and Web designs.

5.3 Conclusion

Given that Green Computing appears to limit the potential for radical (non-incremental, transformational) change, as argued in Part I, this chapter introduces to computing a new understanding of sustainability which has the potential to yield more radical change. This understanding is informed by the critiques of Green Computing made in Part I, and finds affinity in an existing discourse (i.e. 'Radical Sustainability') premised in a Quadruple Bottom Line notion of sustainability. Within this sustainability, the economic concerns that had been so problematic within Green Computing discourse are demoted; and a new sustainability concern that may have been overlooked by Green Computing, namely personal meaning, is elevated in its place.

This reconfiguration of concerns necessarily alters the kinds of questions that are relevant (or not relevant) to a computing discourse on sustainability. To illustrate

[17] It is not assumed that cyberspace and digital technologies necessarily have a place in such a society.

this point, one such discourse is explored, namely that which is here called Cyber-Sustainability. The chapter offers a comprehensive understanding of sustainability within this discourse, combining the high-level concerns of the QBL (practical, social, and personal needs, and economic concerns) with five lower-level concerns that are specific to Cyber-Sustainability discourse.

The next chapter enriches this emerging understanding of Cyber-Sustainability by exploring how these concerns might be expressed through radically different Internet and Web design. A number of propositional design 'solutions' are offered as a means of exploring the implications of these guiding principles and the extent of change Cyber-Sustainability would entail.

Chapter 6

Cyber-Sustainability Patterns

Building a catalogue of ideas for a sustainable digital future

Introduction

The previous chapter defined the basic parameters of a radical new discourse on sustainability in computing, which has significant implications for the kinds of 'solutions' that are needed to address this understanding of sustainability. In particular, this understanding introduces new possibilities for reconceptualising designs for cyberspace that align with sustainability. Some of these possibilities are explored in this chapter in the form of patterns.

The chapter begins (6.1) by introducing pattern language methodology, and providing examples of the various styles of pattern language. A pattern template is developed for use in Section 6.2. The remainder of the chapter describes patterns for Cyber-Sustainability, ranging from high-level, abstract patterns to more specific design ideas. These patterns are offered *propositionally* in order to demonstrate the degree of change that might be required to move towards Cyber-Sustainability, and to provoke new thinking about what a sustainable digital future might entail amongst not only the actual developers of digital technology and those who educate these practitioners, but also technological visionaries who promote narratives about a more technologically 'advanced' society, and those who influence policy surrounding the uses and restrictions of these technologies in society.

6.1 Patterns, AntiPatterns and pattern languages

The term 'pattern' is difficult to define without using 'pattern' in that definition. It is what it sounds like: a pattern is something that reliably repeats. Patterns, therefore, describe a repeating problem, along with a suggestion for a solution that is proposed to solve the problem better than other attempted solutions.

In order to propose and evaluate potential solutions, a problem domain needs to be defined — e.g. architecture that is conducive to wellbeing (Alexander et al., 1977); communication that promotes conviviality (Schuler, 2008); programming that is flexible, elegant and reusable (Gamma et al., 1995). Patterns have been used to break down these and other very complex challenges into discrete, manageable problems with clear solutions, while remaining true to the greater complexity in which that challenge sits. This is the purpose of 'pattern languages': they organise and meaningfully interconnect patterns — often by numbering patterns and cross-referencing them when relevant to the current pattern being described. In this sense, they are more than a collection of patterns, and instead might be described as 'an ecology of patterns' (Schuler, 2008: p. 55). Typically, pattern languages are developed as a sequence, from larger (high-level) patterns to smaller (low-level) patterns (Alexander et al., 1977: p. xviii). Pattern languages are designed to be practically useful, clear, concise, and easily communicable, while inviting new pattern contributions; and to enable this, patterns adhere to standardised templates[1], typically ending with a simple instruction about *what to do*.

Pattern languages provide an extremely flexible method that has been used in a range of disciplines and domains, and the outputs of pattern languages can vary significantly from one another. In addition to the differences in the pattern templates themselves (some being longer and more detailed than others), pattern languages differ along several dimensions, including:

- *Formality.* Some pattern languages adhere rigidly to a template, and to the networked relationships between patterns; whereas others are more conversational and aim to articulate newly emerging (and therefore relatively unrefined) insights into successful design (e.g. Thomas, 2012).
- *Granularity.* Patterns can be pitched at various 'levels'. High-level patterns

[1] These templates are standardised only within the pattern language; as will be shown, these templates vary between different pattern languages.

represent theoretical orientations that contextualise other patterns in the language; mid-level patterns represent major design decisions to be made within these orientations; low-level patterns (of various orders below this) represent practically implementable design decisions or criteria, and may describe patterns that logically follow on as a result of implementation of a mid-level pattern. A pattern language may begin and end anywhere along this scale.

- *Comprehensiveness.* Authors such as Alexander et al., (1977) and Hafiz & Adamczyk (2012) aim to present a fully comprehensive set of patterns, which span all levels of granularity. Holmgren (2002), on the other hand, aims to present a fully comprehensive set of patterns of a smaller subset of levels of granularity (e.g. all fairly high-level)[2]. Other examples (e.g. Thomas, 2012) present a small handful of patterns, which can serve as a starting point for further pattern language development.

- *Validity.* The more comprehensive pattern languages tend to be founded on a greater evidence base for their validity. For example, Gamma et al. (1995) base their patterns on the history of computer programming; Alexander et al. (1977) base their patterns on the long history of architectural design. In domains such as 'sustainability', where it is difficult to demonstrate the success of any given proposed solution, and where there is a shorter track record of experimentation with various solutions, patterns are presented less definitely and more propositionally. Often in these cases, the validity of patterns is demonstrated by referral to similar patterns in other domains — e.g. Holmgren (2002) mimicking biological and indigenous solutions, Thomas (2012) modeling software patterns on examples of successful socialisation.

- *Definitiveness.* While no pattern language can ever be said to be 'finished'[3], patterns can be offered with varying degrees of certainty in a solution. Alexander et al. (1977) indicate their level of confidence in their patterns using either two asterisks (a solution that is believed to be 'a true invariant'), one asterisk (a solution that makes 'some progress towards identifying such an invariant'), or no asterisks (indicating a belief that the pattern has '*not* succeeded in defining a true invariant — that, on the contrary, there are certainly ways of solving the problem different[ly]') (p. xiv–xv). Schuler (2008) suggests that patterns can also be propositional and describe an as yet non-existent reality: 'A pattern, then, is a form of seed. It contains a reflection of current work and

[2]Note that Holmgren does not describe his set of 12 'principles' as patterns, though it appears to fit a model of a pattern language.

[3]Pattern languages continue to evolve as long as people contribute new patterns or modify existing patterns as new solutions are discovered. Patterns, therefore, are hypotheses: 'each pattern represents our current best guess as to what arrangement of the physical environment will work to solve the problem presented' (Alexander et al., 1977: p. xv).

> thinking, as well as the vision of a future in which the seeds have sprouted and borne fruit' (p. 3). Patterns of the latter type are necessarily less definitive than the former.

Tufte once said, 'Good design is a lot like clear thinking made visual'[4]. One might describe patterns, similarly, as 'clear thinking made verbal'. Offering one of innumerable other definitions, Linden describes design as 'an opportunity to continue telling the story, not just to sum everything up'[5]. In this same spirit, a pattern language is not merely a means of assimilating accumulated design knowledge, but is also a means of describing new design directions that reflect knowledge yet to be applied towards a given problem. Pattern language enables this by providing a framework for exploring design concepts creatively (Pan, 2013), and in a way that invites interdisciplinary collaboration towards refinement and expansion of these concepts (Pan, 2013; Erickson, 2000). It is a means of enabling what Parsey describes as the 'opportunity' of designers, namely 'to learn how to handle the complexity, rather than shy away from it, and to realize that the big art of design is to make complicated things simple'[6].

6.1.1 Pattern language templates

It could be argued that all of design involves pattern recognition and application. To the extent that a designer makes a decision about how best to solve a problem, this decision is informed by a recognition of a pattern. For example, Norman (1998) shows that certain designs produce unsuccessful behaviour (human error) from users, whereas others produce successful behaviours, and his book offers solutions for designed objects that produce successful behaviours. Design can also involve the extrapolation of observable patterns towards new solutions. For example, Walker (2006) identifies 'aesthetic identifiers' of unsustainable practice[7], and then articulates sustainable solutions in the form of propositional objects that embody potential alternative patterns.

At a minimum, all patterns include a name, problem, and solution (Brown et al., 2008: p. 31). The difference with other modes of communicating design insight is merely, then, a difference in the formalisation of this insight[8]. A small number

[4] http://quotesondesign.com/edward-tufte-2/

[5] http://adeendesign.com/home/blog/2013/04/29/inspirational-design-quotes/

[6] http://jonathanmoore.com/post/167667029/handling-complexity

[7] These include the following (p. 117–8): a) culturally neutral or bland, b) pristine, polished and fragile, c) concealing and disguising, d) cold or remote, e) curved, rounded and smooth, f) fashionable or showy, g) complete and inviolable.

[8] This means that it is generally possible to translate design insight into patterns. Realising this,

of pattern templates are described below as an introduction to the technique of formalising design insight.

Alexandrian patterns

The original pattern template used by Alexander et al. (1977) can be summarised as follows (see pp. x – xi)[9]:

1. Pattern name and number: concisely capturing the pattern, and numbering for indexing of related patterns.
2. Picture: exemplifying the pattern.
3. Context: a short introduction to the pattern relative to higher-level patterns.
4. Headline: describing the essence of the problem.
5. Body: elaborating the headline, demonstrating the pattern's validity, describing different ways it might manifest.
6. Solution: an instruction for how to solve the problem.
7. Diagram: a visual means of conveying the solution and indicating relative architectural components (e.g. 'alcoves' and 'main room' — pattern #78).
8. Related patterns: a discussion of related patterns, and how they inter-relate, were one to design a complete solution to the problem.

Gang of Four patterns

The idea of a pattern language was first applied to computing (specifically, to object-oriented software design) by Gamma et al. (1995), a.k.a. the 'Gang of Four'. Each of their patterns is structured as follows:

1. Pattern name and classification.
2. Intent: a short description of what the pattern does.

Hopkins has begun to translate patterns of successful Transition (i.e. Transition Town movement) into nine essential 'qualities' (Hopkins, 2010), thus describing a proto-pattern language to be elaborated further.

[9] In addition to these structural components of the patterns, the authors have developed a consistent set of typesetting rules — e.g. the use of three diamonds to break up certain sections of a pattern, the use of bold type, etc.

3. Also Known As: any other names used to describe what this pattern describes.
4. Motivation: a scenario that illustrates the problem and the different 'class and object structures' (i.e. coding elements) that are used to solve the problem.
5. Applicability: describes where and when this pattern can be applied.
6. Structure: a visual mapping of the classes and objects involved in the pattern.
7. Participants: description of the responsibilities of these classes and objects in the pattern.
8. Collaborations: explanation of how these responsibilities are undertaken.
9. Consequences: explanation of how the pattern fulfills the Intent, with a discussion of trade-offs and opportunities for variance.
10. Implementation: tips for avoiding difficulties when applying the pattern, including any language-specific variations.
11. Sample Code: illustrations of the pattern as it would be coded.
12. Known Uses: examples to follow, from more than one domain.
13. Related patterns: a discussion of related patterns, how they inter-relate, and any important differences to bear in mind.

Schuler patterns

In describing patterns of communication that promote conviviality, Schuler (2008) uses a much more minimal pattern template, comprised of the following elements:

1. Pattern name and number: concisely capturing the pattern, and numbering for indexing of related patterns.
2. Picture: (optional) illustrating either the problem or solution.
3. Problem: a brief description of the design challenge.
4. Context: an explanation of how and in which situations this pattern applies.
5. Discussion: articulating the motivation of the pattern, and introducing insight into solving the problem.

6. Solution: an instruction for how to solve the problem, along with a brief justification of how it succeeds.

7. Linked patterns: a list of patterns (referenced by name and number) within the pattern language that might be used together.

AntiPatterns

Appreciating that a significant portion of software projects are unsuccessful[10], and recognising that there is much to learn from common mistakes and pitfalls that lead to these failures, Brown et al. (1998) developed the notion of AntiPatterns, to 'clarify the negative patterns that cause development roadblocks, and include proven solutions for transforming software development problems into opportunities' (p. 2). The authors define an AntiPattern as 'a commonly occurring solution to a problem that generates decidedly negative consequences' (p. 6). Indeed, an AntiPattern is a subset of patterns: 'A design pattern becomes an AntiPattern when it causes more problems than it solves' (p. 2). (By this logic, a Pattern could be understood as a design pattern that solves more problems than it causes.)

Because AntiPatterns contain essentially two patterns with the same intent — one that fails and one that is successful (i.e. a 'refactored solution') — the template for AntiPatterns is more complex than pattern templates (ibid: p. 34–6):

1. AntiPattern name.

2. Also Known As: any other names used to describe what this pattern describes.

3. Most Frequent Scale: describes where and when this pattern can be applied.

4. Refactored solution name.

5. Refactored solution type: reference code (e.g. software, technology, process, role).

6. Root causes: reference to one of the identified (high-level) factors contributing to failure (e.g. haste, apathy, narrow-mindedness, sloth, avarice, ignorance and pride (pp. 12–16)).

[10] Five out of six projects are considered 'unsuccessful', one-third are canceled, and many cost twice as much and take twice as long as originally planned (Brown et al., 1998: pp. 3–4)

7. Unbalanced forces: reference to *primal forces*[11] 'that are ignored, misused, or overused' (p. 35).

8. Anecdotal evidence (optional; generally comic): phrases relevant to the AntiPattern.

9. Background (optional): examples; interesting or relevant information.

10. General form of this AntiPattern: diagram (optional) and summary description of AntiPattern.

11. Symptoms and consequences: list of what results from the AntiPattern.

12. Typical causes: unique causes (in contrast to root causes).

13. Known exceptions: examples of when the pattern may not be wrong.

14. Refactored solutions: explanation of a solution that resolves the forces.

15. Variations (optional): list of any variations and/or alternative solutions.

16. Example: demonstration of refactored solution.

17. Related solutions: lists inter-linked patterns for cross-referencing within the pattern language.

18. Applicability to other viewpoints and scales: explores impacts on other related elements of the system, and how it might manifest at different scales.

6.1.2 A pattern language template for Cyber-Sustainability

Several patterns of different levels of granularity will be explored in the next section, spanning the range of sustainability issues within the context of digital technologies (roughly in order of abstract and coarse grained to grounded and fine grained). These patterns are intended to be *propositional* — i.e. they explore the potential of often radically different designs for producing more sustainable outcomes. The template that will be followed largely emulates Schuler's template. As described below, it captures all of the aspects that it is possible to infer at this stage in the pattern language development:

[11] *Primal forces,* 'are present in nearly all design situations', and include management of functionality, performance, complexity, change, IT resources, and technology transfer (Brown et al., 1998: p. 18).

Final Pattern Template

 # – Pattern: number and name of pattern.

Problem: brief description of the design challenge and the reason a pattern is needed.

Context: [optional] how and in which situations this pattern applies.

Cyber-Sustainability Concerns: list of the areas of concern to which this pattern relates.

Relationship to Quadruple Bottom Line — primarily: list of the aspects of QBL sustainability that are directly addressed by this pattern.

Discussion: [optional] greater detail about the problem, along with information that helps to justify the motivation and the proposed solution.

Solution: description of how this pattern addresses the problem in a way that produces greater sustainability benefits than problems.

Dominant frames: [optional] list of the key frames that underpin this pattern.

Related Patterns: inter-related Cyber-Sustainability patterns, referenced by name and number.

Related Patterns in other Pattern Languages: [optional] many of these patterns were inspired by and/or benefit from the wisdom contained in other pattern languages; these are provided as further justification of the pattern, as well as to begin to contribute towards a larger, meta-pattern language.

The goal of the patterns is not to identify what Alexander described as 'true invariants'; nor is it to present a comprehensive set of patterns that circumscribes all Cyber-Sustainability design issues. Rather it is to a) show that practical solutions[12] *can* be developed to reshape cyberspace development in line with the understanding of sustainability described in Chapter 5, b) explore the design implications of Cyber-Sustainability, and c) invite interdisciplinary collaboration towards further development of these ideas by providing a structure for others to emulate.

[12]The use of the word 'solutions' should not be taken to mean that sustainability will forever be resolved once a pattern language for Cyber-Sustainability is complete; instead it is meant to convey an optimism that design can be used to create an improvement towards sustainability.

6.2 Patterns for Cyber-Sustainability

In Knowles et al. (2013a) — a publication resulting from the first year of this PhD research — four initial patterns were developed by adapting Brown's (1998) AntiPattern template. A subsequent publication (Richards et al., 2013) articulated one further Cyber-Sustainability AntiPattern. The resulting five patterns[13] encapsulate high-level orientations to the problem of sustainability that define what is effectively a Cyber-Sustainability worldview[14]. In this respect, the resulting patterns articulate an emerging understanding of both a) problematic (i.e. unsustainable) frames that apply specifically to digital technology development and use, and b) alternative frames that are more likely to bring this technology into greater alignment with sustainability. This is similar to what Schuler describes as 'theory' patterns, i.e. 'patterns that express the assumptions that we are making about the world and, most important, how we intend to engage in the world' (p. 91).

The development of the remaining patterns occurred in stages, as follows. Having explored the issues pertaining to sustainability as described in Chapter 5, existing pattern languages were read as inspiration for alternative design ideas that might apply in the context of Cyber-Sustainability, and (as part of this) were consistent with the positive frames and values from Part I[15]. Core design ideas from these established patterns were applied exploratively, and a large number of initial Cyber-Sustainability patterns were discussed with colleagues and the supervisors of this dissertation. Over time, these patterns were refined, and many were cut from this dissertation. What remains are the patterns that represent the author's main interests, and the ideas they contain[16] are the ones most likely to be used as inspiration for future research projects. In their current form, these patterns are principally validated through having been *interpretations* of existing pattern languages, which have been validated elsewhere by others.

[13] While originally developed as AntiPatterns, this dissertation focuses on the 'refactored solution' within these AntiPatterns and restates these as patterns.

[14] Norman (1998) and Walker (2006) are examples of this same AntiPattern approach being used less formally — both identifying designs that do not work as a means of discussing designs that work better. These examples differ, however, in their granularity: Walker (2006) identifies high-level orientations for *design for sustainability*, while Norman (1998) identifies low-level patterns for practical implementation.

[15] These inspirational patterns are cited in the 'Related Patterns from other Pattern Languages' section of the template to reflect their influence.

[16] If not the actual patterns themselves, which are not meant to be interpreted as practical solutions (as explained further on page 184).

6.2.1 Different styles of pattern

■

Theoretical patterns: *these patterns define the theoretical orientations of Cyber-Sustainability. These five theoretical patterns correspond to the five key concerns of Cyber-Sustainability, as identified in Chapter 5 (Size, Empowerment, Resilience, Quality, Nourishment; see Figure 5.2), and serve to elaborate these concerns in greater detail. In doing so, they help to contextualise patterns to follow later in this chapter.*

1 — Cyberspace represents infinite possibility: relates closely to 'Size'.

2 — Machines are fundamentally dissimilar to and are relatively simplistic constructs of humans: relates closely to 'Quality'.

