Jan vom Brocke · Stefan Seidel
Jan Recker *Editors*

Green Business Process Management

Towards the Sustainable Enterprise

Springer

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Towards the Sustainable Enterprise

Preface by Richard T. Watson

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Foreword

Green is the new Black. Of course, not in the sense of a new fashion wave or the go-to response for corporate branding efforts; but instead Green is epitomizing an eco-aware movement that has pushed sustainability into the top ten list of business movements in the new millennium.

What used to be a boutique market for tourism and political activists has become probably the biggest business revolution since the e-commerce boom. Public and private organizations alike push towards "sustainable" solutions and practices. That push is partly triggered by the immense reputational gains associated with branding your organization as "green," and partly by emerging societal, legal, and constitutional concerns and pressures that force and encourage organizations to become economically, socially, and ecologically more sustainable.

MIT's Peter Senge, for example, calls for the "necessary revolution" – one that is not merely political but rather induces a paradigmatic shift towards a sustainable economy. Obviously, challenges at a global level cannot be solved by rather reactive solutions that target the mere symptoms rather than the underlying imbalances and potential misbelieves. What is needed is a fundamental, paradigmatic shift. Organizations are hence forced to also recognize the environmental implications of resource consumption and social cost caused by their processes – the processes' ecological and social footprint.

With this book, we intend to immerse deeper into the role of business processes and their management in order to create an environmentally sustainable society. Business Process Management (BPM) has emerged as a comprehensive solution portfolio for businesses to improve performance as well as compliance of their organizational work systems, and also has the power to innovate and continuously transform businesses and cross-organizational value chains. While BPM has traditionally focused on economic imperatives, most notably time, cost, quality, and flexibility, organizations now increasingly recognize its relevance for designing and implementing "green" processes. Because of this potential, this book discusses the emergent role of BPM in the context of ecological sustainability. We thus aim to provide pioneers of the field with a forum where they disseminate their thoughts to a broader audience.

We wish to thank all authors for their valuable contributions to this book. Many experts from the fields of Business Process Management and Information Systems showed great enthusiasm to submit their work. It is our particular pleasure that Richard T. Watson, who has been pioneering the area of Green IS and Energy Informatics, provided a preface to this book. Rick's contribution to the field has been very influential to our own work. We would further like to thank Clemens Malt and Kathi Büchel for their great support in editing this book and Christian Rauscher at Springer, who has been of great support throughout the publishing process.

We hope that you will enjoy the remainder of this book, find it inspirational, and that it will serve you well in your own quest towards more environmental sustainability in both your private and professional life.

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Preface

Humans have been designing processes for millions of years. The process for creating a cutting instrument by striking a hammerstone against another rock to create a sharp-edged flake is perhaps two million years old (Encyclopædia Britannica Online, 2011a). If it is particularly useful, a new process is added to the cultural repertoire of a society and passed on to successive generations. The gradual accumulation of such processes over many years has created today's civilization. This development of a societal endowment of processes was intertwined with the development of information systems. In order for processes to be used within one generation and inherited by another, there needs to be a means of communicating a process from one person or group to another.

Gestures, a strong candidate for the first form of information system, appear to be innate to humans (Tomasello, 2008). When in a country where we don't speak the language, we revert to pointing and posturing to communicate. Thus, we can imagine one person using gestures to show another person how to use a hammerstone, much as we would do it today. When speech emerged some time after the origin of gesturing, humans would have found it easier to communicate processes, and might well have combined gestures and spoken commands to achieve process transfer. Early process management in a subsistence economy was focused on cultural transmission. Better processes (e.g., how to make fire or cook meat) increased a tribe's survival prospects. Though there were seemingly cases where a society became so small it gradually lost its ability to transfer processes. For example, the evidence suggests that when they became separated from mainland Australia, the Tasmanian aboriginals over generations forgot the process for making fire (Richerson & Boyd, 2004).

The emergence of agricultural economies layered a new dominant concern, production, on top of survival. Farmers created a new set of processes centered on production of crops and animals (e.g., how to plant a seed, how to care for a cow). Writing paralleled the emergence of agricultural economies, as farming societies needed to record and collect data to manage their affairs. Processes (e.g., astronomical observation) were also developed to create calendars, a critical information system for deciding when to plant a crop. Thus we see that new processes create a demand for supporting processes, and the accumulation of processes multiplied. There is evidence of the earliest writing scripts being used to record processes, such as medical procedures (Encyclopædia Britannica Online, 2011b).

This pattern of process accumulation continues throughout the agricultural era and gained significant impetus with the arrival of industrial economies, beginning in the United Kingdom in the eighteenth century. The focus still remained on production, but the shift was from growing food to manufacturing goods, and we saw a flourish of new production and transportation processes. Society had already recognized the value of new processes. As early as 1421, a patent had been granted in Italy, and the U.S. Constitution authorized Congress to establish a national patent system (Encyclopædia Britannica Online, 2011c). The process of patenting inventions is perhaps the beginning of the systematic process management. Society had established a public way of describing processes and products.

As the industrial revolution accelerated, new information systems, which can be thought of as bundles of integrated processes for conveying information, emerged. Accounting, a set of processes for recording financial transactions and establishing the value of assets and liabilities, is one of the new systems to materialize early in the revolution, with the first chartered accounting society being established in Edinburgh in 1854. Production is still a dominant societal issue, and today we see elaborate process management systems in the form of Enterprise Resource Planning (ERP) and Project Management Systems, among many others, that make today's production systems highly efficient.

Advanced economies are now ensconced in the service era, with for example over 75% of U.S. workers employed in this sector. Service has become the dominant logic for many firms (Vargo & Lusch, 2004). High quality service requires the reliable execution of multiple processes over thousands of encounters by many customer facing employees (e.g., a fast food store, an airline, a hospital). Consequently, process management has grown in importance, and gained considerable attention in the mid 1990s with the surge of interest in business process reengineering (Hammer, 1990; Hammer & Champy, 1993). The field has prospered, and the breadth and depth of scholarship on business process management (BPM) is readily apparent in a recent compendium (vom Brocke & Rosemann, 2010a, 2010b).

As well as serving existing customers, firms are very concerned with how to create new customers. There is an oversupply of many consumer products (e.g., cars) and companies compete to identify services and product features that will attract customers. They are concerned with determining what types of customers to recruit and finding out what they want. As a result, we have seen the rise of business analytics and customer relationship management to address this dominant issue.

We are in transition to a new economy, sustainability, where the dominant issue becomes one of assessing and mitigating environmental impacts because, after several centuries of industrialization, atmospheric CO_2 levels are causing temperatures to rise, oceans to acidify, and icecaps to melt. Furthermore, we have to learn how to use the limited resources of one planet to meet the needs of six billion people with some level of equity within and across generations.

As a result, a new class of application is emerging, such as environmental management systems, energy informatics (Watson, Boudreau, & Chen, 2010) and UPS's telematics project (Watson, Boudreau, Li, & Levis, 2010). These new systems will also include, for example, support for understanding environmental impact through simulation of energy consuming and production systems, optimization of energy systems, and design of low impact production and customer service systems.

The preceding discussion is summarized in the following figure. Notice that dominant issues do not disappear but rather aggregate in layers, so tomorrow's businesses will be concerned with survival, production, customer service, and sustainability. Consequently, a firm's need for BPM never diminishes, and each new layer creates another set of process needs.

Table 1 Societal focus (Source: (Watson, forthcoming))

Economy	Subsistence	Agricultural	Industrial	Service	Sustainable
Question	How to survive?	How to farm?	How to manage resources?	How to create customers?	How to reduce impact?
Dominant issue	Survival				
		Production			
				Customer service	
					Sustainability
Key information systems	Gesture Speech	Writing Calendar	Accounting ERP Project management	BPM Analytics CRM	Simulation Optimization Design

As we prepare to meet the demands of the sustainability era, it is very appropriate that this book is published. It is one of the first books to recognize that BPM has a critical role to play in creating a sustainable society. Society, across the various types of economies, has shown an increasing concern for managing its processes, and now it needs to be even more attentive to processes. We have learned that well designed processes contribute to the efficient utilization of scarce resources. We have also learned that processes can be redesigned to make dramatic reductions in the use of resources. For example, U.S. based carpet manufacturer, Interfaces, shifted from selling to leasing carpet, and a concomitant redesign of its business processes led to recycling of discarded carpet rather than dumping it in a landfill (Anderson, 1999). We have to learn how to redesign many aspects of contemporary life to become a sustainable economy, and BPM will be a critical driver in this redesign. Indeed, we need a set of meta processes for applying BPM to sustainability problems. This book is an essential step in that direction.

I warmly applaud Jan, Stefan, and Jan for their foresight in seeing the critical connection between BPM and sustainability, and taking action to advance scholarship on this linkage. We can thank them for their perspicacity by applying the many sound ideas in this book to create a greener society.

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Part I
Foundations and Directions

Green Business Process Management

Stefan Seidel, Jan Recker, and Jan vom Brocke

Abstract In managing their operations, organizations have traditionally focused on economic imperatives in terms of time, cost, efficiency, and quality. In doing so, they have been a major contributor to environmental degradation caused by resource consumption, greenhouse emissions, and wastage. As a consequence, organizations are increasingly encouraged to improve their operations also from an ecological perspective, and thus to consider environmental sustainability as an additional management imperative. In order to lessen their impact on the natural environment, organizations must design and implement environmentally sustainable processes, which we call the challenge of Green Business Process Management (Green BPM). This chapter elaborates on the challenge and perspective of Green BPM, and explores the contributions that business process management can provide to creating environmentally sustainable organizations. Our key premise is that business as well as information technology managers need to engage in a process-focused discussion to enable a common, comprehensive understanding of organizational processes, and the process-centered opportunities for making these processes, and ultimately the organization as a process-centric entity,

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"green." Through our review of the key BPM capability areas and how they can be framed in terms of environmental sustainability considerations, we provide an overview and introduction to the subsequent chapters in this book.

1 Introduction

The ever-increasing world-wide population, the demand for living standards, and the on-going exploitation of natural resources have increased a wider awareness for the necessity of sustainability in living as well as organizing, performing, and managing work. Sustainable practices are more than ever on the agenda of organizations, triggered by a growing demand of the wider population towards approaches and practices that can be considered "green" or "sustainable."

Work practices in organizations are often subsumed under the notion of business processes. These processes are enacted to contribute to the value-generation in terms of profit, reputation, or other incentives. Naturally, the design and execution of these processes describes the face, the performance, but also the compliance of organizations.

In designing, implementing, executing and overall managing their business processes, organizations have traditionally focused purely economic imperatives, such as considerations of time, cost, efficiency, and quality.

With the emergence of environmental sustainability as an additional dimension of organizational performance, however, these classical process imperatives are increasingly subjected to critical scrutiny. This is because they do not appropriately reflect environmental objectives such as "minimize energy consumption", "reduce carbon footprint," or "provide ecologically sustainable solutions."

In effect, the classical management of business processes for business improvement – known as the devil's quadrangle of *time*, *cost*, *quality,* and *flexibility* (see Fig. 1) – is due for replacement. As contemporary organizations become increasingly aware of the need to become more sustainable, they look for information technology (IT)-enabled business processes that are successful in terms of their

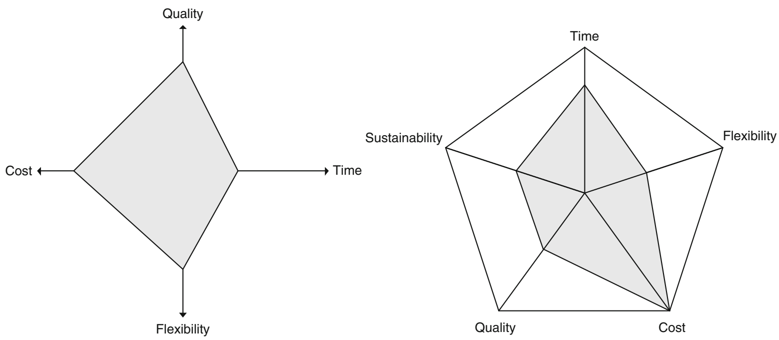

Fig. 1 The devil's pentagon (Extended from Reijers & Mansar, 2005)

economic but also their ecological and perhaps also social impact. Exemplary ecological key performance indicators that increasingly find their way into the agenda of managers include carbon emissions, data center energy, or renewable energy consumption. The devil's quadrangle, therefore, becomes a devil's pentagon, which recognizes *sustainability* as an important emergent dimension in the management of business processes (see Fig. 1).

Considering the implications of the devil's pentagon, the challenge arises how sustainability considerations such as carbon footprint, renewable energy consumption, wastage production, and other environmental performance indicators can be considered in the management of an organization's processes so as to warrant the establishment of "The Sustainable Enterprise."

One of the perspectives towards this challenge that underpins this book is that information systems play an eminent role in the design, implementation, and execution of sustainable business processes. This is because information systems are considered the greatest force of productivity improvement in the last half-century, mostly due to the cross-functional view they offer for an organization, and their ability to understand, change, and reinvent business processes (Watson, Boudreau, & Chen, 2010).

Not surprisingly then, leading scholars in the field of information systems have called their fellow researchers to contribute to a "Green IS" movement, that is, to investigate how the transformative power of IS can be leveraged to create an ecologically sustainable society (Loos et al., 2011; Watson et al., 2010). On the basis of this movement, this book considers specifically how information systems can be designed and implemented so that they contribute to the management of sustainable business processes. So in a way, we ask how green IS can contribute to green BPM.

The intent of this book is to immerse deeper into this question, by examining the role of business processes and specifically the contributions that the management of these processes can play in leveraging the transformative power of information systems for creating an environmentally sustainable society. Specifically, we explore how and where the principles and methods associated with business process management can aid managers in charge to make information systems design, implementation, or use decisions in order to build sustainable business processes.

To familiarize the reader with the intent and contents of this book, the remainder of this introductory chapter sets out to provide some foundations around business process management and its relation to the establishment of a sustainable enterprise. Perusing this background, we will then outline how the subsequent chapters of this book relate to the general notion of "Green BPM." In the following, therefore, we discuss the role of business process management in green initiatives, before we then present a framework for BPM research and practice. The next section then links the subsequent chapters of this book to the framework, thus outlining the main contributions of each chapter.

2 The Role of Business Process Management in Green Initiatives

BPM has evolved as a holistic management practice for managing and transforming organizational operations (Hammer, 2010). BPM is typically defined as “a structured, coherent and consistent way of understanding, documenting, modelling, analyzing, simulating, executing and continuously changing end-to-end business processes and all involved resources in light of their contribution to business success” (Australian Community of Practice, 2004).

In their efforts to manage and improve business processes to enable business benefits in terms of costs, flexibility, time savings, quality, or, indeed, sustainable practices, BPM naturally considered the use of IT and IT-based systems as a key driver for successful business processes. For example, past years have seen the emergence of holistic enterprise resource planning systems (Davenport, 2000), automated workflow systems (van der Aalst & ter Hofstede, 2005), CASE and other process design systems (Orlikowski, 1993), expert systems (Markus, Majchrzak, & Gasser, 2002), virtual collaboration systems (Briggs, de Vreede, & Nunamaker, 2003), and business rule systems (von Halle, 2001) as IT-enabled systems that enable process change and management and thereby contribute to business value generation.

It is at this intersection of IT-system enablement and process change that we believe the biggest potential for sustainability initiatives lies. Our key premise is that business and IT managers need to engage in a process-focused discussion to enable a common, comprehensive understanding of organizational processes, and the process-centred opportunities for making these processes, and ultimately the organization as a process-centric entity, “green.”

Our reasoning goes as follows: A discussion of only those potentials that come out of dedicated information technologies that support environmental sustainability (such as telecommuting systems or virtual servers) is too limited to facilitate discussions that can help business executives in putting these IT solutions into business work. While it is impossible today to think of undertaking a major sustainability change initiative (involving the re-design of major business processes) without considering the possibilities that advanced information technologies can provide to that effect, it is equally impossible to think about any major redesign that does not call for major changes in how employees perform their jobs. Employees and the management of employees are just as important as IT in the transformation to sustainable practices and solutions, and BPM provides just the perspective that enables an integrated, holistic approach to the management of sustainability change.

The proposition that we put forward in this book is that only through process change, and the application of process-centred techniques, such as process analysis, process performance measurement, and process improvement, can the transformative power of IS be fully leveraged in order to create environmentally sustainable organizations and, in turn, an environmentally sustainable society.

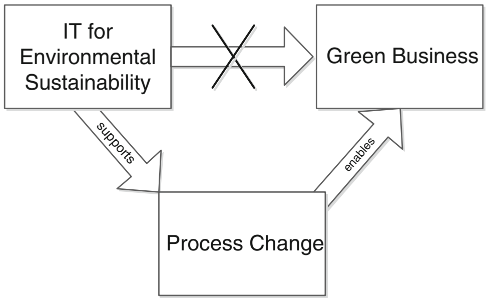

Fig. 2 The role of process change in environmental sustainability

To investigate this proposition further, we contend that researchers and practitioners must consider process-related concepts when examining the role of IT in the transformation towards sustainable organizations. This will not only allow us to better understand the transformative power of technological systems in the context of sustainable development, but also to proceed to more prescriptive, normative advice that can aid and guide the implementation of sustainable, IT-enabled business processes. Figure 2 encapsulates our view.

The model depicted in Fig. 2 suggests that a faithful application of "green information systems" – information technologies dedicated to environmental sustainability – requires a sound understanding of how the technological capabilities facilitate a change in the business processes of an organization. The promise of business process management is that it enables analysts and managers (and also researchers) to (a) understand these change capabilities, (b) understand the implications of the change, and (c) manage the change itself.

Still, business process management to date has not explicitly focused on environmental sustainability as a change objective or driver. Thus, we see a need for expanding our current view of business process management towards the notion of 'Green BPM' that incorporates sustainability as an objective and as a vehicle for managing business process change. To that specific end, this book will contribute to our understanding by providing a comprehensive snapshot of the current efforts and emerging theories around how Green BPM can be defined, implemented, or applied in organizational efforts to become sustainable enterprises. To recap, we identify the following three basic premises that underpin the intent of this book:

- Organizations contribute to environmental degradation through their business processes. In order to become environmentally sustainable, organizations must implement environmentally sustainable processes.
- Green Business Process Management concerns the understanding, documenting, modeling, analyzing, simulating, executing, and continuously changing of business process with dedicated consideration paid to the environmental consequences of these business processes.
- Information systems play an important role in collecting, processing, and disseminating information related to environmental sustainability from and within the business processes. Only through the change of processes, however, organizations can fully leverage their transformative power.

To further define and elaborate on these premises, and to set the stage for the content of the remainder of this book, we will now explore in more detail the concepts that constitute the notion of Green BPM.

3 A Framework for Green BPM Research and Practice

To substantiate our understanding of Green BPM, we describe a framework for Green BPM Research and Practice by building on a model of BPM capabilities (de Bruin & Rosemann, 2007; Rosemann & vom Brocke, 2010) (see Fig. 3).

Essentially, the model describes a set of six capability areas that are key to the management of business processes in an organization:

- Strategic Alignment is the continual tight linkage of business process management to organizational priorities and processes, enabling achievement of business goals.
- Governance establishes relevant and transparent accountability and decision-making processes to align rewards and guide actions in business process management.
- Methods are the approaches and techniques that support and enable consistent business process management actions and outcomes.
- Information Technology is the software, hardware, and information management systems that enable and support business process management activities.
- People are the individuals and groups who continually enhance and apply their business process management-related expertise and knowledge.
- Culture is the collective values and beliefs that shape business process management-related attitudes and behaviors.

For each of these areas, critical factors are also elicited by the model of de Bruin and Rosemann, which, however, are not of dedicated interest to us for the purpose of

Strategic Alignment	Governance	Methods	Information Technology	People	Culture

Process Improvement Plan	Process Management Decision Making	Process Design & Modeling	Process Design & Modeling	Process Skills & Expertise	Responsiveness to Process Change
Strategy & Process Capability Linkage	Process Roles and Responsibilities	Process Implementation & Execution	Process Implementation & Execution	Process Management Knowledge	Process Values & Beliefs
Enterprise Process Architecture	Process Metrics & Performance Linkage	Process Control & Measurement	Process Control & Measurement	Process Education & Learning	Process Attitudes & Behaviors
Process Measures	Process-Related Standards	Process Improvement & Innovation	Process Improvement & Innovation	Process Collaboration & Communication	Leadership Attention to Process
Process Customers & Stakeholder	Process Management Controls	Process Project & Program Mgmt	Process Project & Program Mgmt	Process Management Leaders	Process Management Social Networks

Fig. 3 The BPM capability areas and underlying factors (de Bruin & Rosemann, 2007)

Table 1 Exemplary Green BPM challenges

Factor	Challenges
Strategic alignment	*How can process strategies be designed that appropriately reflect environmental objectives whilst maintaining a sufficient economical focus?*
	What are key strategic indicators to define a successful sustainable enterprise?
	How does sustainability relate to other strategic objectives of an organization?
Governance	*What roles are needed in order to implement environmentally sustainable processes in an organization?*
	What incentive systems can promote the accomplishment of environmental targets across business processes?
Methods	*How can sustainable business processes be analyzed, designed, and implemented?*
	How can the environmental impact of a specific business process be assessed?
Information technology	*How can information systems assist the analysis, design, or implementation of sustainable business processes?*
	How can the information technology portfolio itself be improved from an environmental perspective?
People	*What role do individual factors such as awareness, attitude, or intrinsic motivation play in the implementation of sustainable business processes?*
	How can people be appropriately educated to implement and adopt sustainable practices?
Culture	*How can green values relevant for the implementation of sustainable processes be identified, operationalized, and communicated?*
	How can individual attitudes and commitments be influenced in order to promote more environmentally sustainable behavior?

this book. The model of capability areas, however, provides a comprehensive account of those dimensions critical to successful organizational process management.

We can use this model, in turn, to define how the consideration of environmental objectives can be, or needs to be, incorporated into the management of business processes (Pernici et al. 2012). Indeed, several key challenges emerge for each of the capability areas. Table 1 provides an overview. We see the remainder of this book as an attempt to explore potential answers to these challenges, but also view these questions, as well as those emerging from the subsequent chapters, as a roadmap that can guide our efforts towards a sustainable organizational reality in the future, by directing our attention to the key challenges that require answers.

4 The Remainder of This Book

This book sets out to provide answers to the questions we ask above as well as related questions that did not find explicit mentioning. In the following chapters, different authors present opinions, tools, methods, and cases that show how organizations can become more environmentally sustainable through deliberately analyzing, improving, and managing their processes. In turn, their efforts provide both initial answers to the questions above and raise additional emerging questions that also require our attention.

In general terms, the book is structured in three parts. **Part A** provides foundations of, and directions for, Green BPM as well as Green IS. Next to this introduction, it includes the following three chapters:

Chapter "Unpacking Green IS: A Review of the Existing Literature and Directions for the Future" presents the results from a systematic review of both the practitioner and academic literatures surrounding Green IS. Stoney Brooks, Xuequn Wang, and Saonee Sarker provide a holistic picture by discussing the differences between Green IS and Green IT, identifying different research streams, and providing some specific research questions for IS scholars who are interested in Green IS.

Chapter "Unordered Business Processes, Sustainability and Green IS" explores the role of unordered business processes in sustainability based upon the Cynefin sense-making framework. While, traditionally, organizations have focused on improving those processes with a well-defined subject matter and often high levels of predictability (i.e., ordered situations), it is the unordered processes where the greatest opportunities lie, Helen Hasan writes.

Chapter "Information Systems in Environmental Sustainability: Of Cannibals and Forks" discusses the role of Green IS in creating more sustainable enterprises. Dirk S. Hovorka, Elaine Labajo, and Nancy Auerbach challenge the status quo of IS research, which tends to be rooted in a technological-managerial mindset, and argue for more innovative solutions that move beyond the economic focus of the traditional triple bottom line approach. Specifically, the authors identify three areas of action, namely: addressing collective rather than individual actions, creating, measuring, and monitoring a broad range of environmental impact measures, and designing organizational learning systems for adaptive management practices in the face of unpredictable and nonlinear environmental changes.

Building on these fundamental building blocks, **Part B** then discusses tools and methods for solutions relevant to Green BPM. It includes the following six chapters:

Chapter "Advancing Business Process Technology for Humanity: Opportunities and Challenges of Green BPM for Sustainable Business Activities" discusses how business process technologies can be used in the context of Green BPM. Constantin Houy, Markus Reiter, Peter Fettke, Peter Loos, Konstantin Hoesch-Klohe, and Aditya Ghose describe two application scenarios, propose an approach for environmentally aware process improvement, and discuss opportunities and challenges of Green BPM, based upon the classical process lifecycle.

Chapter "Modeling and Analyzing the Carbon Footprint of Business Processes" then describes an approach to modelling and analyzing the carbon footprint of Business Processes. Jan Recker, Michael Rosemann, Anders Hjalmarsson, and Mikael Lind provide an extension of the Business Process Modeling Notation (BPMN) that enables to account for the carbon emissions of activities within a business process. Then they introduce a method for measuring and analyzing the carbon emissions produced during the execution of a business process, and show the application of their approach to a real-life case.

In chapter "Managing Process Performance to Enable Corporate Sustainability: A Capability Maturity Model", Anne Cleven, Robert Winter, and Felix Wortmann contribute to our understanding of the capabilities that organizations need to develop in order to become environmentally sustainable by presenting a capability maturity model for process performance management (PPM).

While chapter "Managing Process Performance to Enable Corporate Sustainability: A Capability Maturity Model" provides answers as to how sustainability can be managed and measured, chapter "Measurement Systems for Sustainability" sheds more light onto what needs to be measured. Nicole Zeise, Marco Link, and Erich Ortner discuss the fundamentals of measuring sustainability, derive criteria to examine performance measurement systems, and discuss potential method extensions so as to integrate sustainability into performance measurement systems and management systems.

Chapter "Energy Informatics: Initial Thoughts on Data and Process Management" provides insights into the relationships between the emergent field of energy informatics and data and process management. Richard T. Watson, Jeffrey Howells, and Marie-Claude Boudreau explain how case management, complex event processing, and key performance indicators fit into a general model of energy management systems.

In chapter "Change the Game" Gilbert Silvius focuses on the sustainable management of projects. Until now, the project management world has failed to address the important topic of sustainability, he writes.

Finally, **Part C** provides a number of cases and assessments that examine how organizations have been engaging into becoming more environmentally sustainable. It includes the following three chapters:

Chapter "The Potential of a Network-Centric Solution for Sustainability in Business Processes" discusses the potential of a network-centric solution for sustainability in business processes. I doing so, Hans Thies, Ali Dada, and Katarina Stanoevska-Slabeva describe three use cases and introduce a new approach for sharing sustainability indicators.

In chapter "Understanding the Maturity of Sustainable ICT", Edward Curry and Brian Donnellan describe how the SICT-Capability Maturity Framework (SICT-CMF) was developed, how it can be used to measure SICT maturity, and how it has been applied to a number of organizations.

Finally, chapter "Ecosia.org: The Business Case of a Green Search Engine" presents a case study that shows how ecological and economic targets can, indeed, complement each other. Nils-Holger Schmidt, Thierry Jean Ruch, Jasmin Decker, and Lutz M. Kolbe present the case of the search engine Ecosia.org, which donates the majority of its revenues to the World Wildlife Fund (WWF), thus presenting an IT-enabled green business model.

Table 2 summarizes the chapters in this book and their relation to essential capability areas associated with Green BPM.

Table 2 Overview

Chapter	Authors	Title	Relevant capability areas of Green BPM
1	Stefan Seidel, Jan Recker, Jan vom Brocke	*Introduction to Green BPM*	All
2	Stoney Brooks, Xuequn Wang, Saonee Sarker	*Unpacking Green IS: Review of the Existing Literature and Directions for the Future*	All
3	Helen Hasan	*Unordered Business Processes, Sustainability and Green IS*	All
4	Dirk S. Hovorka, Elaine Labajo, Nancy Auerbach	*Information Systems in Environmental Sustainability: Of Cannibals and Forks*	All
5	Constantin Houy, Markus Reiter, Peter Fettke, Peter Loos, Konstantin Hoesch-Klohe, Aditya Ghose	*Advancing Business Process Technology for Humanity: Opportunities and Challenges of Green BPM for Sustainable Business Activities*	Methods, information technology
6	Jan Recker, Michael Rosemann, Anders Hjalmarsson, Mikael Lind	*Modeling and Analyzing the Carbon Footprint of Business Processes*	Methods
7	Anne Cleven, Robert Winter, Felix Wortmann	*Managing Process Performance to Enable Corporate Sustainability: A Capability Maturity Model*	Strategic alignment, governance, methods
8	Nicole Zeise, Marco Link, Erich Ortner	*Measurement Systems for Sustainability: Evaluation and Extension of Common Measurement Systems with Regard to Sustainability*	Strategic alignment, governance, methods
9	Richard T. Watson, Jeffrey Howells, Marie-Claude Boudreau	*Energy Informatics: Initial Thoughts on Data and Process Management*	Methods, information technology
10	Gilbert Silvius	*Change the Game: Sustainability in Projects and Project Management*	Methods, people, culture
11	Hans Thies, Ali Dada, Katarina Stanoevska-Slabeva	*The Potential of a Network-Centric Solution for Sustainability in Business Processes*	Strategic alignment, methods, people
12	Edward Curry, Brian Donnellan	*Understanding the Maturity of Sustainable ICT*	Governance, methods, information technology
13	Nils-Holger Schmidt, Thierry Jean Ruch, Jasmin Decker, Lutz M. Kolbe	*Ecosia.org: The Business Case of a Green Search Engine*	Strategic alignment, information technology

In conclusion, we hope that with this book, we can contribute to a better understanding of how environmental sustainability can become an integral part of organizational work practices. We trust you will enjoy the remainder of this book and that it will serve you well in your own quest towards a greener future.

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Unpacking Green IS: A Review of the Existing Literature and Directions for the Future

Stoney Brooks, Xuequn Wang, and Saonee Sarker

Abstract Green IS is one of the latest manifestations in the realm of sustainable business practices. The decisions surrounding Green IS implementation strategies, policies, and tools provide compelling challenges for organizations. As practitioners have been highly interested in this topic for a while (known as Green IT), there has also been a recent growing interest in Green IS within the IS academic community. In this chapter, we conduct a systematic and comprehensive review of both the practitioner and academic literatures surrounding Green IS. Specifically, our review includes articles published in the IS academic Senior Scholar's Basket of Journals, hybrid journals such as *Communications of the ACM*, *IEEE Software*, and *MIS Quarterly Executive*, and practitioner outlets such as *CIO* magazine and *PC World*. Through this review, we identify the main streams of Green IS-related studies that have been undertaken within both practice and academia, and offer a holistic picture of the current state of research/interest in Green IS. We then identify the overlaps and differences between the two sides (that is, academia and practice) in an attempt to unearth noticeable similarities/gaps between both perspectives. Finally, we not only identify the trends in Green IS research, but also provide academic scholars interested in Green IS more focused directions on the specific research questions to address with respect to Green IS.

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1 Introduction

With the growing awareness of environmental issues such as global climate change, organizations increasingly realize the importance of sustainability. One definition of sustainability is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED [World Commission on Environment and Development], 1987, p. 43). Therefore, sustainability is a complex phenomenon that includes environmental, economic, and social dimensions (Kleindorfer, Singhal, & Wassenhove, 2005; Porter & Kramer, 2006). The essence of sustainability is that these three dimensions need to be addressed simultaneously rather than being viewed as trade-offs or with one of the dimensions superior to the other two. One example of sustainable initiatives is from IBM. On May 11, 2007, IBM launched a $1 billion-a-year service initiative to build and redesign data centers consuming less energy. Later, as an extension of its Project Big Green, IBM launched another program to allow mainframe customers to monitor their energy consumption in real time (CACM Staff, 2007a).

Sustainability can be traced back almost as far as a researcher would care to go. Perhaps the important question is what the motivation and the degree of emphasis at varying times in history were behind what are often called “green practices”. Some in the “green movement” would suggest that “green” is a reaction to the excesses resulting from the development of Western societies and the waste generated from that development. Rather than continuing to emphasize growth at any cost, the green movement suggested that the relationship between humans and their environment must not be taken for granted. Gradually, the ideas of sustainability evolved into what are now almost mainstream acceptance and usage by individuals and organizations.

As sustainability became more and more common in organizations at all levels, oil prices reached $100 a barrel in January 2008. A “wake-up call” as popular usage has it, must have been heard in information technology (IT) departments around the developed world. As firms reacted individually to the challenge of escalating energy prices and other related impacts to their bottom lines, many also found themselves facing increased pressure to reduce their carbon footprint, emissions, or whatever other metric of choice was the focus for variety of regulatory, political, and social actors in their respective domains. Even firms that had not been adopting green practices as a consequence of a commitment to environmental and sustainable operations as part of their business, found themselves facing a whole new reality. They were now going to have to look at every aspect of their business with a “green lens” or face the consequences. Therefore, firms increasingly recognize the importance of sustainability. Green business practices, even if that means just basic recycling practices, can have a significant effect on a firm’s bottom line. Besides, companies have a variety of choices regarding what kind (and what amount) of sustainable investments to make.

Given the size of most firms’ IT investments, it is not surprising that Green IT is gaining in relevance and that the practitioner community has begun to pay attention to it. Practitioners have proposed Green IT as a technological solution to support environmentally friendly business practices. Murugesan (2008) suggests that Green IT is:

> "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment. Green IT also strives to achieve economic viability and improved system performance and use, while abiding by our social and ethical responsibilities (pp. 25–26)".

Green IT was recognized as the most important strategic technology for 2008 (Thibodeau, 2007). In December 2009, Copenhagen, Denmark hosted the United Nations Climate Change Conference, and Green IT was a topic of focus for the 192 members of the United Nations.

Green IT could be seen as just a way to reduce what McKinsey research (2008) estimates will be 3% of worldwide greenhouse gas (GHG) emissions in 2020. The Environmental Production Agency (EPA) told the US Congress in 2007 that data centers in the U.S. used 61 billion kilowatt-hours in 2006 (1.5% of all the power used) at a cost of $4.5 billion (InformationWeek, 9/2007). Perhaps even more important, both the EPA report and McKinsey (among others), says IT could reverse this trend significantly by enabling practices such as telecommuting and productive (non-wasteful) use of energy.

Business researchers have examined sustainability for decades from the perspectives of marketing (Belk, Painter, & Semenik, 1981), operations (Corbett & Kirsch, 2001), and management (Gladwin, 1993; Shrivastava, 1994). Recently, information systems (IS) literature also began to realize the importance of sustainability, and proposed the concept of "Green IS" to better understand the role of IS in dealing with sustainability (Melville, 2010; Watson, Boudreau, & Chen, 2010). For example, the International Conference on Information Systems (ICIS) hosted a submission track for Green-focused papers for the first time in 2009. Yet, there seems to be a lack of direction in term of the specific topics and approach to focus on in term of Green IS.