3 — Technology reinforces the worldview that produced it: relates closely to 'Empowerment'.

4 — The Web is a temporary gift: relates closely to 'Resilience'.

5 — Progress as Nourishment: relates closely to 'Nourishment'.

Several additional, lower-level patterns are articulated in the remainder of this chapter to begin to paint a picture of how these theoretical principles can be enacted practically. These are organised into three further categories of pattern — 'creational', 'structural' and 'behavioural'[17] — and are summarised as follows.

■

Creational patterns: *these patterns pertain to the goals that guide any cyberspace development, and therefore define the most basic parameters of what gets created.*

6 — Cyber Niche: provides a guiding principle for digital innovation.

7 — Rootedness: conceptually reframes cyberspace as it relates to the physical world that should help align digital development with real world needs.

[17] These terms are also used to organise patterns in Gamma et al. (1995), where they are defined in specific terms that relate to programming. Here, the headings are borrowed but redefined, taking on a more general (though related) meaning.

■

Structural patterns: *these patterns pertain to the design of the mechanisms underpinning cyberspace development (e.g. the mechanisms of data sharing and storage), and define the fundamental characteristics of a new Cyber-Sustainable 'Internet' and 'Web'.*

8 — Cyber-Glocalisation: proposes a means of gating data flow over the Internet in a way that enhances communities' ability to self-govern and thrive.

9 — Bounded Replication: an extension of the Cyber-Glocalisation pattern, applied to creative content generated within both the World Wide Web and local Cyberspaces.

10 — The Life Cycle of Data: pertains to cyberspace policy, as well as to the technical design of the Web.

■

Behavioural patterns: *these patterns pertain to the human behaviours and societal and/or community functions that are afforded by Cyber-Sustainable designs.*

11 — Ritual Deletion: articulates a mechanism for addressing the environmental impacts of indefinite data retention while fostering community cohesion and providing opportunities for shared meaning making.

12 — Community Chest: addresses real world community needs by creating a means of capturing and amplifying wealth as a byproduct of cyberspace activity.

13 — Rooted Businesses: describes a specific instance of applying the (higher-level, Creational) Rootedness pattern, and pertains to the business practicalities of Cyber-Glocalisation.

14 — Twinning: provides a mechanism for preventing the potential for abuses resulting from the (Structural) Cyber-Glocalisation pattern.

15 — Sanctuaries: pertains to the designed relationship between real world physical spaces and digital connectivity, and is intended to increase wellbeing.

16 — Carnivals: suggests a means of promoting creative exploration of the latent possibilities of cyberspace.

■

6.2.2 Theoretical patterns

These patterns define the theoretical orientations of Cyber-Sustainability. They correspond to the five key concerns of Cyber-Sustainability, as identified in Chapter 5 (Size, Empowerment, Resilience, Quality, Nourishment), and serve to elaborate these concerns in greater detail. In doing so, they help to contextualise patterns to follow later in this chapter.

N.B.: Because these five theoretical patterns have been published in Knowles et al. (2013a) and Richards et al. (2013), they are summarised in abbreviated form below (see publications for further details).

■ ■ ■

1 – Cyberspace represents infinite possibility

Problem: In our daily use of the Web, it certainly *feels* as if cyberspace is an infinitely expanding black hole in which we can upload content, despite the real (albeit hidden) physical constrains to this growth.

Cyber-Sustainability Concern: Size

Relationship to Quadruple Bottom Line — primarily: Environmental; Personal

Solution: When we start to think of cyberspace in terms of infinite *potential* we can begin to envision more humanly *satisfying* uses of this opportunity that do not require unrestrained growth (Knowles et al., 2013a).

Dominant frames: *Finite Resources* (see page 22)

Related Patterns: (7) Rootedness, (9) Bounded Replication, (10) The Life Cycle of Data, (11) Ritual Deletion, (15) Sanctuaries, (16) Carnivals

■ ■ ■

2 – Machines are fundamentally dissimilar to and are relatively simplistic constructs of humans

Problem: We tend to idolise technological forms of intelligence (e.g. *speed* of retrieval, *quantity* of retention, *accuracy* of recall and calculation) and are quick to dismiss our own human competencies (e.g. *depth* of contemplation, *quality* of retention, *creativity*, *comprehension*, and even *forgetting*). By tacitly conceding our inferiority to machines, we passively accept that what technology can do well is what people need in order to be better people, subtly eroding certain distinctly human values.

Cyber-Sustainability Concern: Quality

Relationship to Quadruple Bottom Line — primarily: Personal

Solution: Asserting that machines are inferior versions of humans prevents us from falling into the trap of being led by what we *can* do from a technological perspective rather than by what we *need* as humans (Knowles et al., 2013a).

Dominant frames: *Embodied Mind*

Related Patterns: (6) Cyber Niche, (10) The Life Cycle of Data, (15) Sanctuaries

Related Patterns in other Pattern Languages: *Alexander et al. (1977):* (205) Structure Follows Social Spaces; *Schuler (2008):* (87) Value-Sensitive Design

■ ■ ■

3 – Technology reinforces the worldview that produced it

Problem: We tend to assume that technologies are neutral. However, whether people use technology for good or for bad notwithstanding, it is naïve to suppose that technology does not change us, potentially blinding us to the environmental, social, spiritual and economic impacts of our digital technologies.

Cyber-Sustainability Concern: Empowerment

Relationship to Quadruple Bottom Line — primarily: Environmental; Social; Personal; Economic

Solution: Once we recognise that technology reinforces the worldview that produced it — a result of the fact that technologies embody and implicitly communicate values and frames — this not only gives us a necessary appreciation of our influence, but also allows us to leverage this influence in a direction that is necessary to ensure sustainability (Knowles et al., 2013a).

Dominant frames: *Embodied Mind*

Related Patterns: (8) Cyber-Glocalisation, (11) Ritual Deletion, (14) Twinning, (16) Carnivals

Related Patterns in other Pattern Languages: *Schuler (2008):* (25) Cyberpower, (87) Value-Sensitive Design

■ ■ ■

4 – The Web is a temporary gift

Problem: Every day, we are designing a world that assumes that cyberspace is not only reliable but will continue to play a key role for humanity into the indefinite future. As a result, we have casually developed psychological, cultural and economic dependencies on digital technologies, believing that there is no risk in doing so because so far the Web has never failed to be there when we need it.

Cyber-Sustainability Concern: Resilience

Relationship to Quadruple Bottom Line — primarily: Social; Personal; Economic

Solution: If we assume instead that the Web may need to fundamentally change shape or scope, we will begin to design a society that not only prepares us in case of unforeseen disruptions, but also enables us to live with greater independence from digital technologies if and when we so choose (Knowles et al., 2013a).

Dominant frames: *Embodied Mind*; *Finite Resources*

Related Patterns: (7) Rootedness, (9) Bounded Replication

■ ■ ■

5 – Progress as Nourishment

Problem: The notion of 'Progress' organises a set of goals that took root at the start of Industrialism, namely speed, efficiency, control, profitability, mastery and so forth. It works to spur a cycle of technological production, consumption and waste that is fundamentally unsustainable, while reinforcing 'negative' values that are themselves incompatible with both sustainable behaviour and (ostensibly) genuine human fulfillment.

Cyber-Sustainability Concern: Nourishment

Relationship to Quadruple Bottom Line — primarily: Personal

Solution: Any chance at realising a sustainable future means extricating human fulfillment from the behaviour of consumerism (understood as the continual encouragement and fostering of consumption). In articulating an amibition for technological development, therefore, it is important to couch any direction for change in terms of how it brings us closer to meaningful notions of what nourishes us as humans (Richards et al., 2013).

Dominant frames: *Embodied Mind*

Related Patterns: (7) Rootedness, (10) The Life Cycle of Data, (11) Ritual Deletion, (12) Community Chest, (13) Rooted Businesses, (15) Sanctuaries, (16) Carnivals

Related Patterns in other Pattern Languages: *Schuler (2008):* (3) The Good Life, (87) Value-Sensitive Design

■

6.2.3 Creational patterns

These patterns pertain to the goals that guide any cyberspace development, and therefore define the most basic parameters of what gets created.

■ ■ ■

6 – Cyber Niche

Problem: Digital technologies that seek to offer enhanced versions of real world activities and services tend to eventually replace the original, physical versions. The digital and physical need not be in competition, however; ideally, they should offer us *different* things, each contributing in its own way to human nourishment.

Context: This pattern relates to ambitions for cyberspace, and provides a guiding principle for digital innovation.

Cyber-Sustainability Concerns: Quality; Resilience

Relationship to Quadruple Bottom Line — primarily: Personal; Economic

Discussion: Digital technology tends to promise delivery of various benefits, e.g. they will save us time and/or stress, give us more for our money (they are very often free!), and most of all, enable us to do what we were already doing but *better*. In part because it is difficult to predict the consequences of introducing a new technology — and perhaps, in part, because despite all of these supposed 'time-savers' we have less time than ever to do more and more things — we rarely question what we may be losing at the same time we are ostensibly gaining these attractive benefits. As Postman explains, however, 'for every advantage a new technology offers, there is always a corresponding disadvantage. . . [and] the question 'What will a new technology do?' is no more important than the question, 'What will a new technology undo?" (1998).

The truth is that digital technologies *can* do many things better than physical versions can, and for this reason, they tend to win a territorial fight. As a result, more

and more real world services are being replaced by digital services — and the real worlds we inhabit become less vibrant (i.e. the so-called 'death of the high street') and employ fewer and fewer people[18].

Solution: To prevent the atrophy of our real world, ensure that a cyberspace contribution fills a unique niche that is not otherwise being filled by a physical activity or service — *particularly* when the real life version serves an important and highly valued purpose. In instances when digital technologies significantly surpass the physical version along certain dimensions, it will be necessary to make room for that digital contribution; but as much as possible, ensure that digital and physical variants compete only with respect to the specific overlap they provide. Specifically, where a digital technology adds greater value to a specific service functionality (e.g. data retrieval), couple the addition of this technology with support systems to enhance the non-overlapping functionalities of the service they are in seeming competition with. This will help the two services slowly adapt to different niches, whereby they are no longer in competition.

Dominant frames: *Shared Prosperity*

Related Patterns: (2) Machines are fundamentally dissimilar to and are relatively simplistic constructs of humans, (5) Progress as Nourishment, (7) Rootedness, (13) Rooted Businesses

Related Patterns in other Pattern Languages: *Schuler (2008):* (3) The Good Life, **(39) Technocriticism**; *Alexander et al. (1977):* (67) Common Land

■ ■ ■

7 – Rootedness

Problem: Perception of cyberspace as an ether floating 'above' and entirely separate from our physical world is not only false but also prevents us from negotiating a healthy, mutually enhancing relationship between these dimensions of what is, ultimately, a shared reality.

Context: This pattern pertains to a conceptual reframing of cyberspace as it relates to the physical world that should help align digital development with real world

[18] It is important to note, further, the redundant real world jobs that are not reproduced in the digital world. Carr writes, 'Many new companies are using the utility computing grid to create burgeoning enterprises with hardly any employees' (2008: p. 130). For example, Skype has approximately 90,000 fewer employees than British Telecom (ibid: p. 131); Kodak, which used to employ over 140,000 people, was put out of business in large part by Instagram, which employs only 13 people (Lanier, 2013: p. xii).

needs. Like the previous pattern (6 – Cyber Niche), it is intended to help internalise real world impacts as a consideration of digital development.

Cyber-Sustainability Concerns: Size; Quality

Relationship to Quadruple Bottom Line — primarily: Environmental; Personal

Discussion: Cyberspace allows us to differentiate between two qualitatively distinct yet simultaneously coexisting realities — the physical world, and the digital world[19]. Wertheim explains:

> *In a very profound sense, this new digital space is 'beyond' the space that physics describes, for the cyber-realm is not made up of physical particles and forces, but of bits and bytes. These packets of data are the ontological foundation of cyberspace, the seeds from which the global phenomena 'emerges'. . . . Because cyberspace is not ontologically rooted in these physical phenomena [of particles and forces], it is not subject to the laws of physics, and hence it is not bound by the limitations of those laws* (Wertheim, 1999: p. 226).

The first problem this perception poses is that it is easier to inadvertently damage the physical world through our cyber activities. For example, many people do not consider the real world CO_2e emissions that result from having to power the storage of content they upload to the Web. The second is that we may view cyberspace as so liberating that we aspire to live in it[20]. This is the science fiction dystopia of Forster's *The Machine Stops*. And this is not necessarily a separate issue from the first. Ultimately, in Forster's story, a growing preoccupation with Machine-mediated life precipitated a decline in concern for (or perhaps even awareness of) the environmental devastation in the reality outside of the hive.

The increasingly popular metaphor of the Web as a 'cloud' is problematic for these reasons. It evokes a heavenly otherworld where one escapes the burdens of physicality. It is also far removed from an awareness of environmental impact, being a deceptive descriptor of what is effectively an infrastructure of electricity hungry hard drives (Glanz, 2012).

Solution: If one were designing the foundations of a building, 'The best foundations of all are the kinds of foundations which a tree has — where the entire structure of

[19] Most of us, however — and especially the Web-savvy and those born into the era of the Web (a.k.a. 'Digital Natives') — navigate fluidly between the digital and our real lives.

[20] Minsky is purported to have aspired to 'create a computer beautiful enough that a soul would want to live in it' (Turkle, 2011: p. 85).

the tree simply continues below ground level, and creates a system entirely integral with the ground, in tension and compression' (Alexander et al., 1977: p. 1006). Cyberspace should similarly be rooted — i.e. both to the reality of the physical impact cyberspace has, and to the potential for cyberspace to meaningfully integrate with the physical world. Specifically, this would be helped by creating regions of cyberspace that correspond directly to physical regions or communities (see Related Patterns).

Dominant frames: *Shared Prosperity*

Related Patterns: (1) Cyberspace represents infinite possibility, (6) Cyber Niche, (8) Cyber-Glocalisation, (13) Rooted Businesses, (15) Sanctuaries

Related Patterns in other Pattern Languages: *Schuler (2008):* (2) The Commons, (13) Back To The Roots; *Alexander et al. (1977):* **(214) Root Foundations**

■

6.2.4 Structural patterns

These patterns pertain to the design of the mechanisms underpinning cyberspace development (e.g. the mechanisms of data sharing and storage), and define the fundamental characteristics of a new Cyber-Sustainable 'Internet' and 'Web'.

■ ■ ■

8 – Cyber-Glocalisation

Problem: Groups cannot effectively and democratically self-govern beyond a certain size (Alexander et al., 1977: p. 11–3). The World Wide Web is a global 'community' (in the very loosest sense of the term) of approximately 2.27 billion people (Pingdom, 2013); Twitter alone, were it a country, 'would be the 12th largest in the world'[21] (Bennett, 2012). This group is comprised of individuals from very different cultures, and from real-world communities that are struggling with real (and different) problems. In order to enable communities to self-govern and address their own needs — both in terms of local resilience and cultural integrity — certain restrictions to the flow of data might be required.

Context: This pattern attempts to address the flow of data between architecturally self-contained regions of the Internet. The pattern does not propose any architectural modification of the Internet; instead it proposes a means of gating communities in a way that enhances their ability to self-govern and thrive, and which may mirror real-world (geographic or interest-based) communities.

Cyber-Sustainability Concerns: Resilience; Empowerment

Relationship to Quadruple Bottom Line — primarily: Social; Personal

Discussion: The Internet is a global technological infrastructure of linked computers that enables the sharing of data between these computers. The Internet architecture contains both backbone Internet Service Providers (ISP) and regional ISPs. Regional ISPs are self-contained in the sense that were they to 'go down'

[21] In terms of population.

(e.g. due to technical failure, major power outage, cyber-attacks, etc) the remainder of the Internet would not also 'go down'. Local area networks (LANs)[22] and Wide area networks (WANs)[23] are also architecturally insular — their failure would not be systemically disruptive from a technical standpoint.

In reality, however, the *data* that flows between regional ISPs and WANs and the rest of the Internet via the World Wide Web is *not* self-contained. The Web is highly integrated, such that performing a single activity on the Web is often dependent on many other parts of the Web performing related activities. The cyber-attacks in Estonia in 2007 demonstrated the havoc that can ensue from localised disruptions, i.e. completely cutting off connections to outside businesses upon which local businesses rely.

The fluidity of data between architecturally self-contained groups of computers is not only problematic in terms of resilience, but also in terms of the difficulties they present for self-governing. Countries differ in terms of legal protections of data privacy and rules about appropriate uses of the Web — and while Web purists bemoan the latter as an infringement of net neutrality, both are assertions of cultural values that work to preserve cultural integrity in a world that is increasingly homogenized.

Efforts such as Portugal's 'independent' Web (Gomes & Silva, 2004) reflect the desire to protect a culture from this homogenization; yet what the Portugal Web does not do is provide greater opportunity for individuals in Portugal to participate in the policy formation regarding this Web — i.e. the particular role that the Web can and should play in Portuguese life. Were Portugal able to adapt the Web to suit its own needs and culture, this might be described as a form of 'glocalisation' (Khondker, 2004; Wellman, 2002). In order to do this, however, certain aspects of the Web would need to be redesigned (as below).

Solution: Enable communities to carve out independently governed regions of cyberspace, with control over their boundaries and gates to outside regions. These community Cyberspaces — whether they are rooted to geographical communities or to communities that share some other common interest — should manifest a local variant of the Web that reflects the values and needs of community members. This requires imagination about the potential purposes the Web may serve beyond the model of the Web as an outboard brain and/or massive library. This pattern is a pre-requisite of several other patterns in the Cyber-Sustainability pattern language.

[22] LANs (e.g. Ethernet) enable high-speed data transfer over a local network of computers and devices that share a connection to the Internet. LANs might be found in homes, schools, small businesses, etc.

[23] A WAN links LANs that may be located around the world. They may also be known as enterprise WANs because global businesses use them to connect globally distributed franchise activities.

Further evidence of the importance of this pattern can be found in other pattern languages (see below, especially bolded patterns).

Dominant frames: *Embodied Mind*; *Shared Prosperity*

Related Patterns: (3) Technology reinforces the worldview that produced it, (7) Rootedness, (11) Ritual Deletion, (12) Community Chest, (13) Rooted Businesses, (14) Twinning, (16) Carnivals

Related Patterns in other Pattern Languages: *Alexander et al. (1977):* **(1) Independent Regions**, **(8) Mosaic of Subcultures**, (12) Community of 7000, (13) Subculture Boundary, (14) Identifiable Neighborhood, **(15) Neighborhood Boundary**, (44) Local Town Hall, (53) Main Gateways, (214) Root Foundations; *Gamma et al. (1995):* Builder, Factory Method, Facade, Mediator, Template Method; *Schuler (2008):* (4) Social Dominance Attenuation, (7) Political Settings, **(16) Linguistic Diversity**, **(25) Cyberpower**, (29) Indicators, (31) Democratic Political Settings, (36) Participatory Design, **(55) Indigenous Media**, (109) Control of Self-Representation, (114) The Power of Story

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9 – Bounded Replication

Problem: There are currently no mechanisms for preventing unnecessary and/or illegal replication of digital content[24], and as a result, the Internet is turning into 'a giant copy machine' (Lanier, 2013: p. 215). This makes the Internet bloated and inefficient, requiring machines to consume energy to store unnecessary data. It also has important sustainability implications related to the value (economic and otherwise) of creative content.