Boudreau, Chen, and Huber (2007) summarize the key difference between IT and IS: "An information technology (IT) transmits, processes, or stores information, whereas an information system (IS) is an integrated and cooperating set of software using information technologies to support individual, group, organizational, or societal goals." This differentiation applies to Green IT and Green IS as well.

To understand and study sustainability comprehensively, we must consider that Green IS involves power consumption and management, manufacturing practices, data center design and operations, recycling and end-of-life concerns for computer equipment, total cost of ownership issues, both micro and macro-economic issues, systems performance and efficient systems use, and environmental, social, and ethical practices relating to IT acquisition, use, and disposal. In short, we conceptualize Green IS as a multi-faceted phenomenon that is comprised of the ideas described as well as having the potential to include other facets not specifically mentioned.

Green IS has a greater potential in research and practice than Green IT because it tackles a much larger problem: it can make entire systems more sustainable compared to just reducing the energy required to operate information technologies (Boudreau et al., 2007). Therefore, our objective for this chapter is to offer specific research directions for the topic of Green IS for IS researchers. In order to give more focused directions, we assess the current state of Green IS studies by reviewing the current literature about Green IS. Given the debate in IS about being both rigorous and relevant (Benbasat & Zmud, 1999; Davenport & Markus, 1999; Lee, 1999; Lyytinen, 1999), in this chapter we review practitioner as well as academic literature so that we can get a clear picture of the topics discussed in Green IS literature from both sides and give more focused directions in terms of addressing topics valuable to Green IS in a rigorous as well as relevant way. Based on the results of our review, we identify the main areas of the published Green IS research and present a holistic picture of the current state of research/interest in Green IS. We then compare the overlaps and differences between practitioner and academic literature. Finally, we identify trends in Green IS research as well as provide academic scholars with more focused directions in terms of addressing topics valuable to Green IS in a vigorous as well as relevant way.

Given the breadth of the concept of Green IS, and owing to the research being in its infancy, there is a noticeable level of uncertainty about what should be examined with respect to Green IS. Hence, our objective in this chapter is to provide research directions on Green IS. Given that most studies we identified in the literature focus on Green IT, we first suggest that future studies should direct their focus on the more encompassing phenomenon of Green IS. This is because we conceptualize Green IT as being a part of Green IS. The research questions that we offer for future study of Green IS span pre-adoption-related decisions: *What motivates a company to decide to begin Green IS initiatives?*; the post-adoption decision: *What are the impacts of Green IS initiatives?*; and the adoption/implementation process itself: *How should the firm manage the process of Green IS adoption?*.

The rest of the chapter is organized as follows: first, we define the concept of Green IS, and give a brief introduction of eco-goals of Green IS. We then review both practitioner and academic literature and present the results. Next, we identify the overlaps and differences between two sides as well as evaluate the current status of Green IS study. Based on that, we offer specific research questions for future Green IS study. Finally, we conclude by summarizing the findings and discussing implications for research and practice.

2 Background of Green IS

2.1 Green IT and Green IS

To be consistent with previous research, we choose to adopt Green IS to understand how IS support sustainability (Watson et al., 2010). Previous studies have found that sustainability is a complex phenomenon and it is necessary to go beyond just environmentally friendly computing. However, given that Green IT is widely used in practitioner literature, it is useful to clarify the similarities and differences between these two terms.

The difference between Green IS and Green IT can trace back to the difference between IT and IS. According to the *Merriam-Webster Dictionary* (online version), IT refers to "the technology involving the development, maintenance, and use of computer systems, software, and networks for the processing and distribution of data". Therefore, it emphasizes the technical infrastructure. On the other hand, IS is defined as "an integrated and cooperating set of people, processes, software, and information technologies to support individual, organizational, or societal goals" (Watson et al., 2010, p. 24). Therefore, the IS discipline proposed Green IS to include a variety of possible initiatives to support sustainable business process, and argues that the concept of Green IT may lead us to emphasize the technology too much and result in a limited focus (Watson et al.). As such, Green IT can be seen as part of Green IS.

Given this distinction, we see that the previous example of IBM mainly focuses on Green IT. If IBM extends its project and considers broader areas of issues such as manufacturing process redesign, product innovation, and social practices of IT use, then the project will become a good example of Green IS.

In conclusion, our definition of Green IS goes beyond Murugesan's (2008) definition of Green IT. Our definition encompasses the technology, the human aspect, and the organizational mindset and culture concerning Green IS as well. As IS researchers, we define Green IS in two ways: as the initiatives to utilize IT infrastructure to change organizational processes and/or practices to improve energy efficiency and reduce the environmental impacts, and to introduce environmentally healthier products and/or services. In the following sections, we use Green IS unless we refer to practitioner literature or when original publications use Green IT.

2.2 Eco-Goals of Green IS Initiatives

Next, we present the potential eco-goals of Green IS initiatives. The eco-goals are quite relevant because the Green IS initiatives that companies choose to conduct heavily depend on the goal they want to achieve. For example, if companies simply plan to reduce energy consumption, they may just focus on data centers. Otherwise, when companies want to create a better image, they may develop new policies on procurement, operations, and/or disposal of computing equipment (Murugesan, 2008). We identify and propose several eco-goals which are relevant to Green IS initiatives: eco-capacity, eco-efficiency, eco-effectiveness and eco-collaboration (Dyllick & Hockerts, 2002).

Eco-capacity is to make profits within the carrying capacity of the earth (DeSimone & Popoff, 1997). It includes three essential "system rules" that human activities need to respect: (1) substances from the crust must not increase systematically; (2) substances produced by society must not increase systematically; (3) the physical base for the production and diversity of nature must not diminish systematically (DeSimone & Popoff). Eco-capacity offers valuable insights that some limits exist and the targets are moving ones. However, it is difficult, if not impossible for companies to identify the precise relationship between their activities and the earth's carrying capability.

Treating eco-capacity as the bottom line, eco-efficiency is defined as "the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing environmental impacts and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity" (DeSimone & Popoff, 1997, p. 47). Eco-efficiency is relevant for Green IS because eco-efficiency captures the notion of reducing inputs (e.g., energy) per unit of output (Gray & Bebbington, 2000). The simplest example would be data center redesign so that the data center would consume less energy while maintaining the same or achieve better performance. Therefore, eco-efficiency is in line with the goals of companies, as companies are continuing to try to achieve their activities with lower cost. Thus, we see eco-efficiency an important eco-goal that a company can pursue with Green IS initiatives.

The concept of eco-efficiency is not without limitation. As McDonough and Braungart (1998) argued, eco-efficiency essentially means "doing more with less" (p. 82). However, as the output of organizations rises, their overall environmental impact continues to rise. For example, the environmental impact of industrialization continues to rise despite significant improvements in eco-efficiency. Therefore, McDonough and Braungart proposed eco-effectiveness which involves the design of product that "celebrate interdependence with other living systems" and "work within cradle-to-cradle life cycles rather than cradle-to-grave ones" (p. 88). As they explained later, eco-effectiveness refers to working on the right things instead of making the wrong things less bad (McDonough & Braungart, 2002). Eco-effectiveness is also relevant to Green IS initiatives and complementary to eco-efficiency. While eco-efficiency might focus on reducing the energy consumption of computing equipment, eco-effectiveness may guide companies to design computing equipment with more environmental friendly or even natural materials.

Nowadays, companies increasingly integrate their business processes with each other, and they realize that Green IS initiatives cannot and should not be limited within companies. For example, Michael Dell suggested holding supply chain partners to the same green computing parameters (Beach, 2008). Therefore, Green IS initiatives may not stand alone and need the collaboration between companies, partners, and even customers. In these contexts, the benefit of Green IS initiatives goes beyond the scope of a single company. Therefore, we propose eco-collaboration and define it as collaboration between companies and other stakeholders, such as partners and customers, to maximize the benefit of eco-efficiency and/or eco-effectiveness through product and/or business process redesign. By collaborating with other stakeholders, companies may achieve more efficient business processes besides lower total cost. For example, a company may collaborate with its customers to design to more environmentally friendly products, or collaborate with its partners to redesign their supply chain management systems so that less energy is required.

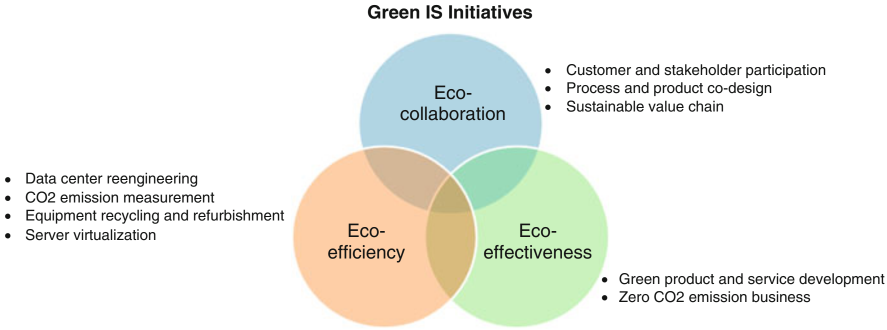

Fig. 1 Three-sided diagram of eco-goals of Green IS initiatives

To summarize, we present our three main eco-goals in Fig. 1. As discussed above, eco-capacity is the bottom line of eco-efficiency. Therefore, we do not include it in our figure. Depending on their specific goals, companies may choose various Green IS initiatives. Examples in Fig. 1 are from practitioner literature (Siggins & Murphy, 2009). Note that the three goals are complementary rather than exclusive, and companies may follow more than one goal at the same time. For example, companies may redesign their data center together with their partners. In this case, their eco-goals include both eco-efficiency and eco-collaboration.

3 Literature Review

3.1 Method

In order to get a sense of the current state of Green IT/IS studies, we examined both practitioner and academic literature.

For the practitioner literature, we reviewed multiple practitioner publications, including *Communications of the ACM*, *CIO*, *PC World,* and *IT Professional*. Additional articles that are relevant and useful for our study are also included in this chapter. For the purposes of our review, obvious advertisements and editorials were eliminated from our analysis.

In terms of the academic literature, our review began with a search of six premier academic IS journals: *MIS Quarterly*, *Information Systems Research*, *Journal of MIS*, *Journal of the AIS*, *European Journal of Information Systems*, *and Information Systems Journal*.[1] However, we only found two "issues and opinions" papers related to Green IS in *MIS Quarterly*. We then expanded our search by including

[1] At the time of the review, these six journals are proposed to be top journals by seniors scholars: http://ais.affiniscape.com/displaycommon.cfm?an=1&subarticlenbr=346.

other journals and conference proceedings. Specifically, we searched *MIS Quarterly Executive*, *AMCIS* (Americas Conference on Information Systems), *ICIS* (International Conference on Information Systems), and *PACIS* (Pacific Asia Conference on Information Systems). Additional studies from other conferences or sources were included if they were determined to be relevant and useful for our study. We excluded two "issues and opinions" papers from *MIS Quarterly* in our review given that these two papers do not examine any specific topic of Green IS. In other words, although we found two articles in *MIS Quarterly*, they are not relevant articles for our review.

We found that the first time the term "Green IT" appeared was 2007 in *CIO Magazine*; as such, we considered 2007 as the beginning date for our search; as such, the search covered the years 2007–2010. We used the terms "green", "sustainability" and "environment" to identify relevant articles by searching their abstract and key words. We conducted our search by going through each outlet mentioned above. Given that "Green IT" or "Green IS" is still new and there are relatively few publications, we also searched Google to identify relevant practitioner publications and Google Scholar to identify useful academic publications.

3.2 Practitioner Literature Review

Based on the review from the published practitioner literature, we identified four classes of articles: benefit, initiation, phases for adopting Green IT, and Green IT approaches and strategies. The publications that we identified are shown in Table 1. Specifically, to come up with the classification, we did not focus on the technical aspects of the articles. Instead, we paid more attention to the issues that each article discussed or tried to address. For example, one article may discuss data warehouses while another deals with cloud computing. As long as they both focus on the benefits of Green IT, we put them into the same category, "benefits". Given that IT advances at a dramatic speed, we believe this approach can help us develop a more stable and useful classification schema. After articles were identified, we conducted a preliminary coding to classify each article. Articles which focused on energy efficiency, cost savings, or profit, for example, are classified into the category of "benefit". For other articles dealing with topics such as adopting, launching, and supporting Green IT, we put them under the category of "initiation". When articles discussed different approaches to treat and manage Green IT initiatives, they are more suitable for the category of "approaches & strategies." Finally, articles were classified into the category of "phases for adoption" when they focused on the processes of adoption and implementation.

In our review of practitioner literature, we searched for "Green IT" instead of "Green IS" since "Green IT" is more popular with practitioners. We would like to note that our search resulted in no articles on Green IS, but many that discussed Green IT. Based on our review, we argue that the main reason for this popularity is that practitioners mainly focus on energy efficiency, such as designing energy efficient hardware, and reducing the energy consumption of data centers (Boudreau

Table 1 Summaries of practitioner literature

Journal/conference	Reference	Topic/research question	Category	Conclusion
CACM	(CACM Staff, 2007b)	Greener pastures	Initiation	Environmental pressures may force organizations to find greener way of doing the business
CACM	(CACM Staff, 2007a)	Mainframe power usage monitor	Initiation	IBM will report power consumption on servers
CACM	(CACM Staff, 2010)	Bell labs and networks' energy usage	Benefit	Bell Labs launched Green Touch to make networks 1,000 times more energy efficient
CACM	(Kurp, 2008)	News about green computing	Initiation	Green computing movement mainly focuses on data centers
CIO	(Beach, 2008)	Talk with Michael Dell about Green strategy	Benefit; initiation	Make green a strategic pillar of the firm
CIO	(Brandon, 2010)	Fuel cells and data center	Benefit; initiation	Fuel cells are highly environmentally friendly, but can also be costly
CIO	(Burnham, 2008)	Green IT budgets getting cut	Initiation	Economic crashes are bad for Green IT
CIO	(CIO Staff, 2008b)	Green initiatives decision	Initiation	Many IT executives still lag in buying energy-efficient products
CIO	(CIO Staff, 2008a)	Intel designed green-certified buildings	Benefits	The building should save about $235,000 annually
CIO	(CIO Staff, 2010)	Sustainability initiatives from CIOs	Benefit; approaches and strategies	Green IT initiatives can improve companies' performance in various ways
CIO	(Nash, 2010)	Sustainability requirements	Approaches and strategies	Businesses require IT vendors to prove sustainability claims
CIO	(Kirk, 2008)	Green IT initiatives in Microsoft	Initiation	Microsoft will launch best practices for running data centers
CIO	(Overby, 2007)	Introduction of new technology into data center	Benefit	VistaPrint expects to save nearly $500,000 and cut carbon emissions by several hundred tons
CIO	(Ricknäs, 2009)	Greener profits	Benefit	European companies net 2% profits
CIO	(Rosenbaum, 2007)	Editorial note	General	Comments on green practices and sustainability in April 1, 2007 issue

(continued)

Table 1 (continued)

Journal/conference	Reference	Topic/research question	Category	Conclusion
CIO	(Sacco, 2008)	Green ranking	Initiation	Sony Ericsson ranks the first
CIO	(Shah, 2008)	Vendors and legislative mandate for recycling	Approaches and strategies	Vendors begin to push through a legislative mandate for recycling
CIO	(Swanborg, 2009)	Raytheon' Green IT strategy	Benefit	Raytheon project showed benefits for company and environment
CIO	(Varon, 2007)	Benefit of Green IT initiatives	Benefit	Businesses can benefit from Green IT initiatives in various ways
CIO	(Varon, 2008)	Green IT and businesses	Initiation; approaches and strategies	Organizations begin to adopt Green IT initiatives
CIO	(Varon, 2010a)	Green product strategies	Approaches and strategies	IT helps support green product strategies
CIO	(Varon, 2010b)	Sustainability and CIO	Approaches and strategies	CIOs are involved in Green IT initiatives
CIO	(Varon, 2010c)	Systems to support sustainable decisions	Benefit; approaches and strategies	Systems are needed to report energy usage so companies can make better decisions
CIO	(Varon, 2010d)	Green metrics	Benefit	Green metrics helps companies more sustainable
CIO	(Walsh, 2007)	Corporate sustainability initiatives	Initiation; approaches and strategies	IT plays a key role in supporting sustainability initiatives
CIO	(West, 2007)	Data center management	Approaches and strategies	Good practices for managing data center costs
PC World	(Brandrick, 2010)	Green PCs	Approaches and strategies	Different ways to green PCs
PC World	(Perenson, 2009)	Reduced power consumption in internal hard drives	Benefit	Saving money and saving power
PC World	(Rebbapragada, 2007)	Tips on a "green" office	Approaches and strategies	How to save energy and money by good "green" practices
IT Professional	(Murugesan, 2008)	How to take advantage of Green IT	Benefit; initiation; approaches and strategies	Benefit, holistic approach to green IT, how to use IT, enterprise Green IT strategy
Online	(Mines, Brown, & Lee, 2007)	Strategies of Green IT supplier	Phases for adoption	Phases of Green IT initiation

et al., 2007). Therefore, practitioners pay more attention to eco-efficiency and relatively ignore eco-effectiveness and eco-collaboration; they focus more on Green IT instead of Green IS.

3.2.1 Benefits

Given that Green IT was recently proposed by practitioners, most articles we identified aimed to inform managers that Green IT initiatives were not simply a liability and companies could benefit from adopting Green IT initiatives. For example, Kurp (2008) exemplified how Green IT initiatives could reduce data centers' energy consumption. In another example, IBM launched a program to monitor energy consumption and demonstrate cost savings (CACM Staff, 2007a). Overby (2007) reported that VistaPrint received significant savings and cut carbon emissions with Green IT initiatives. In a talk about energy efficiency, Michael Dell discussed that Dell was committed to reducing energy consumed by data centers (Beach, 2008). With Green IT initiatives, Raytheon realized more than $11 million of savings in 2008 (Swanborg, 2009). In Europe, companies which conducted Green IT initiatives were found to earn 2% higher profit margin than others in the same industry (Ricknäs, 2009). Lastly, some studies tried to show specific technology in Green IT initiatives. For example, Perenson (2009) discussed a power-saving green hard drive.

The importance of Green IT is becoming slowly recognized in the practitioner literature. Mingay (2007), in a Gartner presentation at the World Economic Forum in Davos, Switzerland, called Green IT a "new industry shock wave." As Pollack (2008, p. 1) pointed out in a report on green and sustainable IT oriented to education, "seldom does a day pass in which we don't hear or read about sustainability or 'going green'."

However, although many organizations have a heightened awareness level regarding Green IT, they may not be completely committed to Green IT beyond simple energy savings. According to GreenerComputing.com (2008), energy efficiency was being used in one way or another to reduce environmental impacts and to cut costs by at least 65% of IT managers. In a survey by Sun Microsystems Australia, reducing power consumption and lowering costs were the major reasons for adopting Green IT initiatives (Murugesan, 2008). We argue that the narrow focus of the benefits of Green IT initiatives may limit the potential of Green IT and prevent companies from thinking of Green IT initiatives from a strategic perspective.

3.2.2 Initiation

Many publications discussed factors which may influence the implementation of Green IT initiatives. For example, Michael Dell mentioned that cost savings was the primary driver, and shareholder or regulatory pressures might also influence initiation of Green IT (Beach, 2008). In another report, the economic environment was found to be an important factor to influence Green IT initiation (Burnham, 2008). Specifically, when an economic crash occurs, CIOs might reduce or cut the budgets for Green IT initiatives.

3.2.3 Phases for Adopting Green IT

Two articles we identified discussed phases for adopting Green IT. For example, Mines et al. (2007) discussed Green IT services engagements and data warehouse solutions in three phases: assessment, planning, and implementation. In the first step, assessment helps organizations understand their current situation and create a baseline of potential Green IT initiatives. Typical activities involve creation of an overall Green IT plan and modeling the return on investment. In the planning step, organizations develop the roadmaps for specific Green IT initiatives and choose Green IT initiatives that are most important for them based on plans developed in the first step. In the implementation step, organizations specify, purchase, and install appropriate IT to implement a specific Green IT initiative. Depending on the scope of the project, organizations may simply implement a new IT, or introduce new process, policies, and/or practices. These steps are similar to other types of IT projects since Green IT are a specific type of IT. To summarize, adopting Green IT initiatives is a complex process and requires careful planning to choose the specific technologies to implement.

3.2.4 Green IT Approaches and Strategies

With respect to Green IT approaches, some articles provided suggestions as to how to achieve benefit from Green IS initiatives. For example, West (2007) provided six suggestions on how to better manage data centers and lower costs. By focusing on computing equipment, Rebbapragada (2007) offers several suggestions on how to reduce costs with Green IT initiatives.

On the other hand, Murugesan (2008) present a holistic approach to Green IT. Specially, the approach categorizes the phenomenon of Green IT into four complementary paths: green use; green disposal; green design; and green manufacturing. These categories encompass areas of emphasis and activities such as:

- Designs and strategies for environmental sustainability including data center design and location (Cameron, 2009; CIO Staff, 2008a)
- Energy-efficient computing including power management and virtualization (Cloud computing and SaaS) (CACM Staff, 2007a)
- Disposal and recycling practices that are responsible, sustainable, and comply with applicable regulatory requirements along with pollution prevention (Murugesan, 2008)
- Green metrics, assessment tools, and a methodology (ISO 14001) for effective use and practice

Murugesan (2008) also argues that enterprise Green IT strategies that a company could follow include a tactical incremental approach, a strategic approach, and a deep green approach. The above discussion emphasizes that Green IT initiatives can go beyond energy consumption reduction and cost savings.

To summarize, although practitioners have started to pay attention to Green IT, they mainly focus on eco-efficiency, given that the benefits they identified from Green IT mainly come from energy efficiency and cost savings. One exception is Murugesan (2008); the four paths identified in the article cover the three eco-goals. Specially, green use and green disposal relate to eco-efficiency, green design and green manufacturing relate to eco-effectiveness, and green disposal, green design, and green manufacturing potentially relate to eco-collaboration. Given that Green IT is a complex and multi-dimensional phenomenon, we suggest that practitioners pay more attention to the other two eco-goals so that they can identify greater potentials and benefits from Green IT.

3.3 Academic Literature

By reviewing the academic literature, we identify four classes of Green IS studies: benefits, initiation, frameworks for adopting Green IS, and enterprise Green IS strategies and practices. The articles that we identified are shown in Table 2. For example, we found one published article from *MIS Quarterly Executive* dealing with Strategies & Practices. A similar approach was used for classifying the academic literature. One difference is that in the academic literature, we have the category of "frameworks for adopting Green IS" instead of "phases for adoption". This category includes articles focusing on topics such as the development lifecycle followed and the implementation frameworks used. The reason is because the academic literature is more theory-driven and the term "framework" is more suitable here.

3.3.1 Benefits

There are two major categories of benefits: environmental benefits and cost reduction benefits.

For environmental benefits, Jørgensen and Jørgensen (2009) examine the potential environmental risks related to IT together with nanotechnology and biotechnology, and recommend future studies on the relationship between technology and society, implying that IT needs to be environmentally green. Realizing that IT is just a part of IS, Green IS initiatives, on the whole, hope to transform organizations, such that business practices become more sustainable.

Cost reduction is a major benefit of Green IS initiatives. For example, Hopper and Rice (2008) showed how system-level optimizations of power consumption could be achieved, which in turn lowered the operating costs. In another study,

Table 2 Summaries from academic literature

Journal/conference	Reference	Topic/research question	Category	Conclusion
ACIS 2009	(Molla et al., 2008)	Green IT readiness framework	Initiation	Attitude, policy, practice, technology and governance are the five drivers
PACIS 2008	(Huang, 2008)	System development lifecycle	Adoption framework	SSDLC is proposed that put emphasis on sustainability
PACIS 2009	(Sarkar & Young, 2009)	Managerial attitude of Green IT	Initiation	Attitudes are transformed into action when a sound model exists, with designed long-term awareness programs
PACIS 2009	(Vykoukal, Wolf, & Beck, 2009)	Relationship between Green IT and Grid technology	Benefit	Green IT has economical and ecological benefits; increases the companies' competitiveness
PACIS 2009	(Molla, 2009)	Organizational motivation for Green IT	Enterprise strategies and practices	A Green IT-reach-richness matrix to classify Green IT strategies and initiatives
PACIS 2010	(Ijab, Molla, Kassahun, & Teoh, 2010)	Spirit, practice and impact of Green IS	Adoption framework	Green IS lifecycle framework is proposed
PACIS 2010	(Lee & Caselegno, 2010)	Business models for sustainability	Green IS initiatives characteristics	Key dimensions are suggested to design new business models for sustainability
AMCIS 2009	(Mann, Grant, & Singh Mann, 2009)	The implementation framework of Green IT	Adoption framework	Three step implementation framework for Green IT
AMCIS 2009	(Sayeed & Gill, 2009)	Explore the implementation of Green IT measures	Enterprise strategies and practices	Organizations can leverage Green IT implementation for strategic purposes by mobilizing dynamic resources
AMCIS 2010	(Iacobelli, Olson, & Merhout, 2010)	Green IT/IS review	General	N/A
AMCIS 2010	(Kim & Ko, 2010)	Identify Green IT leaders	Green IT leaders	Several key variables can reasonably identify Green IT leaders
AMCIS 2010	(Kuo & Dick, 2010)	Exploring the factors influencing the extent of green IT	Initiation	The extent of green IT is influenced by management, bottom line considerations and normative legitimation pressures
AMCIS 2010	(McLaren, Manatsa, & Babin, 2010)	Classification schema for Green IT initiatives	General	A new classification scheme for Green IT initiatives
AMCIS 2010	(van Osch & Avital, 2010)	Sustainable innovation	Benefit	Illustrate how sustainable innovation has a greater potential for change and innovation

AMCIS 2010	(Schmidt, Erek, Kolbe, & Zarnekow, 2010)	Predicators of Green IT adoption	Initiation	Importance and uncertainty are main determinants
ICIS 2009	(Chen, Watson, Boudreau, & Karahanna, 2009)	Institutional pressures and the adoption of Green IS&IT	Initiation	Mimetic and coercive pressures significantly drive Green IS&IT adoption
ICIS 2009	(Hedwig, Malkowski, & Neumann, 2009)	A approach to Taming energy costs of larger enterprise systems	Other (model design)	The prediction of future workload allows about 25% saving of total energy cost
ICIS 2009	(Molla, Cooper, & Pittayachawan, 2009)	Validate Green IT readiness model	Initiation	G-readiness construct and model
ICIS 2010	(Mithas, Khuntia, & Roy, 2010)	Adoption and efficacy of Green IT initiatives	Benefit; initiation	Top management commitment takes an important role; implementation is positively related with energy saving and profit impact
ICIS 2010	(Corbett, 2010)	Literature review	General	Review current literature and develop theoretical propositions
International Journal of e-Business Management	(Molla, Pittayachawan, Corbitt, & Deng, 2009)	An comparison of Green IT diffusion	Initiation	The disposal of IT in an environmentally friendly manner is the most relevant concern about Green IT
MIS Quarterly Executive	(Weiss, 2009)	UPS experience with Green IT	Enterprise strategies and practices	Collaboration between IT and other business units at UPS to implement sustainable initiatives

Vykoukal et al. (2009) argued that Green IT initiatives (Grid technology) had economical benefits for companies.

Thus, the benefits identified from the academic literature are consistent with those from the practitioner literature. However, as discussed above, there are different eco-goals for Green IS initiatives, which result in different benefits. Simply focusing on cost reduction may limit our understanding of Green IS initiatives and prevent us from harvesting other benefits such as better business processes or a more positive company image.

3.3.2 When and Why to Initiate Green IS

Molla et al. (2008) evaluated the readiness of organizations' adoptions of Green IT initiatives. They found five important factors of success in Green IT—attitude, policy, practice, technology, and governance—which together determined if the organization was ready to adopt Green IT initiatives. The combination of these five factors was unique to each organization, and enabled the organization to deploy environmentally sustainable IT and IT processes. Later, Molla (2009) developed a matrix to classify motivation in the adoption of Green IT initiatives, and Molla et al. (2009) examined the status of the diffusion of Green IT initiatives as well as factors that influenced it. In another study, Sarkar and Young (2009) found that the existence of an effective cost model and awareness programs surrounding Green IT initiatives would influence managerial attitudes towards Green IT. More recently, Kim and Ko (2010) used financial and environmental indicators to identify Green IT leaders versus followers. Further, Kuo and Dick (2010) examined how factors such as the influence of management, bottom line considerations, and normative legitimation pressures influenced the extent of Green IT adoption in organizations. Similarly, Schmidt et al. (2010) examined the predictors of Green IT adoption. All these studies offer a good starting point in terms of understanding the initiation of Green IS, though the articles mentioned only focus on IT instead of IS.

3.3.3 Framework for Adopting Green IS Initiatives

Mann et al. (2009) developed a three step implementation framework for Green IT initiatives: determination of the external and internal factors, determination of the sophistication of the strategy, technology, and processes, and measurement of the sustainability of the proposed venture. This framework is similar to the three phases proposed by Mines et al. (2007). More recently, Van Osch and Avital (2010) argue that the sustainable innovation was an extension of the current Green IT/IS frameworks and illustrate how a company could go from Green IT to Green IS to sustainable innovation.

3.3.4 Enterprise Green IS Strategies and Practices

IS researchers seem more interested in the potential of Green IS initiatives from a strategic perspective. For example Vykoukal et al. (2009) argued that Green IT could increase the companies' competitiveness. In another study, Sayeed and Gill (2009) showed that by mobilizing their dynamic resources while implementing Green IT initiatives, organizations were able to take advantage of Green IT for strategic purposes. More recently, Iacobelli et al. (2010) showed five examples of implementation from current leaders in Green IT/IS and how these leaders benefited from Green IT/IS initiatives. Also, McLaren et al. (2010) proposed a classification scheme for Green IT initiatives. Although not directly related to Green IT, Weiss (2009) talked about how to use IT to reduce miles of travel and improve vehicle parts replacement "through a structured approach of gathering data, analyzing that data, and simplifying jobs" (p. 101). Consistent with Molla (2009), Green IS initiatives can not only measure the energy being used but also reduce it. These studies tried to understand Green IS initiatives beyond eco-efficiency and should have great potential in further studies.

To summarize, the IS discipline began to pay more attention to the Green IS phenomenon from 2008. Though many of the articles discuss Green IT, as it is an aspect of Green IS, this research is still useful for understanding the whole. Similar to practitioners, academic researchers also feel that it is quite important to illustrate the benefits of Green IS initiatives and understand and what influences the initiation of Green IS initiatives. Referring back to the three eco-goals discussed previously, these two classes of research also mainly focus on eco-efficiency. Another exciting trend is that researchers are slowly beginning to realize the potential of Green IS initiatives for companies from a strategic perspective, and are trying to understand Green IS initiatives beyond the more direct benefits such as energy efficiency. On the other hand, determining how to ensure the success of implementing Green IS initiatives seems to have received relatively little attention.

4 Assessment of the Current State of Green IS Research

After reviewing the articles from the practitioner and academic literatures, there does not appear to be a large gap between them (refer to Fig. 2). First of all, both communities pay much attention to the benefits of Green IS initiatives. Practitioners especially want to know what this new kind of IT can bring on board for their businesses and how their organizations can potentially benefit from different kinds of Green IS initiatives. Given that Green IS initiatives are relatively new, top managers need to justify why the organization should go with Green IS initiatives. Therefore, the topic of benefits of Green IS initiatives is a major focus from both practitioner as well as academic literature.

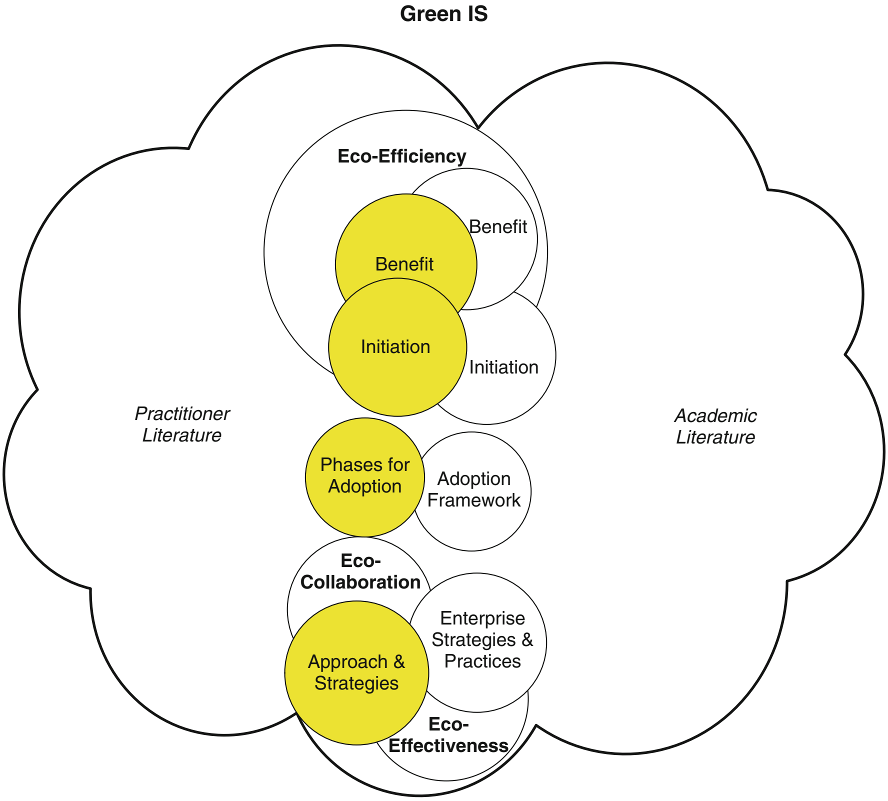

Fig. 2 Focus and overlap in the reviewed literature

Although benefits are one of the main reasons for organizations to adopt Green IS initiatives, it is not the only reason. Other factors, such as government regulation and attitudes toward Green IS initiatives may also play an important role. Therefore, theoretical-based models and approaches are needed to understand the initiation of Green IS initiatives. As such, it is not surprising that initiation is another topic valued by practitioners as well as researchers.

Both communities are also beginning to realize the potential of Green IS initiatives beyond recycling and energy efficiency. Academic literature seems to go a step ahead of practitioner literature and is more excited about other aspects of Green IS initiatives beyond the technical aspect. The studies identified in the class of enterprise strategies and practices certainly go beyond eco-efficiency and touch into eco-effectiveness and eco-collaboration. It once again confirms that Green IS initiatives can be more valuable and beneficial than Green IT initiatives, and that they deserve much attention from the IS discipline.