Context: This pattern is an extension of the Cyber-Glocalisation pattern, applying the principle of decentralisation to creative content generated within both the World Wide Web and local Cyberspaces.

Cyber-Sustainability Concerns: Size; Quality

Relationship to Quadruple Bottom Line — primarily: Environmental; Personal

[24] Although there are tools for detecting this replication, e.g. Copyscrape; but the responsibility generally lies with the owner of the content to check for unwarranted copying.

Discussion: While it is difficult to determine how much of the data on the Web is attributable to data copying[25], BitTorrent alone — whose users trade in pirated copies of music and videos — is estimated to account for half of the bits on the Internet (WeBlogTheWorld, 2010). Given that the carbon footprint of the Internet is estimated at around 300 million tonnes of CO_2 per year ('equivalent to every person in the UK flying to America and back twice over') (Clark & Berners-Lee, 2010), then just our illegal copies of music and videos costs us around 150 million tonnes of CO_2 per year.

Beyond this environmental cost, a design that enables others to steal creative content breeds a culture of entitlement[26] — not to mention exploitation — whereby people imagine that all information (including that which people go to great lengths to protect, and is their legal right to do so) should be freely available. This ultimately impoverishes our creative industries, and may 'usher in a dark age in which everything human is devalued' (Lanier, 2010: p. 82).

Solution: Like the Cyber-Glocalisation pattern, which seeks to increase opportunity for people to self-govern, people should also have control over their creative outputs. To ensure that creators retain ownership, the servers storing creative content would need to be decentralised. People may *link* to this content, but are not able to *copy* the content. This may imply a future in which all digital content is streamed rather than owned — e.g. following the Spotify model of listening to music stored on a server, rather than the iTunes Store model of listening to music stored on one's personal device. Given that there is clearly a need for *some* replication for the purposes of availability, performance, and scalability, creation of copies ought to be bounded, i.e. these copies should not exceed a set number.

Related Patterns: (1) Cyberspace represents infinite possibility, (4) The Web is a temporary gift, (10) The Life Cycle of Data, (11) Ritual Deletion

Related Patterns in other Pattern Languages: *Gamma et al. (1995):* Singleton, Observer; *Schuler (2008):* (2) The Commons, (64) Transparency; *Lanier (2013):* Two-Way Linking; *Blevis (2008):* Decoupling use from ownership

■ ■ ■

[25] Again, however, Gantz et al. (2010) have estimated that 75% of data on the Internet is a copy.

[26] Lanier notes the ethic of openness that pervades digital cutlure: 'The right to copy files on the Internet is held up as a form of free speech in the digital rights community' (2013: p. 215).

10 – The Life Cycle of Data

Problem: Over time, information that was once important can become redundant. Information is replaced by better information; ideas are replaced by better ideas; some knowledge loses its value or relevance. In the real world, we have (often natural) means of filtering out redundant information — theories are abandoned, memories forget; ink fades, pages crumble; books are removed from circulation in libraries, libraries burn down. Deleting redundant information in cyberspace is an essential means of ensuring that we are retaining only that which is actually worth storing.

Context: This pattern relates both to cyberspace policy and the technical design of the Web.

Cyber-Sustainability Concerns: Size; Quality

Relationship to Quadruple Bottom Line — primarily: Environmental; Personal

Discussion: The vast majority of the data in cyberspace is stored on a physical hard drive[27], which means that it accrues a carbon footprint as long as it remains on a hard drive[28]. Problematically, it is difficult (and in some cases impossible) to delete data from the Internet. Even if one were to delete their copy of a file, it still exists wherever anyone has copied that file. Additionally, services like the Wayback Machine retain archived versions of websites that can be located within a three-dimensional index (Internet Archive, 2013).

The main mechanism for filtering information in cyberspace is the search engine. Nodes that are accessed more often and more recently become the top sites returned in subsequent searches. But the less frequently accessed data remains in the network. If cyberspace were a library, the only cost of retention of this information would be the physical space the information takes up, making less room for new information; but in cyberspace, the cost of retention is the hard drive costs plus indefinite accrual of the carbon footprint associated with that data.

All information technology 'is based fundamentally on design judgments about what

[27] Some digital data is, however, transient: 'radio and TV broadcasts that are listened to but not recorded, voice call packets that are not needed when the call is over, images captured for a time then written over on a surveillance camera recorder' (Gantz et al., 2008: p. 4).

[28] Digital content is predicted to continue its trend of exponential growth, which would make the amount of content to be stored '10 times bigger in the next five years' (Gantz et al., 2008: p. 9). In addition to the environmental implications of such a vast storage commitment, this makes the already immense challenge of locating relevant data that much greater. In fact, 'we couldn't store all the information we create even if we wanted to' (ibid: p. 4), indicating that decisions need to be made regarding the relative value of data. As Gantz rightly point out, 'This mismatch between creation and storage, plus increasing regulatory requirements for information retention, will put pressure on those responsible for developing strategies for storing, retaining, and purging information on a regular basis' (p. 4).

to remember and what to forget' (Lanier, 2013: p. 28). We tend to idolise (Fromm, 1997) the capacity for digital technology to remember because it far exceeds our own memory capacity; but designing a Web that complies with the principles of sustainability requires that we exert our human capability for judgment in deciding what to forget.

Solution: Engineer time-based decay (decreased fidelity) and death (deletion) of data (cf. Sas & Whittaker, 2013; Ambrose, 2012). Bearing in mind projected rates of data generation, develop policies regarding the rate of decay and the life-span of data. Because not all data is equally valuable[29], these rates and life-spans should be adjustable according to (first) the originator's determination of the importance of preserving that data and (secondly, and in instances when the originator cannot make such a decision) the public's determination of its importance. The system could work approximately as follows. Whenever a file of a given type is born (i.e. added to the Web), the originator of that data is able to label it with a tentative life-span, based on how long the data seems like it might be relevant. Based on this initial categorization, the data immediately becomes subjected to the rules of decay — e.g. after X period of time, the fidelity is reduced by X amount, etc — and is given a date of deletion. For files that are accessed more regularly, their rate of decay decreases. When the data approaches its death, the originator of that data can opt to extend the life of that data. If the originator of the data does not choose to extend the life of the data, that data will become flagged for deletion, and can only be retained if someone else chooses to extend its life. (In extending its life, that person then becomes the caretaker of that data and is responsible to extend the life of the data in the future.) Extending the life of data should be made as easy as possible — the goal is not to get people to lapse, but rather to add a brief moment of reflection about the value of retention of that data.

Dominant frames: *Finite Resources* (see page 22)

Related Patterns: (1) Cyberspace represents infinite possibility, (2) Machines are fundamentally dissimilar to and are relatively simplistic constructs of humans, (5) Progress as Nourishment, (9) Bounded Replication, (11) Ritual Deletion

Related Patterns in other Pattern Languages: *Alexander et al. (1977):* (248) Soft Tile and Brick; *Schuler (2008):* (13) Back To The Roots, (22) Sustainable Design, (124) Environmental Impact Remediation

[29] As evidence of our willingness to accept this concept in the real world, consider that while we preserve Shakespeare's works, not much remains of his contemporaries.

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6.2.5 Behavioural patterns

These patterns pertain to the human behaviours and societal and/or community functions that are afforded by Cyber-Sustainable designs.

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11 – Ritual Deletion

Problem: Choosing which information to retain and which to delete reflects and reaffirms the values held by the people in charge of that decision. For this reason, both retention and deletion in Cyberspaces can powerfully shape the community and ought to be done with an appreciation of the social import of such activities. As Cyberspaces develop, there may be ways in which the retention and deletion can be handled that maximises the ability of community members to shape their Cyberspace culture and create meaning.

Context: This pattern is closely related to The Life Cycle of Data, and although The Life Cycle of Data is not a necessary pre-requisite of this pattern, this pattern works best when added to The Life Cycle of Data. While The Life Cycle Of Data makes sense at both the global and local level (i.e. for global cyberspace policy or for localised cyberspaces' policies), this pattern pertains to the local level. Specifically, the pattern articulates a mechanism for addressing the environmental impacts of indefinite data retention while fostering community cohesion and providing opportunities for shared meaning making.

Cyber-Sustainability Concerns: Size; Quality; Nourishment; Empowerment

Relationship to Quadruple Bottom Line — primarily: Personal; Environmental; Social

Discussion: Ritual is a powerful means of generating and expressing a shared representation of community values. In totemic societies, objects in the world are demarcated as sacred or profane — sacredness 'is a material representation of the clan' (Durkheim, 1995: p. 124); profanity is that which threatens the clan. In

turn, ritual traditions are created which elaborate the meanings generated by the group. According to Durkheim, 'It is through common action that society becomes conscious of and affirms itself' (ibid: p. 421); and through ritual, the individual experiences a 'collective effervescence' that comes from being part of something greater than oneself (ibid: p. 314). Rituals are repeated 'as often as it is necessary to renew their effects' (ibid: p. 420).

Solution: Involve the Cyberspace community in the process of determining which data to retain and which to delete. This entails as a starting point engaging in discussion with community members about what they value and what they want the Cyberspace to contribute to themselves and their community. (To better craft successful communication, see Schuler, 2008.) This may involve scheduling on a regular basis (e.g. once per year) opportunities for the community to participate in deleting data that does not contribute to and/or directly conflicts with the community's evolving narrative about the 'purpose' of this Cyberspace — delete only the data that those participating unanimously agree should be deleted. (All data will be decaying and dying per the rules of The Life Cycle Of Data anyway, but this ritual deletion enables the community to engage more actively towards a shared vision.) As part of the same process, community members can nominate data (whatever form it may take) that they feel is a particularly important reflection of the community narrative. The community could then vote on which data should be preserved in the Holy Ground area of their Cyberspace, to be retained for future generations — which perhaps need not be unanimous. Once added to the Holy Ground, the data loses its ability to decay and die.

Dominant frames: *Empathy*

Related Patterns: (1) Cyberspace represents infinite possibility, (3) Technology reinforces the worldview that produced it, (5) Progress as Nourishment, (8) Cyber-Glocalisation, (9) Bounded Replication, (10) The Life Cycle of Data

Related Patterns in other Pattern Languages: *Alexander et al. (1977):* (14) Identifiable Neighborhood, (24) Sacred Sites, **(66) Holy Ground**, (70) Grave Sites; *Schuler (2008):* (11) Memory and Responsibility, (29) Indicators, (36) Participatory Design, **(87) Value-Sensitive Design**, **(101) Shared Vision**, (109) Control of Self-Representation, (114) The Power of Story

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12 – Community Chest

Problem: Cyberspaces can only succeed if the people that contribute to those cyberspaces are thriving[30]. The thriving of people is dependent in large part on a flow of wealth towards their needs, and is therefore incompatible with a system that enables a predominant flow of wealth to outside beneficiaries. A mechanism for promoting the circulation (and in turn, accumulation) of wealth within a community is needed to ensure the wellbeing of real world communities.

Context: This pattern assumes the implementation of the Cyber-Glocalisation pattern; it addresses real world community needs by creating a means of capturing and amplifying wealth as a byproduct of cyberspace activity.

Cyber-Sustainability Concerns: Empowerment; Nourishment

Relationship to Quadruple Bottom Line — primarily: Economic; Social

Discussion: The Web is rooted in an egalitarian philosophy that believes that information should be free to all (cf. Kahle, 2007). From its initial inception, therefore, the Web has been free to use — a quality that is vehemently defended not only by the Web visionaries but also by the individuals who have come to expect free access to the Web. It is, of course, an illusion of our accounting system that the Web is 'free'[31]. There are tremendous costs to our planet and to our overall wellbeing that are externalised in order to make this free access viable; not to mention the fact that the running costs of Web services are met through advertising revenue, meaning that one of the visible prices we pay for free access is being subjected to an endless barrage of advertisements[32].

One of the externalised costs of a 'free' Web is best summarised by the popular adage: if you are getting something for free, you are the commodity. For Lanier, a system that entices people to give away their information for free ultimately serves to deplete people's value in an information economy (2013: p. 55). Lanier's solution to this problem is to create a micropayment system that monetizes people's informational contribution such that they are compensated whenever it is used by others. While there may be a place for such a solution within Cyber-Sustainability[33], this solution does not address another implication of the way digital technologies

[30] In Lanier's words, 'A market economy cannot thrive absent the well-being of average people, even in a gilded age. Gilding cannot float. It must reside on a substrate' (2013: p. 37).

[31] And, indeed, many services, including wifi and mobile networks are charged, or entice users with free trials.

[32] Note that research (Kasser, 2002; Schor, 2004) suggests that advertisement is correlated with reduced mental health and wellbeing.

[33] Although in its current form it proposes a problematic equivalence between people's 'value' and their 'data'.

currently enable the distribution of wealth — i.e. not just money, but also wealth-producing time and effort. Specifically, the wealth that is generated by digital services *leaves the circulation* of the community in which the participating individuals live in the real world (see 15 – Rooted Businesses). This means that more and more wealth is being diverted outside of the community. Meanwhile there are countless real world, local community problems that need money as well as time and effort and would greatly benefit from a mechanism that captured and fed this wealth back to the public.

Solution: Cyberspace access[34] should incur a minimal, local-currency-based cost that cycles back into the community's overall pool of wealth[35]. In this way, wealth spent online (i.e. labour time that could otherwise be spent in the community) is not lost to cyberspace; instead, it is captured in a form that encourages people to reciprocate this labour in their physical community. Specifically, each hour an individual spends online should contribute to one's individual debt; this can be repaid through labour time spent in the community, and any debts not repaid are collected in a community chest. Allocation of this wealth should be determined by Cyberspace community participation as part of the self-governing process of the Cyberspace: on a regular basis, candidates for this wealth (e.g. community projects, global initiatives, etc) can be proposed and voted on by Cyberspace members, and community members are encouraged to repay their debt by contributing to these larger community efforts. The result of this pattern is that community wealth, and the well-being associated with it, *increases* with more people using Cyberspace (cf. Lanier, 2013: p. 231). (Explaining this feedback mechanism to the Cyberspace community would be an essential means of overcoming initial resistance to 'paying' for access to Cyberspace.) The core of this pattern is principally that of many local currency initiatives, namely that 'wealth creation' involves designing an alignment between whatever information system is used to abstract value and concrete benefits to individuals in the community (cf. Lanier, 2013 p. 28). The key to designing this alignment is to a) ensure that the system works to generate wealth, b) enable participation in the delineation of the needs of the community, and c) create a means of funneling wealth towards satisfaction of those needs.

Dominant frames: *Shared Prosperity*; *Empathy*

Related Patterns: (5) Progress as Nourishment, (7) Rootedness, (8) Cyber-Glocalisation, (13) Rooted Businesses

[34] i.e. usage of whatever form of Web that is developed by a community

[35] Note that 'wealth' in this case is different than the Self-Enhancement value 'Wealth' described by Common Cause research. Here, 'wealth' is associated with concern for others in one's community, closer to Benevolence, a Self-Transcendence value.

Related Patterns in other Pattern Languages: *Alexander et al., 1977:* (12) Community of 7000, (14) Identifiable Neighborhood, (44) Local Town Hall, **(45) Necklace of Community Projects**, (214) Root Foundations; *Schuler (2008):* (3) The Good Life, (7) Political Settings, (25) Cyberpower, (29) Indicators, (30) Public Agenda, (31) Democratic Political Settings, (63) Community Currencies, **(71) Participatory Budgeting**, **(72) Transaction Tax**

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13 – Rooted Businesses

Problem: Massive international 'dot com' businesses are able to offer products and services at rates that local, real world businesses cannot compete with. In the long-term, the loss of physical business presence denudes society, stripping away localities for real-world socialisation and non-screen-mediated experiences.

Context: This pattern describes a specific instance of applying the (higher-level) Rootedness pattern, and pertains to the business practicalities of Cyber-Glocalisation.

Cyber-Sustainability Concerns: Resilience; Empowerment

Relationship to Quadruple Bottom Line — primarily: Economic; Personal

Discussion: The so-called 'death of the high street' has been attributed to the failure to develop economic models that provide levees to local businesses in an age of increased globalisation. Initially, the challenge to local businesses came from mega chain stores that could offer more selection and at lower costs; high streets soon became homogenized replicas of one another, each populated by a similar collection of globalised chain stores. But now many of these chains are themselves struggling, as they cannot compete with the prices and convenience offered by dot coms, which often use powerful computer algorithms and data mining to enable them to undercut likely competitors (Lanier, 2013: p. 57). This creates a positive feedback loop resulting in a death spiral for the high street: the bankruptcy of these high street stores leaves shop fronts empty, thus reducing the overall appeal of shopping on the high street and turning more people towards online shopping.

Solution: Root all dot com businesses to a specific (Cyber-Glocalised) cyberspace — ideally one that represents a true connection between the business and the community (i.e. geographical, ideological, etc). Root businesses by 'gating' them within

a glocalised web and apply tariffs to pass through these gates. Tariffs would be applied in instances when a transaction meets both of the following criteria: 1) it occurs between cyberspaces, and 2) it could have been made within the local cyberspace (i.e. the transaction is with a competitor to a local cyberspace business). These tariffs would function such that the cost of a non-local transaction is minimally greater than the cost of a local transaction, thereby encouraging local business-to-business and business-to-customer trade. This pattern requires dot coms adopting the mentality described in Burlingham's *Small Giants* (2005), i.e. aiming to offer real benefit to their community rather than simply increase their wealth. Over time, this should not only ensure a more even distribution of wealth (i.e. a move away from the trend of increasingly concentrated wealth in the hands of the few), while working to undo some of the homogeneity between communities and enhancing opportunities to shape communities in accordance with local needs.

Dominant frames: *Shared Prosperity*; *Empathy*[36]

Related Patterns: (5) Progress as Nourishment, (6) Cyber Niche, (7) Rootedness, (8) Cyber-Glocalisation

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14 – Twinning

Problem: Giving communities the power of self-governing their Cyberspaces potentially opens up the possibility for individuals to be disempowered or have their rights abused by dictatorial control within the Cyberspace.

Context: Implementation of the Cyber-Glocalisation pattern requires implementation of some mechanism for preventing the potential for abuses. This pattern is one such mechanism.

Cyber-Sustainability Concerns: Empowerment; Nourishment

Relationship to Quadruple Bottom Line — primarily: Social

Discussion: Oppression and restriction of civil liberties by dictatorial leaders has occurred throughout history. Recently, government attempts to shut down free

[36] This pattern relies on the *Self-Interest* frame to the extent that it supposes that a mechanism for motivating sustainable transactions is to make it economically advantageous to do so; however, it also supposes that businesses can find reason to commit to this plan, as evidenced by the *Empathy* underpinning *Small Giants* (Burlingham, 2005).

speech regarding such activities have been circumvented by the public using Social Media (Web 2.0) — the most publicized example being the use of Twitter and Facebook during the so-called 'Arab Spring'. This example demonstrates the potential of the Web (and potentially other manifestations of communication via cyberspace) as a means of facilitating social justice.

As the main antidote to oppression, however, we have created certain means of intervention, e.g. the United Nations and NGOs. These organizations are entrusted with keeping an eye out for global instances of oppression, and can enter into these countries to 'liberate' oppressed peoples. If cyberspace is carved into autonomous regions, it is important to design some oversight while retaining each Cyberspace's right to create a space that reflects their values. While a cyberspace equivalent of the United Nations might seem appropriate, it may not be necessary — cyberspace is not so distinct from the real world, and the United Nations could intervene in cyber-crimes. Furthermore, there may be a solution that engages smaller communities in global cyber-citizenship, while forging connections with and interacting positively with very different communities.

Solution: Each Cyberspace should be twinned with at least two other Cyberspaces — ideally ones that are both culturally and geographically (if the Cyberspace is rooted to a geographical region) distant from the Cyberspace in question. Twinning occurs in the real world (e.g. twin towns, sister cities, twinned institutions), and represent commitments to cooperation between the twinned parties. Typically, this is in the form of shared projects that benefit both parties. This could be a positive side-effect of the twinning, though the main benefit lies in the ability of a twinned Cyberspace to raise concerns to a larger governing body (e.g. the United Nations) in instances perceived to be infringing on internationally agreed human rights. In this way, Cyberspaces are autonomous insofar as they can create any culture that suits the community's needs so long as it complies with basic freedoms.

Dominant frames: *Empathy*

Related Patterns: (3) Technology reinforces the worldview that produced it, (8) Cyber-Glocalisation

Related Patterns in other Pattern Languages: *Alexander et al. (1977):* (1) Independent Regions, (8) Mosaic of Subcultures, (13) Subculture Boundary, (15) Neighborhood Boundary; *Schuler (2008):* (1) Civic Intelligence, **(4) Social Dominance Attenuation**, **(6) Global Citizenship**, (33) Opportunity Spaces, (43) International Networks of Alternative Media, **(53) Alternative Media in Hostile Environments**

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15 – Sanctuaries

Problem: There is a careful balance to be struck between the Web being accessible and the Web being inescapable. Increasingly, people are feeling overwhelmed by pressures to be 'always on', with negative consequences to health and wellbeing. How can design accommodate the need to find silence and solitude?

Context: This pattern pertains to the designed relationship between real world physical spaces and digital connectivity, and is intended to increase wellbeing.

Cyber-Sustainability Concerns: Nourishment; Quality

Relationship to Quadruple Bottom Line — primarily: Personal; Social

Discussion: It is a rare and potentially disconcerting experience these days to find oneself in a location where one is unable to connect to the Web. We have grown accustomed to the ability to find information whenever and wherever necessary, and to be able to contact people on the move (cf. Elliot & Urry, 2010). Despite the fact that most people that have come to rely on mobile communications can remember a time before technology afforded such 'conveniences', we have grown accustomed to — and in turn, *reliant on* — this ability to connect. 'We are all cyborgs now,' writes Turkle (2011: 2965-71); we are always one foot in the 'real world' and one foot in cyberspace.

As much as people may experience a felt need for connection, however, there is reason to suspect that enabling practices of constant connection is detrimental to wellbeing — e.g. preventing people from being able to switch off and recuperate during 'downtime' (Turkle, 2011: p. 167). There is also abundant reason to be concerned about the way such ubiquitous connectivity erodes opportunity for silence and solitude. Many spiritual and religious traditions ascribe great importance to contemplative time spent alone (e.g. monastic traditions, hermiticism), and associate such experiences with opportunity for depth of thought, enlightenment and spiritual growth (cf. Maitland, 2008).

This tension is described by Marx (1964) as that between the industrial ideal of efficiency and the pastoral ideal of meditative thought (Carr, 2010: p. 168): the solution is to seek a balance, to have 'time to operate the machine and time to sit idly in the garden' (ibid: p. 168). Without opportunity for unproductive time, people are likely to burn out from exhaustion. Less drastically, but no less worrisome, without opportunity for reflective time, people are unlikely to cherish and seek out the very stuff that makes life worth living.

At a minimum, it might be said that connectivity does not add to the sense of fulfillment that can be found in certain real world activities — e.g. '[g]oing for a long run in a warm gentle rain, gratefully and carefully easy my body into the swelter of a hot sprin[g], listening to the first snowfall of winter,' etc (Greenfield, 2006: p. 258). And yet the justification for resisting ubiquitous connectivity must be argued more assertively: in order to be fully human, we need to be able to retreat from the Web. As Thoreau argued in Walden (1854), 'we live "thick," unable to acquire value for each other because there is not enough space between our times together' (paraphrased by Turkle, 2011: p. 274).

People may spontaneously opt out of their connective obligations, and retreat like Thoreau to their own Walden ponds. (Many already have.) Yet design can help people negotiate a healthier balance (or line) between 'the machine' and 'the garden' in three ways. Firstly, designers can create spaces for those that are already aware of a need for a sanctuary from digital pressure, enabling people to choose to enter spaces that are designated as such sanctuaries. Secondly, designers can help those that are stuck in the feedback loop of connectivity by creating opportunities for these individuals to experience disconnection. While these experiences may provoke unease at first, as they become more familiar, they will become less anxiety provoking (cf. Maitland, 2008). As a new norm develops, whereby individuals are allowed to be disconnected in certain spaces, the obligation to be connected at all times should begin to recede, disrupting that unhealthy feedback loop. Thirdly, designers can protect further spaces from becoming connected by consciously designing to not have connectivity.

Solution: The ability to connect to the Web is now a necessity of modern life (Richards et al., 2013), meaning that any viable solution to the problems caused by pervasive connectivity cannot entail a complete rejection of this technology. It should, however, be put in its rightful *place* (Turkle, 2011: p. 294-5) — i.e. not in all of our 'gardens'. It is important to retain spaces in the physical world where people can escape from the pressures of digital society. Designate certain physical spaces as 'connection dead zones' in order to enable people to disconnect. In particular, seek to ensure that places that have historically been used to disconnect from the busyness of life (e.g. parks, gardens, beaches) are protected from the encroachment of connectivity. Analogous to quiet coaches on trains, also consider creating connection dead zones on public transportation (e.g. connection dead coaches, connection dead seats/sections, connection dead services).

Dominant frames: *Embodied Mind*

Related Patterns: (1) Cyberspace represents infinite possibility, (2) Machines are

fundamentally dissimilar to and are relatively simplistic constructs of humans, (5) Progress as Nourishment, (7) Rootedness

Related Patterns in other Pattern Languages: *Alexander et al. (1977):* (24) Sacred Sites, (51) Green Streets, **(59) Quiet Backs**, (60) Accessible Greens, (111) Half-Hidden Garden, (141) A Room of One's Own, (173) Garden Wall, (247) Paving With Cracks Between The Stones; *Schuler (2008):* (3) The Good Life, (38) Mobile Intelligence, (60) Digital Emancipation, (119) Great Good Place

■ ■ ■

16 – Carnivals

Problem: We are so familiar with the current manifestation of the Web that it is extremely difficult to imagine genuinely different visions of what it can be. But in limiting ourselves to the current usages of the Web, we may be missing tremendous opportunities for cyberspace to contribute to the experience of being human.

Context: This pattern suggests a means of promoting creative exploration of the latent possibilities of cyberspace.

Cyber-Sustainability Concerns: Quality

Relationship to Quadruple Bottom Line — primarily: Personal

Discussion: The Web works best when it enables people to be truly creative. The open culture movement is often held up as a shining example of the Web facilitating this creativity. And to the extent that open culture promotes creativity — or at a minimum, an ethos of creativity — this is undeniably in accordance with personal aspects of sustainability. How successfully these ambitions have been realised is a matter for debate. Lanier, for one, describes the open culture movement as a 'disaster':

> *Everything that [the open culture movement] can point to is either a nostalgic recreation or something that has existed in a far better form. . . . If 30 years ago I had said in one of my talks. . . , 'In 30 years computers will be millions, millions of times faster, and the great prize we'll have is a new UNIX release and an encyclopedia online,' and everyone would say, 'Ahh, that sounds pretty boring'* (TheGuardian, 2010).

Current Web design is itself not particularly creative, for two reasons. Firstly, developers have become 'locked in' (Lanier, 2010: p. 119-20) to using the same resources as predecessors, which tends to generate a creative rut and limit possibilities for new affordances. Secondly, developers have sought to digitise perfectly good non-digital creations, rather than using the opportunity that cyberspace affords to enable us to do truly new things.

What the open culture movement has proven is that the world is filled with creative individuals[37]. Perhaps their creativity can be harnessed towards the challenge of imagining new uses of cyberspace.

To this end, it is worth considering the value that carnivals add to society. Alexander et al. (1977) argue that carnivals are important to society as 'socially sanctioned activities which are the social, outward equivalents of dreaming' (p. 299). A similar space for community dreaming ought to be accommodated within cyberspace in order to stimulate fresh thinking about what cyberspace may yet become.

Solution: Create and support (perhaps through funding, competitions, etc) online spaces devoted to creative re-imaginings of cyberspace. Just as carnivals travel from town to town, enable the creators of these alternative visions to 'travel' from Cyberspace to Cyberspace as a means of stimulating new thinking in these communities about what as-yet unimagined benefits cyberspace could offer. (Traveling carnivals should, however, respect the desire of any Cyberspace not to allow this transfer of ideas.)

Related Patterns: (1) Cyberspace represents infinite possibility, (3) Technology reinforces the worldview that produced it, (5) Progress as Nourishment, (8) Cyber-Glocalisation

Related Patterns in other Pattern Languages: *Alexander et al. (1977):* **(58) Carnival**; *Schuler (2008):* **(33) Opportunity Spaces**, (66) Media Diversity

6.3 Discussion

Current trends appear to support two main functions for cyberspace: information storage and information retrieval. Envisaging cyberspace as an infinite storage space encourages the storage of non-essential data and discourages prun-

[37] Lanier said, 'The Web gave us the first empirical evidence that vast numbers of people really *are* creative, really *do* have things to offer, and really will do it, will really get their act together' (TheGuardian, 2010).

ing of this data (1 – Cyberspace represents infinite possibility). Envisaging cyberspace as a massive information index further exacerbates the propensity to retain non-essential data, and prevents creative thinking about the unique value that cyberspace may offer humanity. What is the purpose of cyberspace going to be, if not primarily to support information storage and retrieval?

Generating 'wealth'. One of the functions of cyberspace ought to be as a mechanism for supporting institutions and practices that add real value to society. That value can be measured in economic value, in which case cyberspace ought to enable the harnessing of wealth from digital activity and funnel it towards popular needs (12 – Community Chest). It might also be measured in terms of community resources, for example local businesses (13 – Rooted Businesses), services (6 – Cyber Niche) and skill sets (12 – Community Chest). This function is in keeping with the original meaning of 'community' — 'to give among each other' (Turkle, 2011: p. 238)[38] — and would promote a vision of cyberspace as a shared enterprise motivated to contribute towards fulfilment of real human needs (5 – Progress as Nourishment). As participants in this endeavour, individuals would be actively involved in the co-creation of value through their use of cyberspace.

Producing meaning. A great deal of care is required if cyberspace is to become something which satisfies our many and varied needs. A sustainable cyberspace would, therefore, support the practice of curation (10 – The Life Cycle of Data; 11 – Ritual Deletion), as opposed to mere accumulation. The practice of curation would mean storing only the data that makes a new and/or meaningful contribution, and pruning this collection over time, thereby reducing the environmental impact of the Internet while improving the quality of the Internet as a cultural artefact. Recognising meaning as a product of culture, and acknowledging the great variety of cultures which enrich the world, a sustainable cyberspace would support the integrity of these cultures by accommodating, and indeed cultivating, heterogeneity (3 – Technology reinforces the worldview that produced it; 8 – Cyber-Glocalisation).

Promoting autonomy. Current designs of the Web support freedom in the form of 'freedom from' (e.g. the tenet of 'net neutrality'), i.e. a lack of constraints on individual freedoms (Fromm, 1941). While this is associated with liberty, it does not necessarily empower. A sustainable cyberspace would instead protect individuals' 'freedom to', i.e. freedom to realise one's potential and thrive,

[38] i.e. as opposed to the casual application of this word to current social media which fails to meet this standard yet we have nonetheless accepted as one of the current functions of the Web (see also Lanier, 2010).

which is made possible only through support structures that necessarily entail certain ('freedom from') constraints. This would require that a sustainable cyberspace create opportunities for participation in the governing of cyberspace (8 – Cyber-Glocalisation; 14 – Twinning), and enable greater opportunities to participate in real world governing through cyberspace.

Fostering potential. To guide digital development according to a desire to transcend human limitations through technological augmentation is to miss the greater opportunity for these technologies to function to enhance our innate abilities, helping us become the best *humans* we can be. A sustainable cyberspace would function to enhance distinctly human qualities (2 – Machines are fundamentally dissimilar to and are relatively simplistic constructs of humans). Particularly desirable qualities would be those that appear to correlate with sustainability, e.g. mindfulness (15 – Sanctuaries).

Together, these new ambitions suggest a need for fresh thinking about what society ought to do with the opportunity afforded by cyberspace, and for radical innovation towards realising this vision.

6.4 Conclusion

The process of developing patterns enabled creative thinking about design solutions that appear to fit with the framework for Cyber-Sustainability, and revealed new insight for enrichment and refinement of this initial framework.

Five areas of concern for Cyber-Sustainability were identified in Chapter 5, namely Size, Empowerment, Resilience, Quality and Nourishment. Several cross-cutting themes can now be isolated that pertain to these areas of concern, including:

Curation: a practice of storing only the data that makes a new and/or meaningful contribution, and pruning this collection over time.

Integrity: a commitment to designing a digital society that empowers individuals by accommodating and supporting heterogeneity, rather than designing one-size-fits-all technologies.

Autonomy: enabling people to have influence over the governing of their cyberspace and real world communities.

Independence: designing the Web with an awareness of the potential atrophy of capabilities that comes from over-dependence on machines' capabilities, and potentially designing in added supports, and/or addressing this problem by designing non-technical support structures in society, e.g. developing means of fostering skills that the Web currently erodes.

Development: designing in a way that enables humans to develop their innately human abilities in order to thrive and to better succeed in the face of challenges such as sustainability.

Internalisation: design that both a) exposes true costs (practical, social, personal, economic) of digital technologies to enable debate about whether we can 'afford' them, and b) develops new economic models to reflect and accommodate these costs.

Creativity: supporting experimentation with possibilities of cyberspace.

Wealth: capturing and funnelling the 'wealth' (i.e. resources) created by digital activities towards satisfying the real needs of the masses.

These new concerns suggest several research contributions that computing might make towards Cyber-Sustainability. These contributions are summarised in the form of motivating questions, below, to enable easier comparison with the motivating questions of Green Computing (Table C.1, Appendix C.1).

How can we smooth the transition to sustainability? The patterns reveal that a change to Cyber-Sustainability would entail a fairly significant re-design of the Internet and the Web. For example, while Bounded Replication (9) and Cyber-Glocalisation (8) would ostensibly be more sustainable than the current design, transitioning would need to be done in a way that does not threaten the various systems that currently depend on the Internet. Plans would need to be developed for gradual migration to these new designs. Patterns such as The Web is a temporary gift (4) hint at potentially greater upheaval that computing may need to provide assistance in managing, such as planned downshifting.

How can we buttress necessary support structures? A sustainable cyberspace would actively prevent the atrophy of human capabilities and societal support structures (6 – Cyber Niche), and in doing so, increase resilience by better enabling people to thrive independent of digital technologies. Clearly, designing technological solutions to the problem of co-dependence on technology would not make a great deal of sense. Instead, designing for 'independence'

would mean a) designing with an awareness of the potential atrophy of capabilities, and b) designing (technical or non-technical) support structures in society, e.g. developing means of fostering skills that the Web currently erodes.

How can we design for sustainable lifestyles? In addition to these patterns developed here, the idea that computing may be able to play a role in smoothing transition to a sustainable society opens the door to further possibilities for research, including playing a role in enabling drastically less carbon-intensive living, on the scale that is required to prevent the worst effects of climate change (i.e. designing for 3-tonne per year carbon lifestyles[39]). The focus on *lifestyles*, rather than behaviours (as in Green Computing), indicates a commitment to stimulating long-term, systemic change for sustainability by contributing technologically to macro-systems re-design.

How can we work with policy makers towards realising significant changes? The patterns demonstrate that solutions are not limited to the technology itself or to the people who use that technology; rather, they entail major changes that may only be realised through joint efforts of technologists and policy makers. This suggests that computing will have to learn how to negotiate an effective relationship with policy makers — not only to realise their technological ambitions, but also to enable policy makers to realise the visions of forward thinking governments, which may require technical expertise. If a policy vision includes addressing sustainability at the level of worldview, for example, perhaps computing could develop technologies that work to reify the frames and values that align with the intended worldview shift.

How can we embolden change-makers? While 'persuasion' does not make sense for Cyber-Sustainability in the context of promoting responsible consumption behaviour (see critique in Chapters 3 and 4), 'persuasion' might be a powerful means of facilitating change if imaged differently. For example, technologies that foster Universalism and Benevolence values could embolden policy makers and citizens alike to take necessary actions to enable sustainable lifestyles. Furthermore, reinforcing Benevolence values may help foster community spirit — a necessary prerequisite of many of the Cyber-Sustainability patterns — thereby complimenting the implementation of these patterns. For example, persuasion could be used in motivating local fiscalism (13 – Rooted Businesses) and contributing towards the community resilience. Finally, alternative persuasive technologies could be created to heighten one's sense of connection with nature (see 7 – Rootedness), which could help promote a

[39] See Knowles et al., 2013b.

sense of duty towards environmental stewardship.

How can we help incubate radical innovators? In addition to the range of values that may be beneficial for motivating sustainable lifestyles, there are a range of cognitive traits (i.e. skills) that may better enable the kind of problem solving required for a society facing these wicked sustainability problems (cf. McGonigal, 2010). Computing may contribute by designing technologies that enhance these traits. Further research is needed to better understand which traits would be conducive to such problem solving, but examples such as pattern 15 (Sanctuaries) illustrate how design can enable traits such as mental focus and depth of contemplation.

How can we support creativity in thinking about cyberspace? The patterns demonstrate the potential for significantly reshaping what we think of as the Internet and the Web and developing entirely new uses that are in line with sustainability. It is hoped that the patterns offered so far are just the tip of the iceberg. The more people who can become involved in the process of reshaping the purpose of cyberspace, the more likely we are to design it to satisfy our human needs. Part of the computing challenge, then, is to develop ways of supporting new thinking about cyberspace. Carnivals (pattern 16) are one such suggestion which would require the development of a technological infrastructure to support it.

How can we involve and engage people in the co-creation of a meaningful cyberspace? These patterns require that people actively participate in the co-creation of cyberspace, rather than passively receive the creative outputs of technologists. This is a new dynamic that computing will have to learn to negotiate. This raises questions about how to conduct participatory design on a grand scale[40], and how to do so in a way that remains true to a mature understanding of sustainability.

How can we contribute towards the development of a new narrative about the role of technology in a sustainable society? One of the greatest obstacles to making progress towards a sustainable society is the difficulty in converging on a shared vision[41]. Computing, therefore, needs to work towards this shared vision amongst researchers, as well as communicating this vision in a way that is both clear and inspiring. This suggests a new role for computing, namely designing as one of its outputs an effective political campaign.

Can we develop new economic models to underpin the digital economy that internalise relevant factors, such as environmental, social and personal impact?