Lastly, both communities seem to relatively ignore the process of implementing Green IS initiatives. This is understandable, given that Green IS initiatives are still fairly new and there may be relatively little information or few cases on Green IS initiatives. However, whether or not organizations can harvest the benefits of Green IS initiatives largely depends on the degree to which these initiatives are successfully implemented. From previous IS literature, we know that investing in IT does not necessarily lead to benefits, and organizations often fail to implement IT successfully. Therefore, we believe that this topic is at least as important as other topics, and future studies should pay more attention to it.

Although the gap between the two focal areas of literature is small, the important question to ask is: "Have we as IS researchers done a decent job in terms of studying Green IS?" To date, arguably, we have not. The reasons are as follows:

- The number of papers we identified in our review of the research literature is limited. To be specific, there are only two "issues and opinions" papers, from *MIS Quarterly,* in the six premier IS journals reviewed.
- Limited theories have been developed and applied relating to Green IS.
- Few empirical studies of Green IS have been performed.

Academic research in Green IS is still immature; we suggest that the IS research community needs to focus more on this increasingly important topic.

5 Recommendations for Future Green IS Research

In order to further Green IS research, we identify some of the most important topics of interest in Green IS studies. We hope that the topics we identify will be of use to further the research of Green IS.

A point of interest is that we found few studies that explicitly deal with Green IS in academic literature. One exception is an "issues and opinions" paper from *MIS Quarterly*. In their paper, Watson et al. (2010) propose the concept of Green IS and discuss why Green IS is more suitable than Green IT for IS literature. Therefore, our first recommendation is that future studies should focus on Green IS instead of Green IT. Specifically, although the technical aspects of Green IT are certainly important, we as IS researchers should go beyond IT infrastructure and focus on other aspects of Green IS, such as business processes.

Most of the articles from the practitioner literature discuss the benefits of Green IS initiatives. This is mainly due to the fact that Green IS initiatives are relatively new and immature, and managers need to justify Green IS initiatives. For example, West (2007) describes how good Green IS practices can aid in efficiently managing data centers and lower the costs. He admitted that "convincing your enterprise to fund data center improvements not directly related to business delivery can be a challenge" (p. 64). Thus, we can see that the practitioners are eager to understand the role of Green IS and why they need to fund Green IS initiatives.

In the academic literature reviewed, Sarkar and Young (2009), p. 6 identified two gaps in the existing research literature; one of which is "a lack of understanding of senior IT management attitudes concerning environmental policy". In addition, Molla et al. (2008) also argues that attitude was one of five factors which influence

Green IT success and readiness. Attitude toward Green IS adoption, or to phrase it differently, the motivation to be green, is indeed one of the most important issues to understand in studying Green IS. Here, we use motivation as an example to illustrate how we can understand it from theoretical perspectives. Note that we do not intend to limit Green IS adoption research to motivation only; other perspectives and approaches could be equally or potentially even more important.

One of the most prudent research questions for future study concerning organizational motivation to Green IS initiatives is:

What motivates a company to decide to adopt Green IS initiatives?

Following chronologically through a project's life cycle, after firms decide to initiate Green IS, projects will begin. This substantial undertaking has the potential to manifest any number of policies and procedures concerning how to best manage the project. There have been few published studies as of now that describe how the firm should handle this decision. As such, the next research question to address is:

How should the firm manage the process of Green IS adoption?

Finally, it is not a guarantee that adoption of Green IS initiatives will be wholly beneficial for the firm. If the act of undertaking Green IS initiatives guaranteed a positive outcome, there wouldn't be a need to debate the merits of adoption; every company would adopt every Green IS initiative that is feasibly possible. Given that there might be potential negative impacts or consequences to the adoption of the initiative, our final proposed research question is:

What are the impacts of Green IS initiatives?

6 Conclusion

Organizations are increasingly realizing the importance of sustainability, and many are trying to design or redesign their business processes so that their activities are more environmentally friendly (Klassen & Vachon, 2003). Although IS literature has examined how IS can support various business processes and improve the efficiency and effectiveness of organizations, few studies have focused on how Green IS initiatives can improve organizations' performance by enabling new sustainable practices and processes. The Green IS discussion has not made its way into mainstream practitioner literature yet. But we feel that when the academic IS community begins to focus on Green IS, and demonstrate through empirical research how it can help business, the practitioners will follow suit.

Given that there is a lack of direction in terms of the specific topics and approaches to conduct rigorous research on Green IS, in this chapter, we offer specific research directions on Green IS. By reviewing both practitioner and academic literature, we identified the topics that previous literature has covered as well as the similarities and differences between the practitioner and academic focuses. Based on these results, we present three questions which we believe are relevant and valuable for future Green IS studies. Specifically, the first question deals with pre-adoption motivation, the second question focuses on the process of adoption and the third question examines the impact of adoption. Therefore, these three questions span the whole process of Green IS implementation and should be representative of the entire timeline.

Given the diversity within the academic literature, there can be various topics or approaches to examining Green IS; the research questions we suggest do not aim to be definitive. Rather, our purpose is to illustrate how researchers may start to understand and examine Green IS. We do recognize that there are other valuable questions which can be pursued and help us understand sustainability in general, and Green IS in particular. We hope that our review can further the understanding of Green IS, and that IS researchers pay more attention to this important phenomenon. We believe that we, as scholars, should contribute our knowledge in terms of how to make our planet healthier, and more sustainable, such that there is a benefit for all.

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Unordered Business Processes, Sustainability and Green IS

Helen Hasan

Abstract Green Information Systems (Green IS) provides a socio-technical perspective on the diverse complex phenomena of organisational sustainability. The Cynefin sense-making framework is eminently suitable for making sense of dynamic, complex phenomena and for guiding sensible decisions on how to meet the challenges they present. The Cynefin framework is described here and illustrated in terms of both ordered and unordered business processes. It is the unordered that are the least understood; but they are the most critical when it comes to sustainability. While order may be appropriate in the short term, sustainability issues also demand a more challenging long-term perspective. Just how rapidly and unpredictably business processes can change is well known in the field of IS which understands the revolutionary nature of new digital technologies. This chapter explores ways to manage sustainably in the face of such uncertainty through an appreciation of unordered complexity.

1 Introduction

Environmental issues that threaten our very existence have recently captured global public attention through the efforts of Stern (2006), Gore (2006), Shiva (2011) and others. In the face of environmental threats, such as climate change, together with their economic and social consequences, organisational sustainability has become a critical but complex long-term challenge. However, sustainability is a broad concept that has multiple interconnected dimensions and meanings that are not well understood. For a business to be sustainable it should "... meet the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). This widely-accepted definition implies

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a balance between short term decision-making with long term aspirations in dealing with an uncertain and unpredictable future. The last few decades have shown how rapidly our ways of doing business can change with an increasing rate of change driven by advances in information and communications technologies (ICT). There is every reason to believe that this trend will continue and take us in directions we can hardly imagine let alone predict. Researchers from many disciplines are investigating the underlying principles of this phenomenon but researchers in the fields of Information Systems (IS), Knowledge Management (KM) and Business Process Management (BPM) have a particular contribution to make within the specialisation of Green IS.

The fields of IS, KM and BPM view the role of ICT in businesses processes from an socio-technical systems perspective and are thus well placed to understand the evolutionary changes have occurred since the introduction of computers. Experience of technology-driven revolutionary change suggests that sustainability is rarely achieved if all business processes continue to be managed in an ordered and predictable fashion. The unpredictability of the future economic, social and environmental circumstances and their complex interactions, requires an appreciation of diversity and variety among business processes. Two key concepts for sustainability are thus those of requisite variety and of performance according to the Triple Bottom Line (economic, social and environmental). The Law of Requisite Variety (Ashby, 1957) tells us that an enterprise will only succeed if it includes in its systems the capability to match the level of complexity and diversity of the context in which it operates. The Triple Bottom Line (Brown, Dillard, & Marshall, 2006): implies that long-term sustainability requires a view of business that is more than just making a profit and producing a return on investment. It requires a view that also recognises the ambiguous and often conflicting demands of the social and environmental responsibilities of business.

Diversity, ambiguity and conflict are usually considered undesirable in an environment that needs to be ordered and so, when situations get complicated, every effort is made to reduce them. In contrast, according to the Law of Requisite Variety together with the demands of the Triple Bottom Line, diversity, ambiguity and conflict cannot, and should not, be eliminated in complex situations. Gray (2009) explains the distinction by saying "when you make the complicated simple, you make it better, but when you make the complex simple, you make it wrong". As will be explained more fully later, this dichotomy is the focus of the Cynefin sense-making framework (Kurtz & Snowden, 2003; Snowden, 2002) which was developed for the field of KM as it emerged within the IS community in the 1990s. The KM emphasis on *knowledge* rather than *information* came about with the growing sophistication of ICT-based analysis and decision support systems together with the increased complexity of the business environment as the Internet provided unprecedented global interconnectedness.

In a similar fashion to KM, the field of BPM has emerged from mainstream IS and addresses management and technical aspects of formal business processes. According to its entry in Wikipedia, "BPM enables organisations to be more efficient, more effective and more capable of change than a functionally focused, traditional hierarchical management approach”. Unlike the related field of Business Process Re-engineering (BPR), BPM is more interested in the continuous improve processes and process optimization. As ICT plays an integral role in designing, modelling, optimising and managing business processes BPM has strong link to the more technical end of IS and to Computer Science. However, both BPM and KM are subsets of IS that have a strong industry presence and are well-embedded in current organisational practice. This suggests that the Cynefin framework from KM may be well suited to BPM and, in particular, areas of Green IS related to BPM.

The following section provides an IS perspective on the diverse complex phenomena that are emerging in the 2000s with respect to issues of sustainability. The Cynefin framework is then described and used to make sense of these phenomena. The utility of the framework in making sense of the problems associated with sustainability is illustrated with specific examples of both ordered and unordered business processes. It is the unordered ones that are the least understood; but they are the most critical when it comes to sustainability. A discussion is then presented on the resolution of complex unordered BPM problems. This emphasises the use of ICT-based systems in the complex Domain and indicates how these systems may influence sustainability in an uncertain future.

2 Background to Green IS and Sustainability BPM

Sustainability is about anticipating the future. However, history has shown us that our predictions about the future have often been quite inaccurate in times of turbulence and change. This has been particularly so in the case of information systems with their rapidly evolving capability, expansive adoption and global impact. Go back 10 years and Intranets were quite a novelty. Twenty years ago businesses were only just realising that they needed a presence on the World Wide Web. Thirty years ago few organisations made use of email. Forty years ago only the hobbyists had a personal computer. Few people foresaw the rapidity with which such revolutionary ICT innovations would make us more interconnected, mobile and able to carry out tasks in previously inconceivable ways at any time and in any place. We can only guess at what sort of systems we will have in the next 10, 20 or 30 years and how they will affect the sustainability of human enterprises. What we do know is that change is inevitable and that with the ongoing development of new ICT-based systems what we will be able to do will continue to grow new business capability.

Researchers in the field of IS have been studying ICT-based systems over the past few decades and have accumulated knowledge of their evolving nature; their impact on individuals, organisations, whole industries and on society at large. They know how ICT-based systems have automated almost all routine operations resulting in huge gains in the efficiency of business processes. Few firms can now function without their computer-based systems and networks. E-commerce has restructured the market place blurring the boundaries between businesses themselves and between a business and its customers. ICT-based systems enable the integration of inter-organisational supply chains, support the running of multinational business with budgets greater than many countries and allow micro-businesses to enter the global market place.

IS research has traditionally focussed on organisational systems and processes although, as we approaching the second decade of the twenty-first century, topics at IS conferences have broaden into social media, web-based communities, economics of IS, IS for global development and Green IS. This may indicate that most of the issues concerned with basic organisational ICT systems are now reasonably well understood and that the big challenges now facing organisations are ones where new kinds of social-technical systems are needed. Organisational sustainability, with the support of such systems, is the province of Green IS which is defined as "the design and implementation of information systems that contribute to sustainability of business processes" (Boudreau, Chen, & Huber, 2008).

Green IS is a much broader concept than Green IT which only looks at the Green-House Gas (GHG) emissions from the IT industry itself. A report from the Australian Computer Society (Philipson, 2009) contains a breakdown of data on Green IT and provides evidence that current measures are relatively straight forward and obvious, such as server consolidation through virtualisation, devices to shut down equipment not in use, smart metering and optimisation regimes. Most of the Green IT programs being implemented to date are ones that also have cost savings and so are popular with management. These lie in the domain of ordered problems and solutions. The programs that are more difficult to implement are ones where there is an obvious short-term cost or which involve changing the behaviours of people, such as reading from the screen and meeting virtually. This typifies the domain of unordered business problems and solutions as they involved a mix of economic and socio-technical issues where unpredictable human reactions cannot be ignored.

In practice, organisations realise their relationship with their environment and their social responsibilities towards different stakeholders to varying extents. They value the investments of shareholders and the patronage of customers so tend to treat them well for their own self interest. Employees are sometime not so favoured and government regulation is put in place to ensure that they receive fair treatment. Activities of an organisation affect the local environment and the way the relationship with their community is handled can severely affect an organisation's reputation and ultimately its sustainability. The complex relationship between economical, environmental and social elements is starkly evident when a major industrial environmental disaster occurs. These disasters, which result from organisational negligence or malpractice, negatively affect all three elements of the triple bottom line and lie in the domain of *disordered* problems and solutions.

While the constantly evolving field of IS cannot alone provide a complete roadmap to sustainability, it has the knowledge and skills to deal with challenges that range from simple to complicated and complex. In a landmark paper on Green IS, Watson, Boudreau, and Chen (2010) define an information system as "an integrated and cooperating set of people, processes, software, and information technologies to support individual, organizational, or societal goals". By implication the field of IS investigates the design, development, implementation, use and impact of such systems. Watson et al. (2010) identify research questions for Green IS scholars, many of which cross the boundaries of what is considered typical IS research. They point out special and urgent nature of problems in the Green space, where IS and BPM researchers can play a key role while embracing a new range of methodologies needed to conduct this research. This call to arms provides the incentive to conduct meaningful research into the viability of more flexible, innovative practices using ICT tools that will enable enterprises to embrace sustainability. In the following section of the chapter I describe how the Cynefin sense-making framework use the distinctions between *order*, *unorder* and *disorder* to match problems, and their contexts, with suitable methods, tools and techniques that lead to solutions.

3 The Cynefin Framework: Order, Unorder and Disorder

The Cynefin sense-making framework was developed by Dave Snowden when working at IBM (Snowden, 2002). At that time, developments of decision support systems, expert systems, data warehousing, and business intelligence were elevating information systems from tools which automated and supported operational business processes to the strategic spheres of the organisation. At that time, KM was emerging as a topic of interest in a number of disciplines such as Human Resources, Computer Science, Organisation Science and IS. Each of these disciplines gave a different emphasis to KM: human, technical or organisational, with IS attempting to incorporate this breadth. The Cyenfin framework typified this attempt and has become popular with researchers who want to take a holistic and dynamic view of KM and other related issues.

As depicted in Fig. 1, this framework provides a basis for understanding the variety of contexts, situations, problems, tools and solutions that exist in five

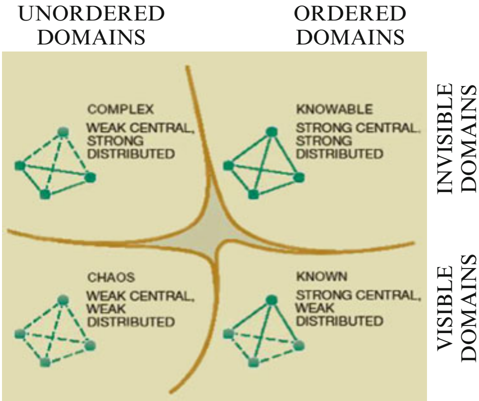

Fig. 1 The Cynefin framework (Drawn from Kurtz & Snowden, 2003)

conceptually different Domains, two of *order*, two of *unorder* and one of *disorder*. As described by Hasan, Kazlauskas, and Crawford (2010)the four outer Domains moving anticlockwise from the bottom right are:

- *The Known or Simple Domain*, in which the relationship between cause and effect is publicly accepted and where there is top down authority. The approach suited to this context is to Sense – Categorize – Respond (SCR).
- *The Knowable or Complicated Domain*, in which the relationship between cause and effect requires analysis or some other form of investigation. Here there are strong vertical and horizontal connections between all actors. The approach here is to Sense – Analyse – Respond (SAR).
- *The Complex Domain*, in which the relationship between cause and effect can only be perceived in retrospect, not in advance. Here, organisational arrangements are network-centric with weak ties to centralised authority. The approach is to Probe – Sense – Respond (PSR) and then allow emergent practice.
- *The Chaotic Domain*, in which there is no relationship between cause and effect and weak ties between all actors. The approach is to Act – Sense – Respond (ASR) to discover novel practice.

In proposing Cynefin, Kutz and Snowden (2003) distinguish between the two large Domains of *order* and *unorder* and then talk about three ontological states, each with a variety of epistemological options: one state of *order* and two states of *unorder*, namely *complexity* and *chaos*,. Order is divided into two smaller Domains namely the Known Domain (sometimes called Simple) and the Knowable or Complicated. In the two bottom Domains (Known/Simple and Chaos) *order* or *unorder* is clearly and publicly *visible* whereas in those on the top (Knowable/Complicated and Complex) the nature of a situation or problem is not publicly *visible* and needs to be discovered in different ways. Situations in the top right Domain are *complicated* but *knowable* so that problems here can be solved by rational 'scientific' analysis.

In contrast, situations in the top left Domain are complex and not completely understood so that the effort is directed towards problem resolution rather than solution using approaches consistent with Complexity Theory. Systems in the Complex Domain are inherently non-linear. Here *attractors and boundaries* replace *command and control* and *self direction* replaces *imposed rules and regulations* so that new patterns of practice can emerge. This is the Domain where the tenets of the Law of Requisite Variety and the Triple Bottom Line are particularly useful. Diversity of perspectives, knowledge and skills are invaluable and approach which do not address the mix of economic, social and environmental imperatives are doomed to failure.

Disorder, the central Domain, is the destructive place of not knowing which ontology you are in and where multiple perspectives compete as different actors interpret the situation on the basis of their preference for action. "Those most comfortable with stable order seek to create or enforce rules; experts seek to conduct research and accumulate data; politicians seek to increase the number and range of their contacts; and finally, the dictators, eager to take advantage of a chaotic situation, seek absolute control. The stronger the importance of the issue the more people seem to pull it towards the domain where they feel most empowered by their individual capabilities and perspectives" (Kurtz & Snowden, 2003, p. 470). This can be seen when there is a breakdown of organisation or where communities are ill-prepared for unprecedented events and disasters, whether man-made or natural. A *disordered* situation is one that fosters or reflects neglect of civil responsibility as well as unethical or illegal activity. "The way out of disorder is to reframe the context so that constituent parts can be located in the other four domains where decisions and action can take place in contextually appropriate ways" (Dotson, Folkman, & Syam, 2008, p. 43). "Entering into the domain of disorder from a single fixed viewpoint or a single Cynefin Domain may be a recipe for further chaos and eventual collapse of an organisational solution" (Fielden, 2006).

4 Grounding Cynefin in Practice

The Cynefin framework can be used as a functional lens for sense-making of both the static and dynamic aspects of business processes. In static mode, a problem can be understood in terms of the ontology of a particular Domain so that suitable methods and tools can be applied. In dynamic mode, problems and situations move between Domains as they evolve and so need to be treated in different ways over time. The boundaries between the Domains are blurred and porous so that how a particular problem or situation is perceived at any point in time can be contentious. The Cynefin interpretation of the static and dynamic aspects of problems and situations are best illustrated by some examples.

Order: All modern organisations rely on information systems to routinely process transactions and provide management information. These systems are well *ordered* and, while they may not be entirely *simple*, their performance is predictably *known*. It is a relatively low-skilled job to carry out basic business functions following well-established procedures using these systems. In Cynefin terms, operations such as Accounts, Payroll, Ordering and Sales appear *visibly ordered* to most people in the everyday running of a business. The *complicated* components of the systems themselves are *not visible* to the average employee, supplier or customer of the firm. These are understood and created by experts in IT, database and programming. The specifications for the systems are also *complicated* and need the skills of professionals in systems analysis and design. The development of organisational information systems assumes that the requirements are *knowable* and that experts can go through the *complicated* process of creating a set of specification and engineering these 'specs' into a software package. To the lay person this is *non-visible order*.

Unorder: The Internet is one system that is *visibly unordered*. It is a chaotic network of networks with no central control and access is open to anyone anywhere at virtual no cost. In the words of Eric Schmidt, CEO Google, the Internet is "the first thing that humanity has built that humanity doesn't understand, the largest experiment in anarchy that we have ever had." The Internet provides the infrastructure for the World Wide Web (WWW) which can be considered the greatest information system ever known. In its short existence, a great diversity of patterns of use of the WWW have emerged, with capability and sophistication that is only apparent once it happens. This is a great example of *complexity* theory in operation. As the dot-com boom and bust has shown, setting up business on the Internet is no guarantee of success but there have been some innovations that have succeeded spectacularly: Amazon, Facebook, Wikipedia, Skype, Twitter and so on. With Google Apps anyone can set up their own management information system and run a business from anywhere there is Internet access. There are low barriers to entry and every encouragement to try out an idea to see if it takes off. What is essential however is the ability to operate in the Domain of Complexity where there are few controls and little ability to predict outcomes.

Disorder: Sudden unanticipated crises such as the Hurricane Katrina, the BP Oil Spill or the events of 9/11 can throw organisations into chaos. In retrospect it is often obvious that these events happened in contexts that were *disordered*. In the case of the natural disaster in New Orleans it was clear that the city and the whole country had done little contingency planning for such as event and were unable to act swiftly as the situation demanded. In the case of man-made environmental catastrophes, investigations of incidents such as Bhopal, Chernobyl, and Exxon Valdez, invariably show poor organisational governance. A sign of *disorder* in the BP context are reports that the U.S. oil fields are increasingly 'killing fields' as deaths among workers rise as inexperienced crews work longer shifts.[1] For the deliberate act of terrorism, the 9/11 perpetrators belonged to a fanatical group of people that distorted religion to justify acts that was abhorrent to the majority of humanity; a group whose activities were neither anticipated or prepared for by other stakeholders. All these situations were not benignly *unordered* but belligerently or negligently *disordered*. Fielden (2006) proposes the concept of 'mindfulness', a neutral state of awareness requiring maturity and wisdom, as a necessary precondition for understanding organisations in *disorder* that may without attention lead to disaster.

The dynamic Cynefin lens can make sense of change as situations move between the Domains. Introducing an attractor into a *chaotic* situation can move it from the Chaos Domain to the Complex Domain (e.g. the ubiquitous water-cooler can encourage previously disconnected employees to talk to each other). Imposing Standards on a *complex* disconnected industry can introduce *order* (e.g. standardising the national rail gauge meant a knowable inter-state train timetable). A catastrophe can change an *ordered* situation into chaos. Automation can move a task from *complicated* to *simple*.

[1] http://www.msnbc.msn.com/id/26645108/ns/business-eye_on_the_economy/.

5 An Appreciation of Unorder

As stated previously, while order is widely understood and valued, unorder is not always appreciated. By its very nature, recognising unorder and choosing tools appropriate to help resolving unordered problems, is itself usually an unordered activity that can best be undertaken by those who appreciated the value of unorder. The Cynefin framework leverages the often unordered human process of sense-making to align methods and tools to the demands of situations, and to solve business problems in holistic ways that are appropriate to situations in each Cynefin Domain. Just as a *complicated* ERP system, such as SAP or Oracle, would not be suitable for a *simple* corner store, Google Apps would never support a large *complicated* company. *Unordered* social networking applications are often banned from *ordered* bureaucratic organisations although encouraged in more open organisations like Google whose espoused culture states "Our commitment to innovation depends on everyone being comfortable sharing ideas and opinions".[2] This way of organising relies on subjective judgement and what follows here are some subjective views on tool-task alignments.

The ability to conduct business transactions over the Internet via e-commerce has made a huge change to the relationship between a business and its customers. Customers now go online and interact directly with the organisation's operational system. They can purchase goods, arrange a loan from a bank or book a holiday without contact with any employee of the business. However these are well-*known ordered* processes and people external to an organisation are not allowed access to anything too *complicated* or too sensitive. The usability laboratory where I work has shown how difficult it is to design a usable public interface when the task itself is not *simple*. One example of a poor attempt to simplify a complex process is the Australian Government online site for people wanting to register a new business; the choices offered are so confusing that most users give up.

Many types of ICT applications that have been developed are deeply embedded with human factors and must be considered as essentially socio-technical. These include Expert Systems, Decision Support Systems, Business Intelligence Systems, Knowledge Management Systems and Intranets. There are limits to which these can be considered *ordered* but they are often used as such, which is not very sensible. In my university, for example, Sharepoint is used as an Intranet but is set up in a very bureaucratic fashion to store documents, templates, procedure and guidelines as well as carry announcements and news. The Intranet loads automatically as a second Tab when we open the web browser on our office computers. However, most of us rarely look at it, relying on emails and word-of-mouth to know what we need to know, and no-one seems to use the 'sharing' or 'collaboration' functions.

Efforts to ensure sustainable through sensible organisation are only just beginning and can benefit from closer examination with the lens of the Cynefin framework.

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[2] http://www.google.com.au/intl/en/corporate/culture.html.

The contrast between *order* and *unorder* is reflected in the dichotomy between Green IT and Green IS. Boudreau et al. (2008) distinguished 'Green IS' from the more widely used term 'Green IT' by saying that in Green IT, IT takes an *ordered* negative view of IT as an energy consumer and a major contributor to GHG emissions. Green IS, in contrast, tackles a much larger unordered problem in a positive manner. The most prominent work in this area is that of Watson et al. (2010) who describe their work on energy informatics but they also suggest that we can incorporate our Green IS knowledge and skills in areas, such as Ubiquitous Computing, Human–Computer Interaction, and Decision Support Systems, to design systems that solve problems of sustainability. These issues involve change, risk, collective knowledge and social learning as well as allowing appropriation of suitable technologies and methods to support *unordered* business processes. They typify what are called 'wicked problems' (Rittel & Webber, 1975) which defy obvious solutions or have conflicting objectives. Wicked problems are ill-defined, with shifting definitions and multiple elements whose conflicting objectives necessitate resolution through a complex, holistic perspective. Hasan and Kazlauskas (2009) recognise that one of the most pressing wicked problems facing humankind, is climate change which comes with a whole raft of interrelated environmental concerns: Water, food, land degradation, species extinction, population growth, pollution etc. The pervasiveness of ICT in all human activity make it sensible that they are considered not so much a part of the climate change problem but as having the capacity to be a necessary part of the solution (Ghose, Hasan, & Speeding, 2009).

In most organisations a state of *order*, or at least a perception of *order*, seems to dominate and only a real crisis will change this. One of my students has been investigating the significance of informal networks within bureaucratic organisations (in her case the Australian Defence Force). Her research is showing that it is only when there is a breakdown of order, or when complete disorder produces chaos, that people take advantage of their informal connections to "Act – Sense – Respond", which is the way of working in the Complex Domain. In crisis zones people do what they can, with what is available and see what works. When most infrastructure was crippled, mobile phones were brought into action in disasters such as the Hurricane Katrina and the Haitian earthquake not just for communication and co-ordination but also to collect information to interactively map locations of need and supply (and more recently outbreaks of Cholera[3]) as well as to galvanise global support. Now Haitian telecoms and banks are racing to sign up residents for mobile banking plans through which payments are made electronically from mobile phone to mobile phone. The money is stored in an "electronic wallet", the phone's SIM card, instead of a drawer or under a mattress.[4] In these examples, people have appreciated the need for innovative solutions to complex problems that often emerge through chaos and disorder.

[3] See for example http://new.paho.org/hq/images/Atlas_IHR/CholeraHispaniola/atlas.html.

[4] http://www.globalpost.com/dispatch/americas/101207/haiti-mobile-banking#.

Most organisations are not facing an imminent chaotic disaster on the scale of the Haitian earthquake and carry on in their traditional *ordered* manner even when face with extremely complex situations. A striking example of the predominance of the ordered approach in business is evident in the Vision 2050 report released at the 2010 World CEO Forum in New Delhi, India. Twenty-nine companies, led by Alcoa, PricewaterhouseCoopers, Storebrand and Syngenta, identified the roles that business must play over the next few decades to enable society to move toward being sustainable and came up with the agenda shown in Fig. 2. This is as ordered as you can get with nine disconnect themes all following the same rigid phases, based on the world as we know it today. There is no flexibility to respond to the unexpected, which is not sensible, and even negligent, given our experience of unprecedented change over the last 40 years. There is obviously no appreciation of the complexity of the challenge and a retreat to a comfortable corporate paradigm of imposing order.

6 Recognising and Appreciating Unordered in BPM

In my opinion, most BPM research and practice assumes order in business processes, or at least seeks to impose order on them. It may be difficult for the field of BPM to recognise that unorder is a valid state and appreciate that it is wrong to always want to simplify and impose order. BPM researchers and practitioners tend to have knowledge and skills that are technical, mathematical and suited to rational analysis. This is appropriate for order but not necessarily for unorder where we find most problems concerned with sustainability and, consequently, their most appropriate means of resolution. Tools, methods and contexts that support enterprise sustainability should include unordered socio-technical systems and even ecosystems that suit the Complex Domain having intricate components, complex interconnections and adapted to rapid change (Hasan, 2005; Hasan & Kazlauskas, 2009). Thus the knowledge and skills required by those working on complex problems should to be broader than the technical and mathematical skills suited to ordered BPM and include systems and social elements.

Researchers and practitioners tend to avoid unordered processes as they are visibly chaotic. However their underlying complexity can be of great interest to researchers and can be the source of innovation in practice where they can to be probed and manipulated to allow new patterns of sustainable processes to emerge. Aspects of Complexity Theory, developed in biology, are relevant to this Domain in particular the concepts of attractors and boundaries to encourage patterns of emergent behaviour leading to innovative responses to challenges of sustainability. Three examples of ICT based attractors and boundaries that have encouraged innovative behaviour follow.

Innovative product design: Some enlightened companies are producing products that their customers and clients really want by involving them as volunteers in the business via the WWW, while at the same time lowering costs and being

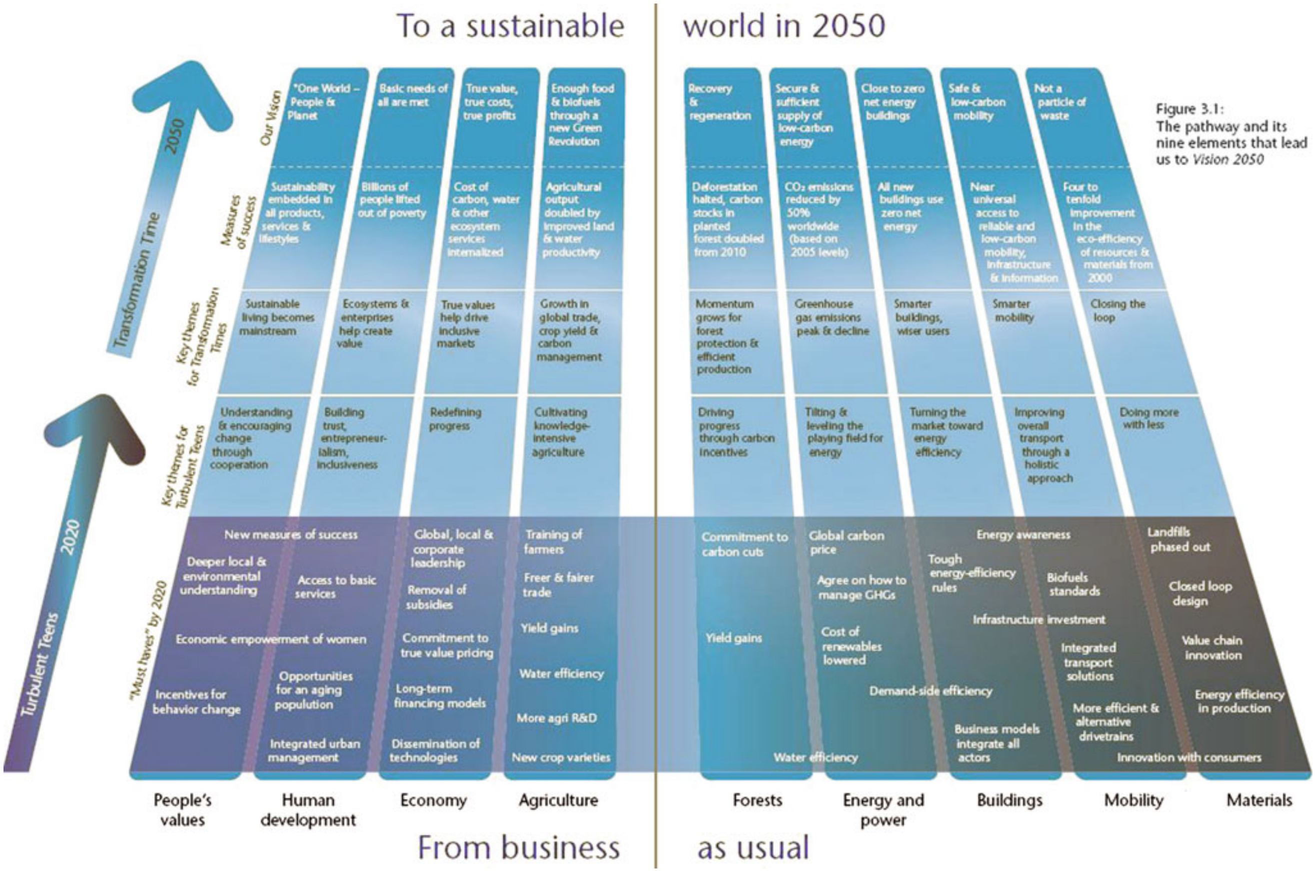

Fig. 2 The Vision 2050 pathway to a sustainable future (Vision2050, 2010)

environmentally responsible. One example of this is the online Lego user community that proposes new designs for the Lego product (Bauwens, 2008). Another is CNN[5] which has instigated a program, i-report, where viewers supply news stories online as text, images and video from every corner of the globe. This replaces the need for CNN to station reporters everywhere or to move them around to trouble spots. In an evolutionary process the stories are monitored and the reputation of these volunteer reporters grows as their submissions prove to be accurate and news-worthy.