[40] See Schuler's (2008) Participatory Design pattern (pp. 210–3).
[41] See Schuler's (2008) Shared Vision pattern (pp. 413–6).

> There are inevitable economic implications of the proposed new purpose of cyberspace. For example, selling users' data to advertisers is not a sustainable means of funding Web-based businesses; nor is selling advertising space on web pages, which currently contributes to distraction and consumerism. How would development of sustainable cyberspace be funded? Furthermore, if it is determined that part of the solution for smoothing the transition to sustainability is to enable less dependence on digital technologies, how can such a project be leveraged into new research and business opportunities in computing? Or, if such a project is deemed necessary but unprofitable, computing would then need to present as part of its political campaign a powerful argument for technology as a philanthropic pursuit, or as a common good funded from taxes.

The significant difference between these questions and the questions that Green Computing is currently exploring is evident, and highlights the influence of the frames that underpin these discourses.

Part II Contributions

This second part of the dissertation has explored an alternative notion of sustainability that might guide new research in computing, capable of making a more significant sustainability impact than Green Computing has to date. To some extent, however, the comparison is one of apples to oranges: the 'sustainability' in question is different for Green Computing than for Cyber-Sustainability. That said, the effectiveness and consistency of the frames underpinning this notion of sustainability have been carefully considered *up front* in the development of this new Cyber-Sustainability discourse, in order to avoid the problematic (Self-Enhancement) values activation that currently undermines Green Computing's ability to meet its 'sustainability' goals.

The patterns developed in Chapter 6 help paint a picture of how far 'sustainability' solutions could diverge from those proposed by Green Computing. Hopefully, this inspires new, creative thinking amongst computing researchers interested in 'sustainability' issues, who may feel stuck in a particular way of approaching the problem. These chapters should also make clear how important it is to debate the premises of Green Computing discourse, as adoption of new frames can significantly alter the space of possibility for solutions. The dissertation proposes that a pragmatic stance be taken in such debate, and that researchers consciously construct a discourse that might enable the realisation of core 'sustainability' goals. These goals need not, necessarily, align with those of Cyber-Sustainability — although a strong case has been presented for a Quadruple Bottom Line basis for sustainability. What is more important, instead, is that computing arrive at some unifying vision of 'sustainability' — or failing that, several clear visions that might be pursued simultaneously without undermining each other. In either case, there is a certain urgency associated with 'sustainability', and these fundamental discursive issues must be addressed as soon as possible, while taking the necessary time to develop a discourse that can make a significant impact.

Chapter 7

Conclusions

Evaluating the contribution of Cyber-Sustainability

Introduction

In this final chapter, the major contributions of the dissertation are recapped. First (7.1), the argument from Chapter 2 to Chapter 6 is summarised. Section 7.2 then revisits the original aims and objectives of the dissertation and describes how these have been achieved. Section 7.3 summarises the key contributions to knowledge offered by this work. Section 7.4 explores limitations and opportunities for future work. And the dissertation ends (7.5) with concluding remarks.

7.1 Summary of dissertation argument

Part I of this dissertation constructs an extensive critique of Green Computing. The following points comprise the essential argument for the need for a new approach to 'sustainability' in computing:

- Green Computing is premised in a set of modernist assumptions which prescribe a limited solution space and a Self-Enhancement based strategy for garnering buy-in and enthusiasm.
- These solutions can at best have an only minor impact towards any measurable 'sustainability' goals, such as carbon emissions reductions; worse, they may reinforce a worldview and a set of values that is incompatible with 'sustainability' and lead to a net negative impact for 'sustainability'.
- Given that these solutions are rooted in a set of assumptions (frames), new frames must be adopted as the foundation for a new 'sustainability' discourse in computing.

Part II then presents possibilities for higher impact computing research for 'sustainability'. A new guiding notion of sustainability is developed in light of the following findings:

- A discourse that would appear to resolve the problems identified within Green Computing discourse (second bullet, above) would be imaginative/radical. (Notably, amongst all of the various genres of 'sustainability' research currently explored by computing, none can be categorised as imaginative and radical.)
- One notion of sustainability that is imaginative/radical and reinforces values consistent with its ambitions is the Quadruple Bottom Line of sustainability.
- Using alternative frames (to those of Green Computing) and the Quadruple Bottom Line as a foundation for a new sustainability discourse in computing, it is possible to develop ideas for radically different sustainability solutions that have yet to be explored, as illustrated through the development of patterns that pertain to the Internet and Web.

7.2 Revisiting aims and objectives

The aims and objectives of this dissertation have been achieved as described below.

- Differences between various discourses on 'sustainability' have been explored through the use of discourse analysis, which included the identification of cognitive frames underpinning these discourses (Section 2.1).
- Differences between 'sustainability' discourses within computing have been identified using discourse analysis, enabling the naming and classification of these competing discourses (Section 2.2).
- Gaps in current 'sustainability' research in computing have been exposed through extensive literature review and discourse analysis (Section 2.3).
- A decade of Green Computing research has been evaluated in terms of its potential impact for 'sustainability' by applying insights from values and frames research to this new domain, which involved the development and application of new values and frames analysis techniques (Chapters 3 and 4).
- A contemporary understanding of sustainability has been developed (adapted from 'Radical Sustainability') that includes notions of human meaning and fulfilment (Section 5.1).
- This understanding of sustainability has been applied towards elaboration of a new discourse in sustainability in computing which a) fills the gap exposed in earlier chapters, and b) is consistent with values and frames that are likely to yield a higher impact than Green Computing (Section 5.2).
- Key sustainability concerns have been identified for this new discourse based on an evaluation of the sustainability implications of current digital trends (Sections 5.2.2 and 5.2.3).
- Initial 'solutions' have been proposed towards realising this notion of sustainability as it relates to Internet and Web technologies, and the beginnings of a pattern language are presented (Section 6.2).
- Plans for future research have been articulated for this discourse and for related discourses that may also fill a gap in sustainability research in computing (Section 7.4, to follow).

7.3 Contribution to knowledge

The anticipated impacts of this research are:

- **Academic impact:** advancing depth of thinking about 'sustainability' in computing, exposing new opportunities for research, and inspiring research in directions that are more likely to make a significant impact for 'sustainability'.

- **Societal impact:** influencing and increasing the effectiveness of policy surrounding 'sustainable' computing, improving wellbeing, and increasing societal resilience.

The critique presented in Part I shines a light on the need to challenge orthodox thinking about sustainability in computing. To facilitate such new thinking, the methods used in this work are, themselves, inventive. Elements are borrowed from established techniques and combined with others towards new purposes. These methods represent key contributions of this work, but more important than that is the way in which they demonstrate the usefulness of this inventiveness for revealing the kind of insights that might spark radical innovation.

Another key contribution of this work is the creation of a new area of research in computing based in a transformative view of sustainability. In addition to highlighting the research opportunity to be found in exploring sustainability solutions from an imaginative/radical perspective, the entirely new field of Cyber-Sustainability is exposed and defined.

Finally, numerous patterns are presented in this work — some of which are admittedly impractical, but represent 'food for thought' regarding future digital development, and serve as provocations to those who may play a role in designing our digital future. This dissertation does not advocate the implementation of these patterns *per se*, and certainly not in the immediate future, as they represent a challenge to society that could be systemically disruptive unless they are integrated as part of a larger constellation of changes. The intended contribution of these patterns, instead, is to inspire developers to ask important questions about the various sustainability implications of digital technologies, with potential to subtly shape how designers envisage a 'desirable' digital future.

7.4 Future work

This research highlights just how much work computing has yet to do with regards to making a 'sustainability' impact. The discourse analysis provided in Chapter 2 describes the apparent understanding of 'sustainability' (both the perceived 'sustainability' problems and potential solutions to these problems) currently being communicated through Green Computing research as a whole, which is undoubtedly not representative of every individual researcher's stance on 'sustainability'. Where researchers differ in approach or in worldview, the 'essence' of these differences ought to be named and enter into a growing lexicon for the community that can enable better communication and debate.

Similarly, Collapse Informatics has entered into the Green Computing community without appreciation of the fundamental differences between the discourses. As a prosaic/radical discourse, Collapse Informatics research cannot simply be assimilated into Green Computing, which is imaginative/reformist. If Green Computing (as a whole or in part) is sympathetic to a Collapse Informatics discourse, this suggests a need to reflect on whether this represents a shift in Green Computing's approach and/or worldview, and what might have caused this shift, or whether this indicates existing schisms in the community that Green Computing had not previously been able to identify.

As new sub-communities continue to emerge — a natural result of a growing lexicon with which to differentiate researchers — the problem of effective collaboration between these groups will become increasingly pressing. There are synergies to be found between Green IT and Sustainable HCI research, and where these synergies exist, it makes sense to capitalise on them. At the same time, there are important differences between communities, and in order for computing to maximise its 'sustainability' impact, these differences will have to be negotiated effectively. For example, where might certain communities have to make concessions to other communities' understanding of 'sustainability' in order to make mutual progress? What, for that matter, is the mutual goal that unites these factions? Once this larger narrative is developed, it may be easier to carve out and prioritise specific research activities for each sub-community.

This dissertation has identified an important opportunity for research exploring new imaginative/radical discourses. Cyber-Sustainability is one such discourse, but many others might be envisaged within this space. If and when researchers

imagine new discourses in this quadrant, the similarities with and differences from Cyber-Sustainability ought to be clearly articulated.

As for Cyber-Sustainability, there are several limitations of the research presented in this dissertation. Firstly, the patterns presented here are initial contributions towards an evolving pattern language for Cyber-Sustainability. This work embraces the in-progress nature of pattern language, and invites others to take up the challenge of developing new patterns and/or refining the set presented here.

A more fundamental limitation of these patterns is that they only partially succeed in transcending purely rational modes of addressing the sustainability problem. Typically, designers arrive at a solution through the process of making (cf. Walker, 2011; Walker, 2006), thereby accessing tacit knowledge and experiential ways of knowing (i.e. direct experience) as the source of inspiration. While the development of these patterns was a creative process, and much was learned through exploring these design possibilities, the 'correctness' of these solutions was developed and justified through rational modes, such as written argumentation. It is possible that such an approach prevented revelation of even more radical alternatives to current uses of cyberspace; though the nature of the design challenge here precluded the option of 'making' — i.e. it was not feasible to program an alternative Web. Future research might contribute to Cyber-Sustainability by exploring alternative paths to solutions, particularly those that involve a design process of learning-through-*making*.

There is also an element of instrumentalisation apparent in these patterns, revealing that they are not entirely successful in transcending the Modernist worldview that is criticised in Chapter 4. There is an argument to be made, however, that a worldview does not shift in an instant, and that it is unreasonable to expect people to jump to a completely new understanding of the world. The fact that these patterns are consciously designed to reflect new frames — if still not completely rejecting Modernity — means that they can begin the slow process of shifting this worldview. It is possible, furthermore, that if the worldview were to change (as a result of these efforts, or more likely, in conjunction with other forces), this would require adjustment of these patterns to accommodate this shift.

Finally, Cyber-Sustainability and Green Computing both currently neglect serious interrogation of major barriers to change — such as vested interests of governments, and commercial interests of businesses. Greater progress on (to be determined) core 'sustainability' issues is likely possible if these interests are considered, and either accommodated, or a plan is developed for incentivising buy-in from these influential parties.

7.5 Concluding remarks

One of the motivations for this work was a personal frustration with computing solutions for 'sustainability'. The discipline seemed to be lapsing into an orthodoxy of approaches resulting in a collection of increasingly minimal-impact solutions for an increasingly serious and imminent environmental problem. The optimism that small changes amount *in the aggregate* to change on the scale that is required to prevent climate change disaster seemed misplaced and therefore dangerous. To quote Crompton & Thøgersen (2009):

> *The comfortable perception that global environmental challenges can be met through marginal lifestyle changes no longer bears scrutiny. The cumulative impact of large numbers of individuals making marginal improvements in their environmental impact will be a marginal collective improvement in environmental impact. Yet we live in a time when we need urgent and ambitious changes.*

While it feels wrong to criticise researchers who are undeniably working in earnest to contribute what they can towards solving this problem, the danger is that these efforts appear to be lulling society into a false sense of security, comforted by the knowledge that a growing community of researchers is applying the best modern techniques towards preventing climate change. The Green IT community seems highly confident in its program of efficiency improvements, despite historical evidence to suggest that such efforts only ever increase overall energy use over time. Meanwhile, the Sustainable HCI community has lost confidence in its primary tool, persuasive technology, and appears to be struggling for new direction (cf. Priest et al., 2013).

Cyber-Sustainability is offered up as a vast new opportunity for computing researchers interested in sustainability. One of the strengths of Cyber-Sustainability as a proposed discourse is that it has been systematically constructed through careful selection of frames and awareness of the influence and importance of values, avoiding at the outset some of the pitfalls that appear to limit the ability of Green Computing to achieve its goals. In this sense, it is instructive for other researchers who are disenchanted with the research outputs of sustainability research in computing, and who want to build a new agenda for high-impact research.

Cyber-Sustainability is not offered here as *the solution* for sustainability. In purely practical terms, the carbon impact of the Internet, for example, is approximately 0.84% of global emissions[1], depending on which factors are internalised in that calculation. It is argued, however, that additional practical benefits could be achieved through worldview change that Cyber-Sustainability might play a role in catalysing, but also that there are additional measures of sustainability success (e.g. social and personal meaning) that Cyber-Sustainability can achieve which have too long been peripheral to our discussions of a sustainable future.

The most important contribution of Cyber-Sustainability, therefore, is to present a new vision of a Web and digital culture worth sustaining, to reveal the scale and quality of change needed to realise this vision, and in doing so, hopefully inspire others to explore radically different approaches that may yet reveal even greater impact solutions for co-creating a truly sustainable world.

[1] This calculation was based on two figures: 1) 'The internet releases around 300m tonnes of CO2 a year' (Clark & Berners-Lee, 2010), and 2) 'Data show that global CO2 emissions in 2012 hit 35.6bn tonnes' (Kivner, 2012).

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Appendix

List of Appendices

A Glossary

Terms are listed below in alphabetical order.

Administrative Rationalism. This is a prosaic/reformist, Problem Solving discourse that emphasises the importance of experts in shaping 'sustainable' policies (e.g. resource management and pollution agencies).

Collapse Informatics. This is a recently emerging prosaic/radical Survivalist Computing discourse that explores the role of computing in easing the process of adaptation in a 'collapse' or 'post-collapse' scenario.

Cyber-Sustainability. This is an imaginative/reformist discourse on sustainability, with a focus on Internet and Web technologies. The frames underpinning this discourse include *Embodied Mind, Empathy, Shared Prosperity* and *Intrinsically Valuable Environment*. The discourse adopts a Quadruple Bottom Line understanding of sustainability, so Cyber-Sustainability is understood as being related to human fulfilment with respect to practical, social, personal meaning and (secondarily) economic needs. Five main areas of concern for Cyber-Sustainability include Size, Empowerment, Resilience, Quality and Nourishment.

Democratic Pragmatism. This is a prosaic/reformist, Problem Solving discourse that emphasises the voice of the people as an important contribution to effectively addressing 'sustainability' concerns, and rely on voluntary commitments to more 'sustainable' policies.

Discourse. A discourse is defined here as a way of understanding a problem and solutions to that problem, which is shared by a group (at least insofar as it is recognisably characteristic of that group compared with another group) and reflected in the ways that group talks about and designs for issues relevant to these understandings.

Ecological Modernization. This is a imaginative/reformist Sustainability discourse that attempts to restructure the capitalist political economy in accordance with Triple Bottom Line sustainability, particularly by promoting collaboration between business and government on environmental and social issues.

Ecomodernism. This term refers to discourses that embrace the 'sustainability' problem as an opportunity to profit and to excel through the application of modernist rationality.

Economic Rationalism. This is a prosaic/reformist Problem Solving discourse that emphasises the the power of market forces to affect 'sustainable' behaviour (e.g. privatisation).

Embodied Mind frame. This frame 'represents the human mind as an emergent phenomenon comprised of vital inputs from the brain, body, and physical/social environments . . . [and] asserts a world that is filled with complex social organisms whose reasoning is profoundly influenced by neurological and cultural processes' (Danton & Kirk, 2011: p. 83).

Frame. Frames are defined by Danton & Kirk (2011) as 'cognitive devices that we use to understand words and things, and by which we structure our thoughts' (p. 67). They continue, 'When we hear a word, it automatically evokes in us a set of ideas, values and feelings. This set of evocations can be described as the 'conceptual frame' for that word. When we encounter new words, we understand then by reference to existing frames, and as we acquire new frames so our understanding moves along. What occurs with words also occurs with sensations and experiences: we understand the world by reference to our existing frames' (p. 67). In this dissertation, 'frame' refers to a complex mental conception that organises one's understanding of a particular concept. Throughout the dissertation, frames describe conceptions that shape notions such as 'the human mind' and 'the environment', with implications for one's understanding of the notion of 'sustainability'.

Free Market frame. This frame assumes that if everyone is seeking to maximise their benefit (i.e. profit), then 'the profit of all will be maximised' (Darnton & Kirk, 2011: p. 84). Markets, therefore, are seen as the natural means of ensuring this utilitarian outcome.

Green Computing. This is an umbrella term encompassing the most common approaches within computing for addressing a perceived environmental 'problem'. Collectively, this is an imaginative/reformist discourse characterised by the belief that computing can bring environmental, social and economic

needs into greater alignment through a) 'sustainability *in* design' and b) 'sustainability *through* design'. The frames underpinning this discourse include *Rational Actor, Self-Interest, Free Market* and *Instrumentally Valuable Environment*. For a description of areas of concern, see Table C.1. This discourse includes within it Green IT and Sustainable HCI, as they are loosely defined (i.e. including related sub-genres). For descriptions of Green IT and Sustainable HCI, see Section 2.2.

Green Consciousness. This is an imaginative/radical Green Radicalism discourse that emphasises a route to change through affecting worldview, in particular through changing how people understand the environment and their fellow humans.

Green IT. This imaginative/reformist Green Computing discourse is rooted in an engineering heritage, and tends to interpret 'sustainability' as a mandate for efficiency improvements, seeking to enable more environmentally sound business operations that also benefit the *economic* bottom line. This discourse is closely related to 'Ecological Modernization'. For a full summary of this discourse, and how it compares with 'Ecological Modernization', see Table 2.3.

Green Politics. This is an imaginative/radical Green Radicalism discourse that emphasises a route to change through affecting problematic social, economic and political structures.

Green Radicalism. This is an imaginative/radical type of discourse that argues that global breakdown can be averted through major psychological, cultural and/or societal transformations.

Imaginative. Discourses that are imaginative challenge the 'rules' of industrialism, and propose new means of promoting growth and/or fostering wellbeing.

Instrumental value. This is the understanding of value as being derived from what is useful. For example, the environment as viewed instrumentally is valuable insofar as it provides use for humans. Relates to extrinsic values and goals.

Internet of Things This is a component envisaged to be part of the next wave of digital innovation, i.e. Web 3.0, and would allow users to connect directly to any object in the world through the Web. This would work by assigning a digital identification to every physical object, against which data can be stored. Recent strides have been made toward realising this vision, e.g. with platforms such as Pachube (https://pachube.com/), a data infrastructure to support the Internet of Things, which allows users to share and connect data streams from various objects (Knowles et al., 2013a).

Intrinsic value. This is the understanding of value as being derived from what satisfies inherent human needs (i.e. intrinsic values and goals).

Problem Solving. This is a prosaic/reformist type of discourse that argues that necessary 'sustainability' changes can be brought about through adjustments to existing systems, e.g. bureaucracy, democracy and markets.

Prometheanism. This is a discourse that denies the notion of a 'sustainability' problem altogether, often arguing that we will use our innate (historically verified and ostensibly infallible) ingenuity to overcome 'sustainability' problems as they arise, or economic forces will stabilise out-of-control consumption, or else we will 'evolve' to the new environmental realities that emerge as a result of our current practices.

Promethean Computing. This is a computing discourse characterised by a denial of the very notion of a 'sustainability' problem and/or a denial of 'sustainability' as falling within the remit of computing.

Prosaic. Discourses that are prosaic accept the 'rules' of industrial society, in particular the aim of increasing material wellbeing through growth.

Radical. Discourses that are radical propose significant changes in industrial modes of living and being as a route to 'sustainability'. Typically, these approaches include rhetoric about rediscovering our 'roots'.

Radical Sustainability. This is an imaginative/radical Green Radicalism discourse that re-orients the sustainability discussion around a strategy for ensuring human thriving along several dimensions of human need, understands worldview change as the 'Plan A' for sustainability, and transcends the pragmatic solution space in an effort to develop deeper, more systemic solutions.

Rational Actor frame. This frame is the understanding of the human mind as a cost-benefit analysis machine designed to make maximally beneficial decisions.

Rationalistic Computing. This is a prosaic/reformist type of computing discourse that is characterised by the belief that computing can be made 'sustainable' through adjustments (e.g. efficiency improvements) to everyday computing practice, rather than through specific 'sustainability' technological interventions (typically industry).

Rebound Effect. This describes a phenomenon whereby environmental gains enabled by efficiency improvements are largely eradicated by a) the increased usage consumers feel free to enjoy due to the perception that this consumption is now not only cheaper, but also 'less bad' for the environment, b) the fact

than money saved is often spent on consumption in other areas, and c) the fact that efficiency savings in one region lowers energy cost in other regions, encouraging greater consumption (Berners-Lee & Clark, 2013: pp. 50–4).

Reformist. Discourses that are reformist seek solutions within familiar modes of rational management, rather than proposing significant changes in industrial modes of living and being, as a route to 'sustainability'.

Semantic Web This is a technological transition from linked documents (Web 1.0 and Web 2.0) to linked data, intended to improve our ability to find relevant information and discover new connections (Knowles et al., 2013a).

Shared Prosperity frame. In contrast to the *Free Market* frame, this frame presumes that the market does not guarantee wealth, but rather, people must design into the market support systems that enable the market to create prosperity (Darnton & Kirk, 2011: p. 84).

Survivalism. This is a prosaic/radical type of discourse that denies the notion that our ingenuity will stave off environmentally-induced systemic breakdown, and prepares a 'Plan B' for adapting a very different (harsh) reality of our own making.

Survivalist Computing. This is a prosaic/radical type of computing discourse characterised by an insistence on the futility of attempting to solve 'sustainability' (i.e. engineering 'sustainability' through computing or any other means), and a focus instead on the role of computing in mitigating the societal disruption that might result from organic, potentially crisis induced, evolution toward 'sustainability'.

Sustainability (capitalised). This is an imaginative/reformist type of discourse that argues that global breakdown can be averted through strategic interventions that bring environmental, social and economic needs into greater alignment.

Sustainability (lower case). This is the definition of sustainability developed in Chapter 5, i.e. relating to the Quadruple Bottom Line of sustainability.

'Sustainability' (lower case). This definition of 'sustainability' pertains to a specific discourse to which it refers (in text), which is different from the understanding of sustainability developed in Chapter 5.

Sustainable Development. This is a imaginative/reformist Sustainability discourse that promotes a notion of environmentally- and socially-benign economic growth.

Sustainable HCI. This imaginative/reformist Green Computing discourse is rooted in a humanities (e.g. psychology) heritage, and tends to target individual consumption behaviours. Sustainable HCI seeks to understand the potential role of computing in enabling more sustainable living. This discourse is closely related to 'Sustainable Development'. For a full summary of this discourse, and how it compares with 'Sustainable Development', see Table 2.6.

Sustainable IT. This is a proposed 'stronger' mode of Green IT which focuses less on 'sustainability *in* design', and more on the role of computing in promoting cooperation between businesses and government toward more significant, long-term change. It is reformist, but more imaginative than Green IT.

Triple Bottom Line, TBL. This is an imaginative/reformist approach to 'sustainability', which proposes a mutual relationship between the pursuit of environmental, social and economic 'sustainability'.

Quadruple Bottom Line, QBL. This is an imaginative/radical approach that defines sustainability as the satisfaction of human meaning as it relates to practical, social and personal meaning (and economic needs).

Value. Values are self-orienting beliefs that are core to an individual's sense of self and help guide actions that are in accordance with this sense of self.

Web 3.0 This is the next stage of development for the Web, and includes two main components: the Semantic Web, and the Internet of Things.

B Publications and other outputs

B.1 Resulting from Chapter 2

Knowles, B., Blair, L., Coulton, P., and Lochrie, M. (2014) Rethinking Plan A for Sustainable HCI. In: *Proc. CHI '14*, Toronto, 26 April — 1 May 2014. This paper critiques the contributions made by Sustainable HCI with respect to the enormous and urgent challenges presented by climate change, and proposes five new areas for Sustainable HCI contributions to be made.

Knowles, B., Blair, L., Hazas, M. and Walker, S. (2013) Exploring Sustainability Research in Computing: Where we are and where we go next. In: *Proc. UbiComp '13*, Zurich, 8–12 September 2013. Details are provided in this publication of the analysis of the research questions that motivate Green Computing, and the differences in focus between Green IT and Sustainable HCI. These questions, it is argued, are indicative of Green Computing's reformist orientation to 'sustainability'; and a small number of more radical research questions are proposed as inspiration for new directions for research.

B.2 Resulting from Chapter 3

Knowles, B. (2013a) Re-Imagining Persuasion: Designing for Self-Transcendence. In: *Proc. CHI EA '13*, Paris, 27 April — 2 May 2013. This paper and corresponding poster present the findings of the values analysis, and were presented at the CHI '13 Student Research Competition.

Knowles, B., Blair, L., and Crompton, T. (2014) A Route to High-Impact Sus-

tainability Research in Computing (tentative title). This policy report, currently in progress, will be published through Common Cause as part of an EPSRC Impact Acceleration grant. In collaboration with Tom Crompton (WWF-UK and Common Cause), and with a forward by Mike Berners-Lee, this document will be written for the EPSRC and is intended to apply the insights of this same values analysis to re-orient and re-scope the research agenda and policy for sustainability in computing.

Forthcoming methodology paper. A paper is currently in progress which details the values analysis methodology.

B.3 Resulting from Chapter 4

Knowles, B. (2013b) Deep Interventions to Change How We Think and Act. 'Post-Sustainability', a *CHI '13* Sustainability Community Workshop, 27 April 2013, Paris, France. This publication provides a summary of the key points of Chapter 4.

Forthcoming methodology paper. A paper is currently in progress with Paul Chilton and others (to be published through Common Cause) that details the frames analysis methodology.

B.4 Resulting from Chapter 5

Richards, B., Walker S. and Blair, L. (2011) Cyber-Sustainability: Leaving a lasting legacy of human wellbeing. In: *Proc. BCS-HCI '11*, British Computer Society, Swinton, UK, pp. 1–6. Initial thoughts about the nature of Cyber-Sustainabiltiy are explored in this publication, and concerns that are raised here form the seeds of the discussion in Chapter 5.

B.5 Resulting from Chapter 6

Knowles, B., Walker, S., and Blair, L. (2013) 'Design for Cyber-Sustainability'. In: *The Handbook of Design for Sustainability*. Ed. by S. Walker & J. Giard. Oxford: Berg Publishers, 2013. Chap. 30, pp. 488–512. This book chapter presents four high-level, abstract patterns for a sustainable digital future, along with

a more mature (than the above publication) description of this proposed Cyber-Sustainability discourse, which is further refined in Chapter 5.

Richards, B., Walker, S., and Blair, L. (2013) Reframing Progress in the Digital Age: moving forward sustainably. ***The International Journal of Social Sustainability in Economic, Social, and Cultural Context,*** **8.4, pp. 53–61.** This journal publication critiques the notion of 'progress' that underpins digital pursuits and appear to be in conflict with sustainability. One additional, high-level pattern is presented as an antidote.

C Green Computing discourse analysis

C.1 Ten Motivating Questions of Green Computing

Table C.1 summarises the ten questions motivating Green Computing, as determined through thematic analysis and situational analysis (see Knowles et al., 2013b for details). Along with a description of the question, the table provides (column 2) the approaches used to answer these questions and (column 3) types of solutions that have emerged in response.

Table C.1: Ten motivating research questions in Green Computing

Motivating question	Approaches	Solutions proposed
1. How can we support more responsible disposal of electronic waste? Addresses the symptoms of unsustainable patterns of consumption but it does not address or attempt to critique this consumption.	• Preventing waste production • Minimising harm caused by waste • Waste management solutions	• Reusable components • Developing less toxic technological components • Tracking waste via pervasive sensing technologies)

2. How can we reduce CO_2 emissions? Addresses the consumption stage of the IT product life-cycle (i.e. reducing energy consumed during use of technology). Embodied carbon of IT is omitted from the problem domain.	• Helping consumers reduce their carbon footprints • Reducing the carbon footprint of technology itself	• Persuasive technology, ambient awareness • Product innovation, process innovation, energy-aware and energy-efficient technologies
3. How can we better monitor the state of the natural environment? Focuses on technological means of enabling environmental data collection and motivating such collection by citizens.	• Monitoring the environment • Citizen sensing	• Pervasive sensing technology • Enabling public engagement with data about the state of the environment
4. How can we use technology to foster environmentally responsible behaviour? Aims to promote conservational behaviour, overwhelmingly focused on energy usage.	• Visualising and/or communicating consumer impacts on environment • Helping motivate behaviour change	• Eco-feedback, ambient awareness • Persuasive technology
5. How can we make better use of renewable resources? Ostensibly inspired by popular consensus that non-renewable energies are likely to become increasingly (and perhaps prohibitively) expensive in years to come.	• Integrating renewables into existing technology • Developing new infrastructure for organising and delivering energy • Developing means of capturing/using new renewable forms of energy	• Data centre innovation • Smart grid innovation • Energy harvesting, human-powered technology
6. How can we make more efficient use of resources? Addresses the production stage of technologies (both hardware and software), focusing on storage issues and automated controls to reduce waste.	• Dematerialisation (i.e. converting atoms to bits) • Enabling sharing of resources and eliminating the need for physical products • Reducing human-generated inefficiencies in consumption	• Digital archiving, digitisation of businesses and governments • Virtualisation, cloud services • Algorithmic controls

7. How can we improve operational and process efficiency? Motivated by the desire to reduce costs (overwhelmingly, though not exclusively, business costs). Environmental benefits are considered a 'bonus'.	• Reducing energy waste	• Energy-efficient and energy-aware technologies
8. How can we use technology to make society more efficient? Targets infrastructure (rather than individuals, businesses, and/or technology) as point of intervention, and attempts to coordinate action for environmental benefit.	• Coordinating energy usage • Improving transportation efficiency	• Smart grid technology • Car sharing applications, smart routing, tools to aid logistics businesses
9. What is the role of technology in making society sustainable? Focuses on the philosophical underpinnings of the research and the boundaries of the solution space.	• Exploring possibility of new targets for sustainability intervention • Addressing political aspects of 'sustainability' solutions • Exploring the tension between 'sustainable' living and a technology-rich society	• Formative user studies, reflective research • Discourse analysis • Formative user studies
10. How can we promote less destructive and more satisfying patterns of consumption? Addresses what is perceived as unsustainable patterns of consumption.	• Intervening in culture of waste • Determining causes of current consumption behaviour	• Slowing obsolescence cycles, cradle-to-cradle design, reducing preoccupation with newness • Formative user studies

C.2 Top 100 Green Computing publications

Given the difficulties in categorising the entire body of Green Computing research, a smaller corpus was developed as a representative and highly regarded slice of

the corpus. Details are published in Knowles et al. (2013b) but are duplicated here as a reference.

The corpus was developed to include the 100 most cited papers written in the last 10 years (2002 to 2012) and available through the ACM Digital Library and IEEE Xplore archives (chosen for their reputations), or appearing in references of previous surveys (e.g. DiSalvo et al., 2010; Goodman, 2009) (so as to include papers that have been deemed relevant, if not explicitly using these key search terms). It was generated by the following steps:

(i) Searching ACM, IEEE and the references of prior surveys for papers matching search strings such as 'green computing', 'green IT', 'green ICT', 'sustainable IT', 'sustainable HCI' or 'sustainable interaction design'.

(ii) Reading titles and abstracts of the results to ensure relevance to sustainability.

(iii) Recording the highest cited (about 150 papers) in a spreadsheet.

(iv) Ranking the list of papers in order of citation count according to Google Scholar. In the event of a tie, papers were ordered by citation count in ACM or IEEE, and if still tied, the number of Mendeley readers.

The 100 most cited papers were then coded according to ten motivating research questions by reading the abstracts and conclusions of each paper (and where necessary, the entire paper), resulting in the data represented in Figure 2.3.

D Green Computing values analysis

D.1 Details of the Schwartz (1992) study

Building on and expanding Rokeach's list of 36 values, Schwartz developed descriptors for 56 specific values to be investigated using a cross-cultural questionnaire (Schwartz, 1992: p. 17). Approximately 4,000 participants from 20 different countries — speaking 13 different languages, and broadly representing 8 different religions and religious orientations (including atheist) — were asked to rank the order of importance of these 56 values 'AS A GUIDING PRINCIPLE IN MY LIFE' from '*supreme importance* (7)' to '*not important* (0)', and including '*opposed to my values* (-1)' (ibid: p. 17). The survey asked participants to rate the importance of values in the abstract, i.e. without any particular contextualisation, providing insight into people's ideal vision of themselves.

Statistical analysis of these responses was performed to determine correlations and oppositions between values[2]. Each of the values was then spatially ordered such that 'the distances between the points reflected the empirical relations among values as measured by the correlations between their importance ratings' (ibid: p. 21). The resultant arrangement of values was then segmented into types: Self-Direction, Stimulation, Hedonism, Achievement, Power, Security, Conformity, Tradition, Benevolence, and Universalism (see Appendix D.3.2 for definitions of these

[2]Schwartz used 'the intercorrelation matrix of Pearson correlations between the importance ratings of the values [which] was analyzed with the Guttman-Lingoes Smallest Space Analysis (SSA)... [and] is one of a variety of nonmetric multidimensional scaling (MDS) techniques for structural analysis of similarity data' (1992: p. 21).

types).

The key contributions of Schwartz's seminal study are the following:

- Provided empirical evidence of clustering of values into different types;
- Provided empirical evidence of dynamics between these types, specifically the cognitive compatibilities and incompatibilities of certain value types pairings;
- Demonstrated the universality of values across different cultures;
- Demonstrated cultural variance in the patterns of self-reported importance of values.

D.2 Values Analysis Methods Summary

D.2.1 Rationale

Systematic Literature Review (SLR) is considered beneficial for any of the following research objectives (ibid):

- *Summarising evidence of the effects of an intervention.* For example, SLR has been used in medical research in order to aggregate data from various medical trials of specific medicines or procedures; and it has been used in software engineering to determine the desirability of a particular design or approach.
- *Identifying gaps in research.* Determining what research has already been done to answer a particular research question can illuminate redundancies — research that seems to repeat other research — as well as gaps that need to be filled.
- *Developing a framework for positioning new research.* As opposed to a regular literature review, SLR enables a comprehensive overview of a research domain, which can help with integration of works into a unified framework.

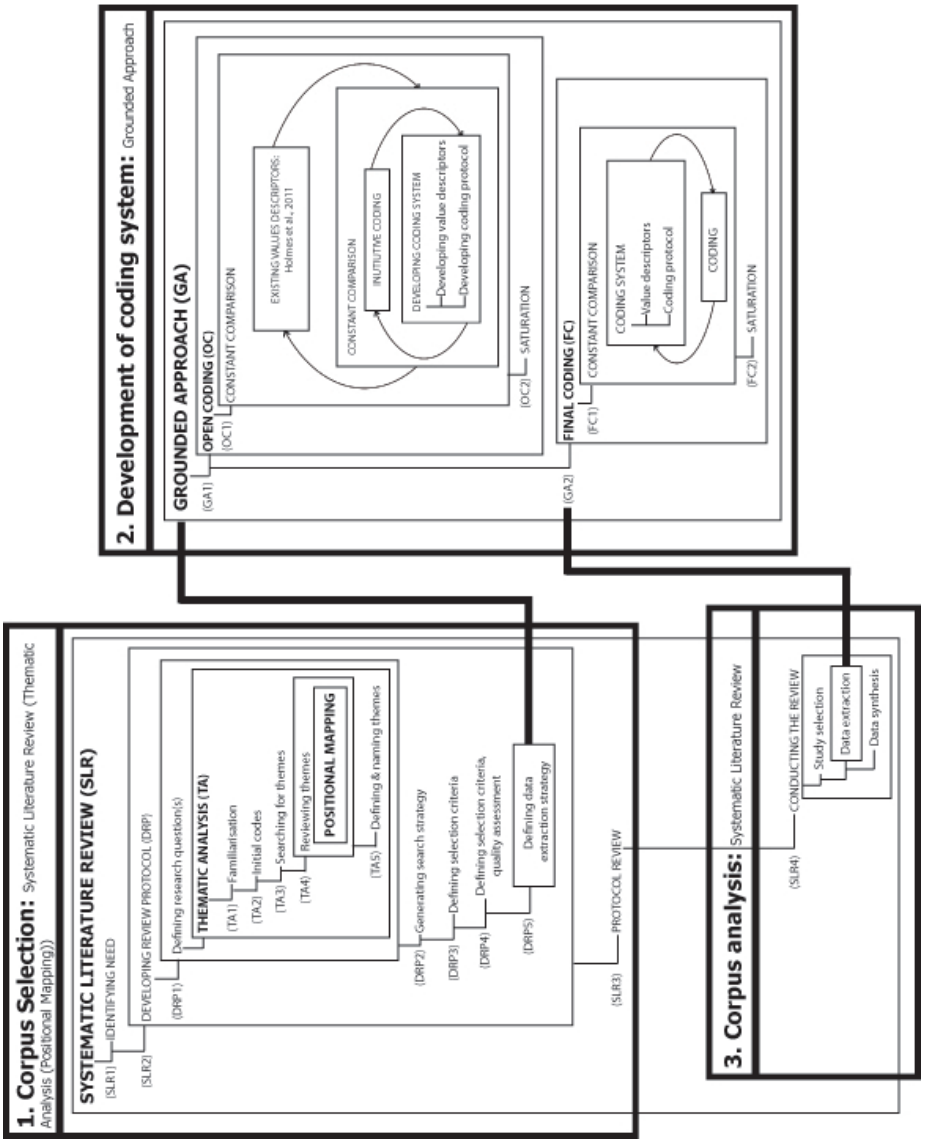

Figure D.1: Detailed overview of research methods for the Green Computing corpus values analysis.