A military community of practice: As Generation Y is moving up the ranks in the military, there are emergent changes in the use of Internet and social technologies in the field. Baum (2005) reports that, in Iraq, young platoon and company commanders were exercising their initiative in the face of a lack of training for the conditions they encountered. The younger officers had created for themselves, in their spare time, a means of sharing with one another, online, information that the Army did not control. These officers had been trained by members of previous generations and equipped to fight a war against numbered, mechanized regiments in open-manoeuvre warfare. Here they were patrolling foreign city streets where the next building could house an innocent family or a sniper. Instead of looking up to the outmoded Army for instructions, they were advising each other how to fight the war in this more complex setting generating a new more relevant field manual.

Funding innovation: There are many stories told of the glory days in Silicon Valley where money was thrown at bright young ICT whizzes in the hope that they would come up with the next great invention. This same approach can work for innovation within traditional companies where employees are offered some funds, resources and a portion of the company’s time if they want to explore and experiment with new ideas.

In each of these three cases there are obvious boundaries on what could be done but enough attractors, include new ICT systems, to encourage valuable outcomes. While there are no guarantees of what the outcomes will be, these are typical of projects that use an appropriate approach for the Complex Domain. They have low economic, social and environmental costs, but good chances of valuable outcomes.

7 Resolving Complex Unordered Problems

From my knowledge and experience of situations such as those described above, I recommend the steps listed in Fig. 3, for resolving problems in the Complex Domain. It is advisable that these nine steps are followed in a collaborative and iterative manner with attention to performing well along the triple bottom line (economic, social and environmental) and to generating the level of diversity

[5] http://www.cnn.com/iReport/.

1. Acknowledge the problems or situations as complex
2. Envisage possible desirable outcomes
3. Identify possible path s for resolution towards those outcomes
4. Identify suitable attractors and boundaries and apply
5. Probe and evaluate response in order to recognise pattern formation
6. Encourage / reward those patterns that make progress along that path
7. Look for unexpected innovations
8. Continuously revaluate the situation to see if it is still complex or, if order has emerged change the approach
9. While still complex – re-evaluate the identify paths, attractors etc and change if necessary

Fig. 3 Steps for resolving problems in the complex domain

warranted by the context. There are also other concepts relevant to the Complex Domain.

One of these is the wisdom of looking for, and fostering, ‘hidden attractors’. Many complex business processes work because of hidden attractors that are often not recognised and may only become visible when they are removed. Here is an example of this. When I started work at my present university over 20 years ago we had morning and afternoon tea time with ‘tea ladies’ to set up and clean up afterwards. Between duties, the tea ladies from all over campus would get together and ‘exchange gossip’ (i.e. transfer knowledge). It was at morning and afternoon tea that much useful communication took place and through the tea ladies that we all found out what was happening in other parts of the university. These are classical hidden attractors for a happy workplace. Then, in an effort to show a tangible gain in productivity, the “tea ladies” were retired and the tea-times no longer supported. In less than a year management was complaining that people were no longer communicating and that barriers had built up between Schools and Departments. Since then many quite expensive programs have been put in place to re-connect members of different units and there have been several instances of restructuring in an effort to revive the old collegial atmosphere. It might be noted that an effective way to locate hidden attractors in organisations is through story-telling, a techniques often used by Cynefin consultants.

Advocates of Cynefin suggest that when working in the complex domain begin with a few small-scale trial initiatives. If the outcomes are desirable they are then supported and extended. If the outcomes are undesirable then the initiative is discouraged and something different can be tried. It is also desirable to allow ‘safe-fail’ where all initiatives are set up to fail without serious damage to the organisation or blame on the individuals. This is the opposite of ‘fail-safe’ where initiatives are designed not to fail. A basic principle of complex systems is that small differences in the starting conditions (and every problem context is different) can result in very large differences in the outcomes. While developments may be understandable in retrospect they were not predictable at the time of their instigation.

8 The Big Changes and Problems

The advice of starting small echoes the environmental mantra of "acting locally but thinking globally". So the 'small focus' also implies the 'big picture' where we see the problems of sustainability locally complex but also embedded in an unpredictable changing global context that includes climate change. The big picture sees some fascinating revolutions underway to whole industries as the following examples show.

Digital Products: ICT and the Internet have completely revolutionised those industries dealing with products that can be digitised: information, knowledge, education, news, books, movies and music. With no need for physical products there is a lower carbon footprint but many firms have had to change their entire business model to remain viable.

Retail: In Australia there is a crisis in the retail industry as with the high value of the Australian dollar and no Goods and Services Tax on items from overseas more and more people are buying foreign goods online. A new phenomenon here is for customers to try products such as clothing in the store and then go online to buy them. Companies in the retail industry are reassessing what is the 'shopping experience' that brings customers to their stores that will thus provide them with business.

Financial Services: Just as many businesses are recovering from the Global Financial Crisis other issues are emerging. The growing use of online services is driving government agencies, banks, insurance companies, and investment brokers to cut costs by closing down local branches. As a result they are losing personal touch with customers and clients. At the same time there is a growing use of Customer Resource Systems (CRM) to store and make available all sorts of data on customer habits, preferences and lifestyles.

Other industries are in the midst of change from more contentious issues: in agriculture the benefits of genetic engineering are being opposed by public reaction; the coal industry is beset by uncertainties about what governments may do to cap or tax GHG emissions; health is strained by the rising burden of an aging population with no obvious means of matching funding; the military rarely engages in big battle between international forces but rather in civil conflicts and peace keeping duties to rebuild and train; and industries that deal with the public, such as airlines and sports promoters, must take care of increasing security risks without being over intrusive to innocent members of the public.

9 The Holistic View

There are many aspects of these big concerns that are knowable and can be dealt with by complicated but basically ordered processes. However, there are also contradictions that inherently cannot be resolved completely and hence remain complex. When business are perceived through the Cynefin lens, sustainability thus becomes a matter of sorting out whether problems or situations are order, unordered or disordered and proceeding along the following lines.

- *Order*: When cause and effect are known and consistent over place and time, use the familiar "design, develop and then implement the solution" form of engineering. Such approaches work well in ordered situations.
- *Disorder*: Where there is disharmony, inequality, a lack of ethics, poor governance, corruption, greed or neglect then there is disorder, a blatant need for change and the potential for disaster. As well as preparing for possible disaster recovery, these problems and their source need to be addressed moving them to one of the other domains (e.g. through regulation to order or culture change possibly to unorder). In respect of the latter it is interesting to note that one of the causes of the lack of detection of the threat that led to the 9/11 disaster was stated as a "lack of imagination". Imagination, and other attributes of emotional intelligence, are rarely listed as a job requirement in intelligence agencies but maybe should be.
- *Unorder*: Where the situation has characteristics of complexity follow the steps of Fig. 3, being careful not to remove any helpful hidden attractors and apply the principle of safe-fail where possible to learn from mistakes and to change a culture of concealing mistakes are through fear of retribution.

As discussed above, there is a lack of research on problems in the Complex Domain and lack of suitable social-technical skills among BPM professionals to recognise and address complex processes. More attention to this area may provide much of the understanding and innovation required for sustainability.

10 Speculating on the Future

Most of the Green IS literature focuses on ways ICT can help mitigate climate change by reducing GHS emissions. This is typified by the work on energy informatics (Watson et al., 2010). I believe we should also focus on how ICT can help us adapt to the impact of climate change. As I write this chapter, an area the size of France and Germany combined is flooded in North Queensland. Australia has plenty of experience in dealing with such large scale disasters: floods, fires, cyclones, droughts etc, and so has developed a diverse set of resources that mobilise in response. However over the past few years we have had too many of these and they have been more severe than ever. There is widespread agreement that the world will experience many more of these extreme events as the climate changes and we need to adapt.

As the flood events unfold, there is much discussion in the media on how the devastation will affect the local and national economy, what businesses have been affected, how communities will recover and what new facilities can be put in place to flood proof infrastructure.

Governments here are also beginning to plan for the persistent and recurring consequences of climate change more generally. These consequences include the rising costs and scarcity of resources such as energy, water, food; conflicts over these resources; local overpopulation; movement of whole populations; and reshaping of cities and neighbourhoods. Note that 85% of the population of Australia lives in coastal regions, many of which will be affected by even small rises in sea-levels.

In all the political and public media discussion, the role of ICT is rarely mentioned which is surprising considering that the cost and rollout of a new National Broadband Network has regularly been in the Australian political spotlight. ICT that can support *unordered* ways of working involve Web 2.0 social media, virtual collaborative tools, and streaming video for health, education etc. There is resistance to these in many traditional organisations (Hasan & Pfaff, 2007) but they are taking hold.

But what of the future? The Vision 2050 plan shown in Fig. 2 looks forward 40 years from now. Forty years ago did anyone envisage how the Internet would globalise business and everything else? It is thus foolish try to predict the technological advances of the next 10–40 years. However, a useful technique to use with unordered problems is to imagine possible future scenarios. The following are trends where we could imagine future ICT-based systems driving new innovation as follows:

- *Easing the strain on the big cities*: intelligent systems to stagger business hours in the CBD, mobile guides to public transport, flexible tele-commuting arrangements
- *Improved lifestyles for regional, rural and remote area*: services for remote business customers, support for employees to sea-change or tree-change away from working in the city, broadband services for education health, government and financial services,
- *Reducing the need to travel for business*: going virtual with socio-technical approaches that are useful and usable, affordable multisite teleconferencing and collaboration tools
- *Devolved decision making for a more democratic workplace*: investigating different ways of organising that put more resources into doing the business at the coalface and less resources into managing the organisation from the top; in other words inverting the organisational pyramid to put the customer at the pointy end, and giving self directed sales teams the authority to make strategic decisions. All this would need support from very different ICT systems to the ones we have now with more open policies on access and end-user design.
- *Optimising in the large not the small*: for interconnected systems, independent optimising of parts of the system may lead to non-optimal performance overall.
- *Qualitative evaluation of performance on the triple bottom line*: the use of heuristics for key performance indicators, the use of stories to represent what is happening countering the tendency of simple statistics to cover up and only provide 'green-washing'.

- *Avoiding loss of corporate memory*: when the current generation of workers retires: setting up communities of practice which maintains contact and interaction after retirement.
- *Leveraging the skills of Gen Y and the digital natives*: as Web 2.0, 3.0 4.0 come online. There is evidence of changing values with each new generation that tend to be more cooperative, more socially and environmentally aware and more tolerant of diversity.[6]

11 Conclusion

The need for businesses to focus their attention on sustainability is undeniable but making sense of the diversity of problems is an enormous challenge even before they seek solutions. Some environmentally-related threats to sustainability are well-known: energy costs will rise and non-renewable resources will become scarce. We are receiving a wake-up call from the increasing frequency and severity of large-scale environmental disasters and extreme weather: unprecedented floods, mudslides, fires, earthquakes followed by tsunamis, blizzards, hurricanes and cyclones. Businesses need to do what they can to prevent these, mitigating climate change by reducing GHS emissions and good governance against industrial catastrophe. However the greater sustainability effort may be in preparing for the unexpected and adapting to continually changing circumstances. ICT and the Internet are already playing a significant role in spreading this message and getting information to the masses.

Despite the enormity of the problem, the Cyenfin framework provides a way of making sense of its many facets and then guiding choices on appropriate ways to proceed. Identifying situations as ordered, unordered or disordered provides a starting point. For those situations which are ordered we already have methods that work and skills to follow these through. Disordered contexts can be toxic where situations need to be converted to order or unorder. Situations which are unordered seem visibly chaotic but most of these have an underlying complexity where the steps in Fig. 3 can be followed towards desired outcomes. This may be the least comfortable domain for BPM but one with the greatest opportunity for sustainable innovation.

We are currently living in a volatile time and the future will be more so. While the challenges of each organisation is unique to its own circumstances, the Cynefin framework can be used as a sense-making tool in particular to understand complexity and developing appropriate skills and socio-technological systems to work on the complex problems of sustainability. Two extant concepts that support Cynefin in explicating complex issues of organisational sustainability are the Law of

[6] http://millennialmarketing.com/2009/07/values-shift-gen-y-sees-things-differently/#.

Requisite Variety, which advises organisations to leverage diversity to match that of their environment and Triple Bottom Line which assumes that an organisation is more likely to be sustainable if it honours its responsibilities to its environment and to all stakeholders (shareholders, customers, employees and the community) in providing products or services. The message of this chapter is that an order roadmap such as that shown in Fig. 2 is virtually meaningless when we look 40 years into the future. There are clear signposts that organisations need to develop much more flexible and adaptable ways of working if they are to be sustainable in the twenty-first Century. This implies embracing unordered business processes and investing in ICT systems that support these.

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Information Systems in Environmental Sustainability: Of Cannibals and Forks

Dirk S. Hovorka, Elaine Labajo, and Nancy Auerbach

Abstract That individuals, communities, and organizations need to change patterns of behavior and interactions to create a sustainable future for the biosphere has become a widely accepted concept in both organizational practice and sustainability research from multiple disciplinary perspectives. Information systems and the organizational, community and individual actions they support have the potential to alter the current trajectory of resource consumption, negative environmental impacts, and ecosystem degradation. Although the Information Systems discipline has begun to address the problem of environmental sustainability, current models adhere to a technologic-managerial mindset which supports the organizational status quo. By critiquing the assumptions of the established Triple Bottom Line framework, this research proposes that Information Systems research can be expanded in three directions: addressing collective rather than individual actions, creating, measuring and monitoring a broad range of environmental impact measures, and designing organizational learning systems that enable adaptive management practices in the face of unpredictable and nonlinear environmental changes. Recognition of these additional research avenues will emphasize the difficulty of the problem domain and support transformational research thinking.

> "Below was a welcoming planet. There, contained in the thin, moving, incredibly fragile shell of the biosphere is everything that is dear to you, all the human drama and comedy. That is where life is; that's where all the good stuff is."
>
> Loren Acton, astronaut

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1 Introduction

That individuals, communities, and organizations need to change patterns of behavior and interactions to create a sustainable future for the biosphere has become a widely accepted concept in both organizational practice and sustainability research from multiple disciplinary perspectives. The call for a paradigm shift towards a sustainable economy (Senge, Smith, Schley, Laur, & Kruschwitz, 2008) is being heeded, as reflected by the increasing interest of the Information Systems (IS) community in the role of socio-technical systems in creating environmental sustainability.

A paradigm shift (Kuhn, 1977), by definition, requires a new way of conceptualizing fundamental beliefs about the world in which new problem domains are identified, new methods created, and new exemplars identified. In this case, what Senge at al. (2008) challenges is the creation of the future, by reflection on the past, in an evaluation of ourselves as individuals, as families, as communities, as organizational actors, as to our place within the natural world of the future. The difficulty is that such a shift requires alteration of the fundamental beliefs people have about the world and of the assumptions that are held about what sustainability of the natural world means. Furthermore, there must be a determination of both the role of a market-based economic system, and the role of organizations in relationship to environmental sustainability.

Dourish (2010) notes that although there exists a wide range of sustainability studies performed by researchers in Human Computer Interaction (HCI), the dominant emphasis is on the role of information systems as a persuasive force for behavioral changes at the individual level. Recent research has expanded this view to encompass the "role that IS can play in shaping beliefs about the environment, in enabling and transforming sustainable processes and practices in organizations, and in improving environmental and economic performance" (Melville, 2010). The reference perspectives of these recent research contributions are largely drawn from organizational management approaches, and include value chain and competitive activities, the development of sustainability portfolios, and "eco" goals (i.e. equity, efficiency and effectiveness). The exemplar research problems are identified as application of information technologies to reduce system flows such as transportation costs and energy consumption, to monitor emissions and waste, and to modify consumer behavior (Malhotra, Melville, & Watson, 2011).

Thus the foci of recent IS research frameworks is on managing the interface between organizations and something quite distinct and separate called "the environment." These approaches are well aligned with the precepts of techno-corporate Ecological Modernization Theory (Mol & Janicke, 2009), which assume that environmental sustainability is a managerial or technologically determinant problem which can be solved through technological modernization and without radical changes to current free market economics (York, Rosa, & Dietz, 2003). These assumptions also underlie the widely adopted concept of the Triple Bottom Line

(TBL) (Elkington, 1997) in which overall sustainability is an aggregate of three separate components: financial, environmental, and societal sustainability.

In contrast, other theorists view the current economic patterns of production and consumption as constituting a Treadmill of Production (Gould, Pellow, & Schnaiberg, 2004), such that even efficient organizations utilizing state-of-the-art environmental practices and technologies, grow to serve higher consumption demands, and ultimately increase their total ecological footprint.

The purpose of this chapter is twofold: to critique the current modality of environmental sustainability research being adopted in IS research as providing reasonable initial steps but needing more depth and weightiness to be truly transformative, and then to move from critique to constructive engagement by offering new entry points for IS research. This research suggests three areas into which IS research can be expanded:

- Matters of the scale of the phenomenon and the societal level of response,
- The measurement of impacts of organizational practice, and
- Designing adaptive management systems which enable organizations to learn from, and respond to, management responses to emerging threats to the environment and to better respond to the dynamic nature of environmental sustainability challenges.

IS researchers must avoid unreflectively adopting concepts from other disciplines and simply recreating the paradigmatic status quo of "business as usual." Instead we must "carefully and critically examine the conceptual foundations upon which our system and our reasoning are based" (Dourish, 2010, p. 8). We argue that the dominant approach to IS research in environmental sustainability is inherently self-limiting, because it has not challenged the dominance of productivity, cost reduction, profitability, and economic efficiency (Watson, Boudreau, & Chen, 2010) as the ultimate goals of human activity, and it provides a narrow scope with which researchers can engage the domain. As poet Stanislaw Lec asked, "Is it progress. . .if a cannibal uses a fork?" (Elkington, 1997, p. vii).