Additionally, the rigorous nature of SLR adds validity to any framework produced.

The primary justification for SLR for this analysis was to develop a framework for understanding the different kinds of research being undertaken in the area of Green Computing. As mentioned in Knowles et al. (2013b), however, this SLR has had the added benefit of exposing research gaps within Green Computing.

While a normal literature review is far easier to undertake, there were two reasons why such a review would not suffice for the purposes of this stage of the research:

1. *Scale.* The body of relevant research was so enormous that a process needed to be developed for combing through it all.
2. *Justifying inclusion.* An initial corpus of literature was developed before undertaking SLR, and the 40 chosen papers were coded for values. This yielded interesting results, but because there was no clearly articulated criteria or process for selection, it was not possible to determine whether these 40 papers were representative of Green Computing on the whole. Rather than cherry-picking papers, which could bias the analysis, SLR was used to develop a representative corpus.

D.2.2 Identification of research questions

The research question for this stage of the study was exceptionally broad: *What are the values appealed to by Green Computing?* An ideal question for SLR would be narrow enough that a researcher would be able to analyse all relevant literature. (Indeed, the fact that no papers are excluded is what makes SLR useful for eliminating biases.) Yet the intended goal of the coding the corpus was to be able to reflect on the discourse of Green Computing *on the whole*; so it would be undesirable to narrow the scope prematurely[3].

The eventual solution to this problem was to carry out the additional steps of:

[3] Admittedly, there was some unavoidable narrowing of scope required for performing searches for 'Green Computing' in the first place. Initial boundaries of 'Green Computing' included any computing research that was related, however distantly, to the environment. While arguments could be made that this prematurely excludes/biases certain facets of Green Computing from the literature corpus, this scoping was grounded in common definitions of Green Computing, such as that found in Wikipedia: 'Green computing... refers to environmentally sustainable computing or IT' (`http://en.wikipedia.org/wiki/Green_computing`; accessed 16th July 2012). The degree to which this biased the search results is, therefore, minimal, and such terminological pivoting is endemic to any SLR endeavour.

1. systematically breaking the main question (*What are the values in Green Computing?*) into several more manageable sub-questions by first exploring the different facets of Green Computing (i.e. first asking *What is Green Computing?* — see Section 2.3, Figure 2.2);

2. developing a protocol and rationale for selection of a subset of the literature relevant to each sub-question.

Research questions for the Systematic Literature Review were identified using Thematic Analysis, and within this Positional Mapping, as follows (see also Knowles et al., 2013b):

Thematic Analysis phase 1: familiarisation. A general Web search was performed for conferences and journals related to 'green' or 'sustainable' + 'computing' or 'technology'.

Thematic Analysis phase 2: initial codes. Topics of interest were mined from these venues and collated in a spreadsheet until the search reached saturation. An emerging range of topics were recorded.

Thematic Analysis phase 3: searching for themes. Sixty papers were selected to be read in depth, specifically chosen by keywords and abstract to represent this range of topics. While reading these papers, major themes, minor themes, and sub-themes within these were recorded as they emerged.

Thematic Analysis phase 4: reviewing themes. In following with the Positional Mapping approach, instead of aiming to map differences in groups (e.g. between existing sub-communities in sustainable computing), the aim was to identify similarities and differences between themes. Three broad types of interests were found — pollution, resource management, and society & culture — which served to enable organisation of lower-level themes.

Thematic Analysis phase 5: defining & naming themes. A final mapping solution was achieved by rephrasing emerging themes as questions (e.g. 'How can we reduce CO_2 emissions?') and spatially arranging these onto the three areas of interest such that neighboring questions reflected relative similarity — a process similar to axial coding (Corbin & Strauss, 1990) in Grounded Theory.

These ten motivating research questions identified using Thematic Analysis were then adopted as the ten research questions used for the Systematic Literature Review.

D.2.3 Search strings used for each question and paper type

For each sub-question and category, a search string was created (cf. Kitchenham, 2004). This was an iterative process. An initial search string was developed directly from key words found in the sub-question. If the search results from the initial search string were largely irrelevant to the sub-question (i.e. after looking through abstracts of 500 results it was not possible to find 7 relevant papers), a new search string was tested. This was repeated until 7 relevant papers were found for each sub-question and category.

Below are the search strings and inclusion criteria for each of the categories (the 10 sub-questions and 3 additional categories of reflective, legislative, and formative user study), developed to ensure relevance of the selected papers[4].

Q1: How can we support more responsible disposal of electronic waste? Search string = 'electronic waste'. Abstract and/or keywords and/or title and/or conclusion must reference at least one of the following: electronic waste, WEEE, the life cycle of electronic products, hazardous substance management, or recycling.

Q2: How can we reduce CO_2 emissions? Search string = carbon dioxide emissions + environment. Must appear in the Top 100 of the most cited Green Computing papers.

Q3: How can we better monitor the state of the natural environment? Search string = environmental monitoring. Must propose means of monitoring the environment (e.g. not a survey of the field).

Q4: How can we use technology to foster environmentally responsible behaviour? Search string = persuasive technology environment. Abstract and/or keywords and/or title and/or conclusion must reference persuasive technology and environmental concerns. Must propose means of fostering environmentally responsible behaviour (e.g. not a survey).

Q5: How can we make better use of renewable resources? Search string = 'renewable energy'. Abstract and/or keywords and/or title and/or conclusion must reference renewable energy (e.g. 'renewable energy' or 'wind', etc).

[4] It was also decided that any paper that had been awarded a CHI Conference Best Paper Award or Honorable Mention (and was relevant to the sub-question) was automatically included, regardless of citation counts. This was decided because a) it was deemed a measure of both impact and popularity (voted top quality at one of the most respected conferences in the world), which were the reasons for using citation counts as an inclusion criteria, and b) because some of these papers have not had as long as others to accumulate citation counts.

Q6: How can we make more efficient use of resources? Multiple search strings used (results compared and highest citations used). Search strings: 1) virtualization and green; 2) 'resource efficiency' and green computing, 3) cloud green computing, 4) digitization and sustainable, 5) dematerialization and sustainable. Must propose means of using resources more efficiently.

Q7: How can we improve operational and process efficiency? Multiple search strings used (results compared and highest citations used). Search strings: 1) 'green computing', 2) 'green IT', 3) 'sustainable HCI'. Must propose means of improving business efficiency[5].

Q8: How can we use technology to make society more efficient? Search string = 'smart grid'. Abstract and/or keywords and/or title and/or conclusion must discuss inefficiencies that the technology can address (need not use the word 'efficient'). Must propose means of making society more efficient.

Q9: What is the role of technology in making society 'sustainable'? Multiple search strings used (results compared and highest citations used). Search strings: 'quality of life' and (sustainable or 'green computing' or 'green IT'). Abstract and/or keywords and/or title and/or conclusion must include the phrase 'quality of life'. Must propose means of improving the quality of life[6].

Q10: How can we promote less destructive and more satisfying patterns of consumption? Search string = 'sustainable design'. Must propose means of promoting healthier and more satisfying patterns of consumption.

Type: Reflective. Multiple search strings used (results compared and highest citations used). Search strings: 1) 'green computing', 2) 'green IT', 3) 'sustainable HCI'. Must provide an overview of the direction of Green Computing research.

Type: Formative user studies. Search string = 'sustainable design'[7] (also searched DiSalvo et al.'s (2010) references for 'formative user studies').

Type: Legislation. Search string = green and legislation. Abstract and/or keywords and/or title and/or conclusion must mention legislation. Must clearly be about legislation, not merely presenting ideas for compliance.

[5]Note that this question was formerly called 'How can we improve business efficiency?' Though the chosen papers for this category reflect an earlier understanding of the Green Computing questions, they still represent unbiased selection.

[6]Note that this question was formerly called 'How can Green Computing improve our quality of life?' As above, although the chosen papers for this category reflect an earlier understanding of the Green Computing questions, they still represent unbiased selection.

[7]Although this is the same search string as Q10, papers were deemed either a best fit for Q10 or formative user studies, not both.

D.2.4 Selection criteria and quality assessment

Justification for the selection criteria is as follows:

- *Published in the last 10 years (2002 – 2012).* The initial date range for the study was 2007 to 2012, as 2007 was the year that many attribute to the beginning of 'Sustainable HCI'. Yet this new field did not emerge from nothing, and indeed referenced an important body of (often heavily cited) works. Ultimately, the dates were extended backwards both to ensure that these important works were included, and to avoid biasing the corpus by bounding it with a specifically HCI-related date range. Finally, because Green Computing research moves fairly rapidly, it was determined that any papers that were older than 10 years would certainly have related, more recent publications that would be eligible for inclusion.
- *Top 5 most cited papers from each sub-question category.* The rationale for using citation counts was that it was an indicator of impact — i.e. how important the ideas are within the community — and popularity. The purpose of this phase of the study was to create a corpus that was representative of Green Computing, and popularity and impact were useful criteria for developing such a corpus.
- *Relevance to Green Computing and best fit for sub-question.* If papers that were generated by the search engine were irrelevant to Green Computing, they were immediately dismissed. This was determined by reading the abstract, and if this was insufficient basis for making a judgment, the conclusion of the paper was read[8]. Further selection criteria were developed for each sub-question. And an additional quality assessment was done to determine relevancy to the sub-question or category. If after reading the abstract (and if necessary, the conclusion), the paper seemed a better fit for another sub-question or category, it was not included in the 'top 7' list for the sub-category being investigated. (It could, however, appear in the other sub-question or category 'top 7' if it met the inclusion criteria and had enough citations.) If after reading the paper fully it was determined a better fit for another category, it was removed from the top 5 and another paper was selected.

To constrain the scope within manageable limits, it was decided to include 5 publications from each of these categories (i.e. the ten motivating questions and the

[8] In cases when the abstract and conclusion did not provide clues as to the reason the paper was returned by the search engine, keywords were searched in the entire paper as a basis for determining relevance.

three paper types), making a corpus total of 65 publications to be coded for values content. This was done in two stages, as follows.

Identifying the top 7 publications Using the above search criteria, an initial 'top 7' was determined for each category, according to the following steps:

(i) order search results by citation count;

(ii) compare ACM Portal and IEEE Xplore citation counts — if the same paper is in both, take the highest of these; across these two archives, take the top 7 most cited;

(iii) if there is a tie in citation counts (e.g. if when choosing the 7th paper, it is tied with several other papers with the same citation count), take the paper of these which has the highest Google Scholar citations;

(iv) if there were two or more papers by the same authors, only the most cited was included; authorship had to be exactly the same names (though could be in a different order) to merit exclusion of a paper for author repetition.

Identifying the top 5 publications Further refinement was carried out on each 'top 7', in order to arrive at a final 'top 5'. The final (top 5) papers for inclusion were then determined by these additional steps:

(i) find the Google Scholar citation counts for all of the top 7 papers;

(ii) take the top 5 most cited of these;

(iii) if there is a tie between two papers on Google Scholar, take the paper which has the highest ACM or IEEE citation count; if these counts are also tied, take the paper with the highest number of readers on Mendeley; if these counts are also tied, the paper that is deemed most relevant to the research question is selected.

While there was a high correlation between the top cited papers in ACM Portal and IEEE Xplore and high Google Scholar citation counts, it was not always the case that a paper with a higher ACM/IEEE citation had a higher Google Scholar citation count. And, indeed, some papers with a lower citation count in ACM/IEEE (high

enough to be included in the top 7 for a sub-question or category) had much higher Google Scholar citation counts than papers that were ultimately included[9].

Finally, all citation counts were verified and accurate to the date 8 May 2012. (Papers included in the final corpus are noted in the supplemental materials of Knowles et al., 2013b, and are included here in the bibliography.)

D.3 Developing a Coding System

D.3.1 Development of Descriptors

In order to develop a coding system that was grounded in the existing Common Cause (Holmes et al., 2011) values framework, a grounded theory method of constant comparison (Melvin, 1992; Corbin & Strauss, 1990) was used. The steps involved in creating the coding system are summarised as follows:

1. *Understanding existing values descriptors.* There are 56 values that have been found by Schwartz (1992) to be universal. Schwartz's original descriptors for these values (which were used in his 1992 survey study) have been slightly modified (including the addition of two more values) and further researched by Holmes et al. (2011) in the *Common Cause Handbook*.

2. *Interpreting values in a small set of papers.* Approximately 10 papers were coded intuitively based on an interpretation of these Holmes et al. (2011) definitions applied to this technological context. Throughout the coding process, descriptors for codes were recorded alongside coded excerpts, and a set of rules and procedures that seemed to 'feel right' were also recorded.

3. *Test for repeatability in a second set of papers.* A second set of 10 papers were coded, based on a growing intuitive understanding of the 58 values. Descriptors and rules were again recorded, but were then compared with

[9] One example was for Q3: a paper entitled 'SensorScope: Out-of-the-Box Environmental Monitoring', which had only 14 IEEE citations, but 101 Google Scholar citations. Given the need to strictly follow a selection process — and that a) most often than not this did not happen, and b) it was decided that ACM and IEEE counts were better indicators of impact — this and similar instances were not accommodated by inclusion.

the descriptors and rules already created. If there were differences between these, explanations were sought to reconcile them, and an improved descriptor or rule was proposed.

4. *Repeat until saturation.* This process was repeated until descriptors and rules no longer needed adjustment as they were followed without disagreement.

5. *Codify descriptors and rules.* A final set of descriptors and rules were then recorded. These served as the strict guidelines for coding the systematically selected corpus of 60 papers.

Details of these values descriptors are provided in Appendix D.3.2 to follow. Details of these final coding procedure rules are provided in Appendix D.3.3.

D.3.2 Values definitions and descriptors

In table below, a list of the 58 Common Cause values is provided, along with the Common Cause definitions of these values (column 3) from Holmes et al. (2011). The four broad categories, Self-Enhancement, Openness to Change, Self-Transcendence and Conservation, are abbreviated (column 1) as SE, OC, ST and C, respectively.

Column 3 provides the descriptors for each value, which were used as a guide when coding the values content in the systematically selected corpus.

Table D.2: Values definitions and descriptors

	Value	Holmes et al. (2011)	Indication (coded positively)
SE	**Power**	Social status and prestige, control or dominance over people and resources	
	Social power	Control over others, dominance	Suggesting that adoption of technology would be competitively advantageous (e.g. for business)
	Wealth	Material possessions, money	Mentioning financial incentives for adopting technology
	Authority	The right to lead or command	Suggesting that adoption of technology or research in this area (e.g. Green IT) is desirable because of the potential to influence other people's actions

	Preserving my public image	Protecting my 'face'	Mentioning others' (negative) judgment as motivator for adopting technology
	Social recognition	Respect, approval by others	Mentioning others' (positive) judgment as motivator for adopting technology
SE	**Achievement**	Personal success through demonstrating competence according to social standards	
	Intelligent	Logical, thinking	Advocating highly rational, logical route to sustainability wins (e.g. greater information or analysing capabilities); advocating increased information as route to success
	Capable	Competent, effective, efficient	Mentioning efficiency improvements; leveraging audience's desire to demonstrate mastery over a problem; 'managing' problems
	Successful	Achieving goals	Suggesting means to evaluate whether ('sustainability') goals had been met; mentioning accuracy (relative to target); emphasising the achievement of goals; sparking competitive spirit
	Ambitious	Hard working, aspiring	Emphasising the satisfaction of tackling a difficult problem; indicating aspirations beyond others (e.g. other researchers or technology)
	Influential	Having an impact on people and events	Implying or asserting the audience's ability to make a difference; mentioning the 'importance' of a technology
SE/OC	**Hedonism**	Pleasure and sensuous gratification for oneself	
	Pleasure	Gratification of desires	Directly mentioning 'pleasure'; suggesting appealing to audience's desires
	Enjoying life	Enjoying food, sex, leisure, etc	Suggesting that adoption would lead to greater enjoyment/quality of life

	Self-indulgent	Doing pleasant things	Indicating accommodation (through design or modification of ambitions) of audience's potential to be self-indulgent
OC	**Stimulation**	Excitement, novelty and challenge in life	
	Daring	Seeking adventure, risk	Suggesting that adoption of technology would be an adventure and/or dangerous; emphasising 'surprise' as a benefit of the technology
	A varied life	Filled with challenge, novelty and change	Emphasising novelty of technology as beneficial to engagement
	An exciting life	Stimulating experiences	Emphasising the degree of stimulation of technological engagement or excitement in working on this problem
OC	**Self-Direction**	Independent thought and action — choosing, creating, exploring	
	Self-respect	Belief in one's own worth	Suggesting appealing to audience's feelings of self-worth
	Privacy	The right to have a private sphere	Mentioning of privacy concerns as necessary design consideration; (security NOT coded — this is a technological characteristic, not human)
	Choosing own goals	Selecting own purposes	Indicating a 'goal-setting' stage (either in change plan or in the use of a technology)
	Creativity	Uniqueness, imagination	Indicating the role of audience's creativity in generating desired outcome; mentioning the creativity or innovativeness of the proposed solution
	Curious	Interested in everything, exploring	Directly mentioning 'curious'; indication of audience's curiosity as a feature exploited by technology solution
	Independent	Self reliant, self sufficient	Imploring audience to take matters into their own hands (i.e. possibly because of a failure of others to solve the problem); suggesting that the technology increases independence

	Freedom	Freedom of action and thought	Advocating a non-regulatory approach; designing ability of audience to choose aspects of the technology look or output
ST	**Universalism**	Understanding, appreciation, tolerance and protection for the welfare of all people and for nature	
	Broadminded	Tolerant of different ideas and beliefs	Indicating an effort to promote tolerance to different ideas, beliefs, worldviews, or lifestyles
	Unity with nature	Fitting into nature	Indicating an effort to enhance cognitive or emotional links between audience and nature
	Equality	Equal opportunity for all	Directly mentioning 'equality'; seeking to provide equal opportunities for all
	Protecting the environment	Preserving nature	Mentioning negative impact of current technologies on environment; indicating effort to mitigate or eliminate these negative impacts
	Inner harmony	At peace with myself	Indicating appealing to people's need to feel good about themselves and their decisions (e.g. being able to sleep better at night)
	A world of beauty	Beauty of nature and the arts	Highlighting or emphasising a particularly beautiful aspect of nature (e.g. that the technology might be able to preserve) or of life
	A world at peace	Free of war and conflict	Appealing to audience's desire for a world free from war and conflict (i.e. as a motivator for adoption of technology or change in technology design)
	Social justice	Correcting injustice, care for the weak	Referencing specific social injustices as motivation for change (in behaviour or design)
	Wisdom	A mature understanding of life	Accommodating 'beyond rational' thinking; indicating aspirations for wisdom beyond greater access to information; referencing complex knowledge or learning

ST	**Benevolence**	Preservation and enhancement of the welfare of people with whom one is in frequent personal contact	
	Responsible	Dependable, reliable	Directly mentioning 'responsible'; appeal to audience's sense of duty; mentioning 'dependents' who rely on audience; (mentioning 'reliability' NOT coded, as this is a system, not human, characteristic)
	Loyal	Faithful to my friends, group	Suggesting appealing to audience's sense of importance about being faithful to friends or group members
	Meaning in life	A purpose in life	Indicating that contributing to meaning was a serious design objective
	True friendship	Close, supportive friends	Indicating an effort to enhance aspects of friendship that are intrinsically (not extrinsically) valuable
	Honest	Genuine, sincere	Appealing to audience's feelings of trust and trustworthiness
	Helpful	Working for the welfare of others	Appealing to audience's collectivist goodwill or team spirit
	Forgiving	Willing to pardon others	Indicating an effort to enhance audience's capability to forgive
	Mature love	Deep emotional and spiritual intimacy	Indicating an effort to enhance audience's capacity for deep emotional and spiritual intimacy
	A spiritual life	Emphasis on spiritual not material matters	Directly mentioning 'spiritual'; indicating consideration of spiritual needs in the design process
C	**Conformity**	Restraint of actions, inclinations and impulses likely to upset or harm others and violate social expectations or norms	
	Self-discipline	Self restraint, resistance to temptation	Suggesting that adoption of technology would help audience practice restraint (e.g. because of greater awareness of reasons to do so)
	Politeness	Courtesy, good manners	Indicating an effort to enhance good manners

	Honouring of elders	Showing respect	Indicating an effort to help audience show respect to elders or superiors
	Obedient	Dutiful, meeting obligations	Mentioning legislative compliance as motivator for adoption or behaviour change
C	**Tradition**	Respect, commitment and acceptance of the customs and ideas that traditional culture or religion provide the self	
	Humble	Modest, self effacing	Indicating an effort to engender modesty or humility
	Detachment	From worldly concerns	Advocating transcendence of material or worldly concerns
	Devout	Holding to religious faith and belief	Accommodating religious beliefs or practices; emphasising the value of faith or devotion
	Respect for tradition	Preservation of time honoured customs	Indicating an effort to create continuity with past (non-Digital Age) traditions
	Moderate	Avoiding extremes of feeling and action	Explicitly hailing the intrinsic (rather than extrinsic) virtues of using less
	Accepting my portion in life	Submitting to life's circumstances	Indicating an effort to foster audience's satisfaction of needs with current solutions and fostering sharing behaviour
C	**Security**	Safety, harmony, and stability of society, of relationships, and of self	
	Healthy	Not being sick physically or mentally	Directly mentioning health and well-being benefits of adoption of technology; mentioning 'toxicity' of alternatives
	Family security	Safety for loved ones	Suggesting adoption of technology would increase safety of loved ones
	Social order	Stability of society	Suggesting adoption of technology or change in design would lead to greater social stability, resilience or vitality
	Clean	Neat, tidy	Mentioning cleanliness as a virtue or a benefit of adoption of technology or behaviour change

Reciprocation of favours	Avoidance of indebtedness	Accommodating audience's efforts to reciprocate others' goodwill
Sense of belonging	Feeling that others care about me	Mentioning audience's position within a larger group and leveraging this as a means to adoption of technology or behaviour change
National security	Protection of my nation from enemies	Suggesting adoption of technology or change in design would improve the audience's nation's security (both in terms of safety and economic security)

D.3.3 Coding rules and procedures

The following rules were developed to ensure fairness and consistency in the coding:

- *Values may only be coded once per paper.* This rule was created because the purpose of the study was to determine whether certain values were commonly activated across a range of papers, not how strongly these may be activated in a given paper. This was in part because values research has not been able to demonstrate whether repetition of a value significantly affects behaviour; but it has demonstrated the influence of value activation. Qualitative analysis was deemed better for reflecting on these issues.
- *Values are only coded when they are actively activated in a target group.* For example, if the paper reports on a prototype solution, values were only coded if they were specifically designed for. If, on the other hand, the aim of a paper is to propose alternative routes forward in Green Computing, the entire paper was coded.
- *Values should not be inferred if doing so requires filtering through the coder's values.* For example, if the paper mentions 'reducing carbon footprints', this might be interpreted by one coder as reflecting implicitly the values of 'Responsible', 'Health', and 'Protecting the environment'; whereas for another coder, this might be interpreted as reflecting the values of 'Capable', 'Intelligent' and 'Successful'. In other words, values are only coded when they are deemed not to be interpreted any other way.

- *Values activated by way of literature review were not coded.* This rule was developed because it is often difficult to tell how strongly the authors agree with the literature being cited.
- *Values activated by way of ethnography were not coded.* This rule was developed, again, because it is often difficult to tell how strongly the authors agree with the people they are quoting.
- *Values activated purely rhetorically were not coded.* Some authors will make a statement so as to refute it. In these cases, the statement being refuted is not coded.
- *Values should be evaluated for 'fairness' at the end of reading a paper.* Values are coded as the coder reads. But at the end of coding, the coder must reflect on whether any of these values does not reflect the overall sentiment of the paper. This rule was developed because papers sometimes have a logical arc whereby values activated at the start are later explicitly de-activated. This rule is only applied in these rare cases.

E Green Computing frames analysis

Incorporating the results of the discourse analysis in Chapter 2, a pioneering technique was developed to evaluate certain key frames in terms of their consistency with the reinforcement of either 'positive' or 'negative' values.

E.1 Development of a frames analysis methodology

While this dissertation uses the terms 'Self-Transcendent' and 'Self-Enhancement' values, Common Cause uses the terms interchangeably with 'intrinsic' and 'extrinsic' values, respectively. Importantly, however, these terms originate from different empirical approaches to studying values. In contrast to Schwartz's cross-cultural values questionnaire, Grouzet et al (2005) asked respondents to rate the importance of various *goals*, which have subsequently been organised under the headings of intrinsic and extrinsic goals, and relate to intrinsic and extrinsic values. The difference between values and goals is that:

- goals tend to be situation-specific, whereas values tend to transcend a given situation, in that they are core to the individual's sense of self (Schwartz et al., 2012);
- goals are achievable and can be completed, whereas values have to be lived and are never completed (Tim Kasser; Values and Frames Workshop, Lancaster University, 13/6/12).

As will be demonstrated below, however, goals may help unite the concepts of values and frames in a way that can be operationalised for the purposes of evaluating whether a frame is 'positive' or 'negative' for Green Computing.

An example frame analysis

Frames can be conceptualised as narratives that help people make sense of the world (Lakoff, 2008). Linguistically, frames are simply structures of thought with 'slots' (indicated by underlines below) that are related to each other in a specific way and are filled with specific 'actors'[10]. The classic example of this is the *Transaction* frame, which relates the actors 'buyer' and 'seller' to each other in a meaningful way: 'A buyer gets goods from the seller in exchange for money'. Within this, there are presupposed frames for 'buyer', 'seller', 'goods', 'money' and 'price':

- 'Goods are things that people need and/or want';
- 'Money is something we exchange for goods';
- 'A buyer has money and needs and/or wants goods';
- 'A seller has goods and needs and/or wants money';
- 'A price is the value of a good in an amount of money, which the buyer exchanges for goods[11].

People are able to combine these lower-level frames to enable us to make sense of commercial exchanges. Part of that understanding, therefore, is enabled through an implicit understanding of actors' *goals*. The buyer's goals, for example, can be re-written in a form that matches the goal statements used by Grouzet et al. (2005): 'I will get the goods.' Related to this, it is possible to infer goals that would enable the realisation of this primary goal, such as, 'I will have enough money to buy everything I want', 'I will have a job that pays well', and 'I will be financially successful.'

Psychologists (Grouzet et al., 2005; Kasser & Ryan, 1996) have found that goals tend to cluster into goal types. For example, goals that fall under the heading 'Community feeling' include, 'I will assist people who need it, asking nothing in

[10] Explanation and example provided by Professor Paul Chilton, Lancaster University Linguistics and English Language Department; personal meeting 18 December 2013.

[11] A more nuanced narrative may be understood to include the idea that a price must provide the seller with profit while providing the buyer with value for money. This nuanced understanding may be interwoven with *Free Market* narratives about supply and demand, deregulation, etc.

return', 'The things I do will make other people's lives better', and 'I will help the world become a better place'. The goals identified for the 'buyer' in the *Transaction* frame fall under the heading of 'Financial success' goals. These studies (ibid) have shown that when people complete an Aspiration Index questionnaire, 'Financial success' goals tend not to be important to people who score high on 'Community feeling' goals, and vice versa. Given that 'Community feeling' has been correlated with a concern for 'bigger-than-self' problems (i.e. similar to Self-Transcendence in Schwartz's terms), it can be said that a campaign that seeks to promote concern for 'bigger-than-self' problems a) ought to promote 'Community feeling' goals, and b) ought not to promote 'Financial success' goals. Indeed, this is precisely the conclusion reached by Darnton & Kirk (2011), who suggest that for Oxfam to increase public concern for world poverty, they should abandon their use of the *Transaction* frame as it relates to donors because it reinforces 'Financial success' goals and undermines their 'justice not charity' (i.e. 'Community feeling') slogan. In other words, *Transaction* is a 'negative' frame for Oxfam's *Make Poverty History* because:

- the frame is commonly linked with 'Financial success' goals;
- these goals are empirically correlated with extrinsic values (Grouzet et al., 2005); and
- extrinsic values, like Self-Enhancement values, are empirically correlated with a relative lack of interest in 'bigger than self' issues, such as poverty (cf. Chilton et al., 2012).

Operationalising these insights

A technique for evaluating frames has been developed for this dissertation based on the logic described above, the stages of which are summarised below.

Stage 1: Identification of frame The first stage involves discourse analysis to determine the frame(s) underpinning the chosen discourse or campaign. This stage has already been completed for Green Computing in Chapter 2, which identified *Rational Actor, Self-Interest, Free Market* and *Instrumentally Valuable Environment* as key frames of interest.

Stage 2: Identification of narrative The next stage involves deconstructing the frame to reveal the abstract narrative implicit in the frame. While narratives may

be more or less complicated depending on one's understanding of specific details (e.g. see footnote on page 244), the aim of this stage is to identify the most basic narrative that makes the frame cognitively useful. Many of these narratives can be discerned from the descriptions of frames that are commonly understood by other researchers. In this work, all frames have been recognised in prior publications, which minimises the amount of interpretation required in this stage.

Stage 3: Identification of goals The next stage involves interpretation of the goals that would logically pertain to the actors in this narrative. Again, while actors in real life instances of these narratives may differ with respect to their goals, the aim of this stage is to identify the goals that relate to a (necessarily fictional) construction of an actor as his/her *ideal type*, in order to determine the goals that are cognitively associated with these actors. It is proposed that these are the goals that would be implicitly understood upon activation of a frame.

Stage 4: Linking goals to values These goals can then be linked to values, using as a guideline the empirical findings and analysis of Grouzet et al. (2005) and subsequent related publications which explicate these associations[12].

Stage 5: Evaluating frame If the goals are associated with intrinsic (i.e. Self-Transcendence, 'positive') values[13], the frame is labeled 'positive'. If the goals are associated with extrinsic (i.e. Self-Enhancement, 'negative') values, the frame is labeled 'negative'.

While this process undoubtedly requires subjective interpretation through these various stages, this is often the case for linguistic analysis as evidenced by precedents such as Lakoff (2008), Westen (2007) and Darnton & Kirk (2011). The benefit of this technique in comparison with these precedents is that it enables the systematic documentation of the kind of logical analysis that is largely implicit in other analyses, and presents details that can be debated amongst researchers.

[12] While the Aspiration Index reveals an individual's goals, the frames represent a commonly held understanding of an actor's motivation; i.e. a frame implicitly communicates how an actor is motivated. The difference is that the Aspiration Index asks people what their goals are; frames involving human actors tells people what their goals should be (or at least what most people's goals are). Studies have not yet tested the priming effect of frames to show that frames can generate such activation/reinforcement, but sufficing for the purposes of frames evaluation here, activation of values can be *consistent or inconsistent with* a given frame.

[13] Recall that values are only 'positive' or 'negative' with respect to a given aim; in this case 'positive' and 'negative' are used with respect to the success of Green Computing.

In the next section, this technique is used to evaluate the *Rational Actor* and *Self-Interest* frames in Green Computing, with additional implications for the *Free Market* and as discussed further in Section 4.1.

Identification of narrative

Rational Actor The narrative of the *Rational Actor* frame involves 'people', 'brains', 'machines', 'information', 'costs and benefits', and 'actions', arranged as follows:

> People have brains which operate like machines by processing information into comparative weightings of costs and benefits, which people then use in order to determine which actions to take (i.e. the one that best maximises benefits and minimises costs).

This is the basic narrative that emerged from the Enlightenment (cf. Descartes), which not only celebrated the intellectual potential of the brain, but simultaneously devalued ostensibly non-rational routes to 'truth' (e.g. intuition, tradition, etc) (cf. Bourke, 1962: p. 263). In other words, the *Rational Actor* frame also produces a related narrative: *people have the capacity for non-rational thinking, but this should not be used to guide behaviour.*

Self-Interest The *Self-Interest* frame incorporates the *Rational Actor* into its narrative (hence it is sometimes referred to as the *Rational Self-Interest* frame), which involves 'rational actors' and 'personal costs and benefits', arranged as follows:

> Rational actors assess personal costs and benefits of actions, and decide to take the action that will maximise their own benefits and minimise their own costs.

'Rational' pursuits, in this (Modern, *Self-Interest*) context, are considered only those that maximise one's self-interest, i.e. result in more good and less bad. This is consistent with the characterisation of people offered by Rational Choice Theory (a.k.a., Rational Action Theory) (cf. Becker, 1976). Put a slightly different way, the self-interested rational actor is able to determine 'expected consequences' to his- or herself, and from these decide a plan of action that leads to the most desirable consequences (Darnton & Kirk, 2011: p. 48).

Identification of goals

In order to better understand the goals associated with the 'self-interested rational actor', it is helpful to imagine what these frames communicate if taken to the extreme. What follows is a caricature of this actor, and while it may not represent any real person, it represents the 'ideal' version of the 'self-interested rational actor'[14].

The 'self-interested rational actor' is person who makes every decision logically with respect to his/her self-interest. Such a person would want to be smart, to know as much information as possible to help them determine the most rational decision. This person would also want to be as efficient as possible, thereby reducing costs and maximising benefits. This person would also want extrinsic rewards that are associated with good, such as money, recognition, power, etc, and want intrinsic goods such as health and safety.

Relevant goals for the *Rational Actor/Self-Interest* narrative include:

1. 'I will think logically.'
2. 'I will gather enough information to make the correct decision.'
3. 'I will do things efficiently.'
4. 'I will overcome obstacles using my cognitive abilities.'
5. 'I will have enough money to buy everything I want/need.'
6. 'I will be able to satisfy all of my desires.'
7. 'I will enjoy life.'
8. 'I will have the ability to pursue what is in my best interest.'
9. 'I will be healthy.'
10. 'I will be safe and secure.'
11. 'I will control events in my life.'
12. 'I will control others to get what I want.'
13. 'I will be rewarded for my hard work.'
14. 'I will avoid punishment.'

[14] This caracturing is precisely the tactic of Mill when attempting to isolate characteristics of the ideal human in capitalist societies, i.e. Economic Man.

15. ‘I will have all the resources I need.’

There are also goals that the ‘self-interested rational actor’ would not find worth attaining[15]. This person would not necessarily see value in accommodating the feelings or beliefs of others (including traditional or religious beliefs) if these are not informed by rational thinking. This person would not see value in self-sacrifice for others’ benefit, or ensuring that one’s own gain did not come at the expense of others’ good. Seeking to detach from worldly concerns and the pursuit of material gain would be viewed as counter-intuitive and potentially counter-productive.

Opposing goals for the *Rational Actor/Self-Interest* narrative include:

1. ‘I will consider other people’s feelings and beliefs.’
2. ‘I will employ non-rational or ‘higher’ thinking to understand the world.’
3. ‘I will cultivate spirituality in my life.’
4. ‘I will learn from traditional beliefs and ways of doing things.’
5. ‘I will commit myself to my religious faith.’
6. ‘I will help others (when it does not personally benefit myself).’
7. ‘I will give to others who are less fortunate.’
8. ‘I will ensure that my benefit does not come at the expense of others.’
9. ‘I will transcend concerns about material things.’
10. ‘I will learn to live with and cherish what I have, even if I do not have everything I desire.’

Linking goals to values

Values consistent with the relevant goals of the *Rational Actor/Self-Interest* narrative include[16]:

- ‘I will think logically.’
- ‘I will gather enough information to make the correct decision.’ $\Longrightarrow$ ‘Intelligent’

[15] This is not to say that these are necessarily things that they actively avoid, but rather that there is no assumed mechanism for attracting this actor to these goals.

[16] Values definitions are borrowed from Holmes et al. (2011), as described in Appendix D.3.2.

- 'I will do things efficiently.'
- 'I will overcome obstacles using my cognitive abilities.' $\Longrightarrow$ 'Capable'
- 'I will have enough money to buy everything I want/need.' $\Longrightarrow$ 'Wealth'
- 'I will be able to satisfy all of my desires.' $\Longrightarrow$ 'Pleasure'
- 'I will enjoy life.' $\Longrightarrow$ 'Enjoying life'
- 'I will have the ability to pursue what is in my best interest.' $\Longrightarrow$ 'Freedom', 'Privacy'
- 'I will be healthy.' $\Longrightarrow$ 'Healthy'
- 'I will be safe and secure.' $\Longrightarrow$ 'National security'
- 'I will control events in my life.' $\Longrightarrow$ 'Influential'
- 'I will control others to get what I want.' $\Longrightarrow$ 'Social power'
- 'I will be rewarded for my hard work.' $\Longrightarrow$ 'Social recognition'
- 'I will avoid punishment.' $\Longrightarrow$ 'Preserving my public image', 'Obedient'
- 'I will have all the resources I need.' $\Longrightarrow$ 'Protecting the environment'

Inconsistent values, pertaining to opposing goals of the *Rational Actor/Self-Interest* narrative include:

- 'I will consider other people's feelings and beliefs.' $\Longrightarrow$ 'Broadminded'
- 'I will employ non-rational or 'higher' thinking to understand the world..' $\Longrightarrow$ 'Wisdom'
- 'I will cultivate spirituality in my life.' $\Longrightarrow$ 'A spiritual life'

• 'I will learn from traditional beliefs and ways of doing things.'	$\Longrightarrow$ 'Respect for tradition'
• 'I will commit myself to my religious faith.'	$\Longrightarrow$ 'Devout'
• 'I will help others (when it does not personally benefit myself.'	$\Longrightarrow$ 'Helpful'
• 'I will give to others who are less fortunate.'	$\Longrightarrow$ 'Equality'
• 'I will ensure that my benefit does not come at the expense of others.'	$\Longrightarrow$ 'Social justice'
• 'I will transcend concerns about material things.'	$\Longrightarrow$ 'Detachment'
• 'I will learn to live with and cherish what I have, even if I do not have everything I desire.'	$\Longrightarrow$ 'Accepting my portion in life'

E.2 Evaluating Frames

The values consistent with (and potentially reinforced by) the *Rational Actor/Self-Interest* framing, as well as those inconsistent with (and potentially diminished by) these frames, are summarised in the main text, Section 4.3, Tables 4.1 and 4.2. These tables show the analysis leading to the conclusion that *Rational Actor* and *Self-Interest* (as they work together) are negative frames for Green Computing.