2 IS Sustainability Research

Although there is a wide range of "Green IS/IT" research in the IS discipline, a thematic survey of the role of HCI and sustainable development (DiSalvo, Sengers, & Brynjarsdottir, 2010) reveals a focus on information technologies as a mechanism of persuasion which can alter individual action, rather than a means of coordinating collective, political or regulatory activities. Recent IS literature has expanded this focus to encompass organizational strategies focused on the TBL framework, and defines IS for environmental sustainability as "IS-enabled organizational practices and processes that improve environmental and economic performance" (Melville, 2010, p. 2) or sees an opportunity for IS "to tackle sustainable development while improving productivity, reducing costs, and enhancing profitability" (Watson et al., 2010). Other research at the organizational level of analysis includes a framework of IT-enabled business transformation (Elliot, 2011), the conceptualization of organizational sustainability portfolios (Hart, 1997), or creation of a set of eco-goals (DeSimone & Popoff, 1997; Gray & Bebbington, 2000). In examining these approaches, we agree with Dourish (2010) that there is a dearth of research that conceives of sustainability as a trans-disciplinary problem at different scales which goes beyond current practice or inspires changes to the traditional business orientation of much IS research.

For the purpose of critique, we subsume all the approaches to IS research on sustainability mentioned above under the TBL framework, as they all either implicitly or explicitly align with it. The framing imposed by the TBL which these studies adopt was first articulated as a method for organizations to assess their impact in three dimensions: environmentally, socially, and economically (Gibson, 2006). For many organizations, the TBL approach has become a synonym for "sustainability" or "sustainable development" and represents an ideal framework with which to contribute to the sustainability challenge. But rather than fulfilling Elkington's (1997) original desire that the TBL be a Trojan Horse which would lead to a broad understanding and vision of sustainability, the TBL is frequently a strategic logic for organizations, and is used primarily to enhance shareholder value, while attending to limited engagement with social benefits and perhaps a reduction in negative environmental impacts (Figge & Hahn, 2004; Hart & Milstein, 2003). This is fundamentally a financial orientation which prioritizes organizational economic well-being and assumes that environmental and social well-being are amenable to the same type of utility measures as economic success.

But as argued by Winsor (2001), the predominant discourse around sustainability constructs the relationship between financial, societal, and environmental values based on *organizational interests*. Vanclay (2004) further argues many organizations have succumbed to the use of the TBL as an accounting procedure which forgoes any deeper initiative to address the fundamentals of environmental sustainability. Second, he suggests that the measures of TBL are a naive and simplistic view of social and environmental impacts which obscure the true consequences of organizational activities on society and the environment.

Although an organization's performance is often measured in terms of profitability, an organization's impact on society and the environment are often temporally or spatially displaced. The dramatic focus on ever-increasing shareholder value and the frequent lack of immediacy of observed consequences make the undesired effects of organizational activity easy to ignore.

But the techno-managerial approach risks being "hobbled by an unflappable sense of technological optimism" (Hannigan, 2006, p. 26). The assumption that a transition from the polluting industrialization of the past can be based on a silicon-chip revolution that is ecologically neutral is by no means warranted. IS research must begin to address two significant issues:

- The logic by which "large scale phenomenon can be reduced to the aggregated effects of rational actors through self-interest" (Dourish, 2010, p. 2) privileges economic prosperity ahead of environmental sustainability or social justice, and reduces consideration of government regulation or collective action. The only stakeholders considered are the organization (and its investors) and the consumer. Nowhere is the environment considered a stakeholder in its own right.
- The linear mindset of designing IS to manage specific input–output processes without consideration of the dynamic and non-linear characteristics of the environmental systems that need to be sustained represents "current-next" thinking. This thinking assumes that the processes embedded in the system to achieve environmental goals are currently adequate and will continue to be adequate in the future. On the contrary, both environmental and social domains are changing with a range of anthropogenically induced environmental transformations already occurring. Although reduction of carbon footprints, energy consumption, and waste production are all critical, much deeper analysis of organizational impact on environmental factors such as biodiversity (Wilson, 1994), ecosystem services (Daily, 1997) and the influence of ecosystem economics (Hanley, Shogren, & White, 2007) must be included.

3 Defining Sustainability

As IS research moves into the realm of environmental sustainability, it is critical to recognize the multidisciplinary history and the variety of perspectives brought to the domain of inquiry. In this discussion, we focus on the concept of maintenance and stability of the natural environmental such that humans can live comfortably, and that plants, animals and ecosystems are not at risk from human activities. The term *sustainability,* and the notion of *sustainable development,* are claimed by many different actors who use the terms in many different social, political, environmental, and developmental contexts (Norton, 2005). The ambiguity of the term sustainability has become a major barrier in the organizational transition towards a society which exists within the means of the environment. For example the term "sustainable growth" is a term widely adopted by extraction industries and in land development. However if "sustainable growth" implies increasing resource consumption through usage of more land, more water, more food, and production of more "things" for more people, then the term itself is an oxymoron (Bartlett, 1994). When the term "sustainability" is used, it is necessary to be cognizant of what is being sustained and what the boundaries of the system are.

As in any scientific inquiry, it is important to avoid vague and ambiguous use of language. For system models of sustainability to have any legitimacy, it is critical to bound what is being sustained (the organization? the environment? the current global population?); how long it is to be sustained (decades or centuries?); and in what state the system is being sustained (continued organizational profitability? current rate of species extinction? current level of poverty and global health?).

Current organizational practices are sustainable if we are willing to accept the current rate of climate disruption, species extinction, and habitat destruction. It is a very different problem for techno-managerial perspectives like the TBL if the goal is sustainability for the billions of the world's poor people, much less the projected population increase, or a reduction in the current rate of habitat destruction and consequent loss of ecosystem services.[1] A system dynamic view reveals that it is clear that a reduction in the rate at which non-renewable resources are consumed will extend their lifespan, but at current rates of increasing use, the timeframe for many resources, such as oil, is in decades, rather than centuries.

A widely adopted definition of sustainability, drawn from the Brundtland Report (1987), states that sustainability is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This form of *weak sustainability* assumes natural and man-made capital are substitutable with one another (Pearce, 1993) and asserts that sustainability can be achieved within a 'growth economy' while ignoring the dynamic that growth is intimately linked to environmental degradation.

In contrast, *strong sustainability* (Milne, Ball, & Gray, 2008), defines sustainability as a concept that entails a comfortable standard of living within the capacity of nature and that "sustainability implies that nature's capital should be used no more rapidly than it can be replenished" (Wackernagel & Rees, 1996, p. 34). In this paper, we adopt this concept of strong sustainability which emphasizes maintaining intact natural capital and recognizes that ecosystem services, such as clean water supplies, fisheries, CO_2 uptake by vegetation, and agriculturally productive soils, are non-substitutable and essential for the welfare of human beings (Pearce, 1993).

Advocates of the TBL model argue that it captures the essence of sustainability (Savitz & Weber, 2006) and is an effective framework in helping organizations to incorporate sustainability concerns into organizational accountability (McDonough & Braungart, 2002). This perspective suggests that the TBL is seen as a model that helps an organization to be "sustainable." Thus, when used in these parameters, sustainability refers to the ability of an organization to continue their operations in perpetuity or to "sustain" profits in the long term.

While acknowledging that frameworks like the TBL provide organizations with initial engagement in the sustainability agenda, it is also worth recognizing that the TBL prioritizes financial goals, enhancing profitability and improving productivity, and is unlikely to be effective in the "improvement of the natural environment" (Melville, 2010, p. 1), although attempts may be made to improve a human-degraded environment, such as in revegetation of mine tailings. Frequently, the pursuit of the TBL may lead to greater levels of *un*-sustainability (Milne et al., 2008). As organizational activities become more cost effective and efficient, and organizational growth remains a primary economic focus, population growth and

[1] "Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily, 1997, p. 3).

increasing consumption will drive organizations onto the treadmill of production and increase their total environmental footprint. A reduction in the rate of increase of energy utilization and resource consumption is worth pursuing, but if the goal is *environmental sustainability,* such a reduction will only serve to slow environmental decline.

4 Environmental Sustainability

To achieve strong *environmental* sustainability requires a radical change in the positioning of humans and social organizations regarding the environment. Human activities depend on healthy functioning ecosystems, and humans refashion environments both materially, as consequences to their activities, and cognitively, as they apply differing value systems and definitions to what they deem the "environment" (Woodgate & Redclift, 1998). There is no single "environment" that lies distinctly and unproblematically discrete and separate from human affairs, and thus different actors will construct different views of their environments in relation to their specific interests, cultural norms, historical trajectories, and local knowledge (Dourish, 2010). One challenge for IS is to "find a research approach that consciously reflects the nature of [productive activities] as the coevolution between culture and environment, both in the past and the present" (Gliessman, 1990, p. 8).

Environmental sustainability is often used to refer to a small set of measureable goals for organizational input/output impacts such as the reduction of energy consumption, reduction or reuse of waste, and reduction of CO_2 contributions. However, the demands of the macro-economic system and reified organizational goals pressure organizations toward growth and an overall increase, albeit more efficient, use of resources (Meadows, 1998). More importantly, organizational impacts go far beyond the limited environmental measures currently identified under many TBL frameworks in which environmental impacts can be externalized or traded off (Kondoh, 2009).

For IS research to contribute to *environmental* sustainability, additional areas of concern must be identified and addressed. For example, the biodiversity of life at the genetic, species and ecosystem levels, as well as the environmental or ecosystem services humans depend upon, are increasingly at risk as human and global change pressures intensify (Daily, 1997). The ecosystem services provided to human activities are themselves dependent on biologically diverse ecosystems. As the environment become degraded, the costs for these services are shifted to the organizations (and people) who consume them (e.g. the increasing need for hydrocarbon-based fertilizer for large-scale agriculture). Yet the role and stakeholder status of the natural environment, and the ecosystems supported by it are not represented in recent IS sustainability research models.

In the dominant research perspective, the environment is viewed as external to the organization and as something that "just is" that can be managed as any other capital. Because the environment and the organization are viewed as separate, researchers tend to restrict the role of IS to managing the inputs from, and the outputs to, the environment. Indeed, the conceptual model of Watson et al. (2010) bounds the system model at the organizational boundary rather than extending the consideration of organizational impacts into the environment or society. For example, in stating that *suppliers* provide energy, the model implies that energy (e.g. oil, natural gas, coal, solar) can be extracted at *no cost to the environment*. This is an unwarranted assumption given the impacts of oils spills, organizational activities in oil extraction areas such as the Niger Delta, and the reported effects on groundwater supplies from practices such as hydraulic fracking.

To transition from weak to strong sustainability entails acknowledging that the *natural environment* itself meets criteria of power, legitimacy, urgency and proximity and becomes a stakeholder (Driscoll & Starik, 2004), not merely something that can be managed separate from the organization. A coevolutionary perspective acknowledges that people's "activities modify the ecosystem and how the ecosystem's responses provide cause for subsequent individual action and social organization" (Woodgate & Redclift, 1998, p. 13). Organizations transform the environment to fulfill such human needs as living space, raw materials, and the assimilation of human waste. But simultaneously, the natural environment constrains the activities of organizations and the opportunities of future actors because there are limitations to the availability of natural resources and ecosystem services. As the chain of connections between organization and the environment becomes more complex, sustainability becomes a large scale policy goal against the backdrop of social choice and environmental constraints.

5 IS Environmental Sustainability Research

Although a coevolutionary perspective and a deeper comprehension of the meaning of sustainability will help in the necessary transformation of thinking, there are research areas in which IS can directly contribute. The following sections briefly outline how IS research can address issues of scale, the problems of measuring environmental impact, and how the design of adaptive management systems can enable organizational learning.

5.1 A Matter of Scale

Building on sustainability research at the individual and organizational level, IS research can begin to explore the opportunities in problems of scale for information systems' support for networks of actors and environmental and political mobilization. The IS discipline provides a level of expertise in the creation, maintenance, and analysis of technical and social networks. As noted by Watson et al. (2010), the scope of environmental sustainability is far beyond a single organization. Information networks can support the coordination and the interconnection of supply/demand networks. These same networks are invaluable in coordinating actions and in re-envisioning the scales at which people act upon, and in turn are acted upon, by the environment.

Social network research may continue to reveal how consumption choices can be altered and how collective actions by disparate groups can be supported. Dourish (2010) notes that alliances of groups with diverse concerns (e.g. recreational hunters working with wetlands conservationists; surfers aligning with water monitoring programs) can support similar strategic goals. Thus, in addition to supporting political persuasion, communication and coordination activities, IS networks could enable identification of interest alignment, thereby fostering large scale political mobilization. The ability to create and support networks of organizations will result in “significant changes in larger systems [that] requires building similar networks connecting many different organizations, and even different types of organizations” (Senge et al., 2008, p. 225). IS research into collaborative system-thinking and organizational learning for businesses and governments (i.e. Sustainability Consortium, World Business Council for Sustainable Development, Global Sustainable Food Lab) may enable systematic changes to core environmental problems (Senge et al.).

The application of spatial analysis and location-enabled data will be transformational in our understanding of how we, as a species, inhabit the world (Ellis & Ramankutty, 2008), and of our impacts on ecosystem services and environmental health. This may result in initiating changes in the social logic of consumerism and re-evaluating the definition of prosperity (Jackson, 2009). System dynamics perspectives on the interconnections among organizational activities and impacts will emphasize the need for recognizing limits, particularly the limits of environmental exploitation.

5.2 Measurements and Impacts

Although current exemplar problems posed for IS sustainability research are largely focused on energy consumption, resource and material usage, level of emissions, and waste management (Melville, 2010; Suggett & Goodsir, 2002; Watson et al., 2010) these are largely factors which pertain to *organizational sustainability*. Each organization is treated as an isolate with the view that if 1, or 100, companies reduce the rate at which their energy consumption is increasing, then environmental sustainability can be achieved. But this perspective ignores the dynamic nature of the natural world, changing ecosystems and environments, and the social world of increasing consumptive demands from a burgeoning population. Researchers must be careful to identify *ceterus parabus* assumptions and recognize that practices which may be sustainable for a global population of six billion people are unlikely to be sustainable for the mid-range prediction of 10.1 billion by 2100

(United Nations, 2011). Energy resources that are sustainable at a specified level of per capita consumption may not be sustainable as millions more people obtain cars, consumer electronics, and increase their material standard of living.

Although the TBL has been adopted by large organizations and business councils, environmentally meaningful implementation has proven problematic, because in many cases impact indicators have been oversimplified and watered down relative to assessment frameworks developed in the field of social impact assessment (Vanclay, 2004). IS research has significant expertise to offer in the domain of the development of measures and constructs, and the subsequent data collection, analysis and presentation. But the current business focus on sustainability does not leverage the considerable knowledge of state indicators from long standing research in social impact analysis, ecology, and the bio-geophysical disciplines. Thus with forward thinking, IS research approaches can become the nexus for reconciliation of impact assessment and the contributions to sustainability in a trans-disciplinary approach.

5.3 Designing Adaptive Management Systems

There is a marked need to monitor and learn from organizational sustainability initiatives. Environmental challenges are dynamic in nature, requiring management to respond accordingly. For example, the most important determinants in loss of ecosystem services and biological diversity involve land use change (habitat destruction) climate alteration, and biotic exchange or invasion (e.g. feral species) (Vitousek, Mooney, Lubchenco, & Melillo, 1997) all of which are occurring at increasing rates. Although global biodiversity challenges appear to be well-recognized, most indicators of the state of biodiversity show declines, even though responses in an attempt to reverse the trend are on the increase (Butchart et al., 2010). Individuals and groups of species operate within ecological structures and processes at different scales, and ecosystem behavior is non-linear in nature (Peterson, Allen, & Holling, 1998). Ecosystem management needs to be better understood, and knowledge of ecosystems better communicated for better recognition of their importance to society (Walker et al., 2002).

In response, ecologists, land managers, and conservationists have implemented adaptive management perspectives which can incorporate natural variance and non-linearity in emerging environmental threats, management interventions, and outcomes (Salafsky, Margoluis, Redford, & Robinson, 2001). Sound process models are seen as a core element of adaptive management (Rumpff, Duncan, Vesk, Keith, & Wintle, 2011), such as in the case of managing the re-introduction of endangered species (Armstrong, Castro, & Griffiths, 2007). The principles of adaptive management are quite similar to the build/evaluate cycle of design science research (Hevner, March, Park, & Ram, 2004) in that the goal is not merely to create a functional artifact or management plan, but to learn from the activity.

This requires significant monitoring and evaluation of the impacts of sustainability initiatives at a collective scale, rather than at the level of individual organizations.

IS sustainability research can expand on initial research on business process technologies, regulatory audit systems, and energy informatics, to ensure that organizations can learn from sustainability initiatives. The conceptualization of monitoring systems that enable learning by networks of organizations and which can support learning organizations (Senge, 1990) for the purpose of cooperation, rather than competition, will be crucial to modifying the dynamics of the organizational-environmental system.

6 Discussion

Sustainability is a systems concept incorporating spatial and temporal dimensions which require the collaborative effort of various entities and associations at the individual, local, national and global level. Despite the genuine efforts of organizations, many of their environmental and social initiatives are executed in isolation and do not demonstrate any significant contribution towards long term sustainability of the environment. Even if the ecological footprints of some individual organizations are being reduced, the collective ecological footprint of organizations is still increasing (Gray & Milne, 2002; Kondoh, 2009).

In this chapter, we have argued that although recent entries into sustainability research by IS researchers provide much needed initiative, IS research constrains itself by adopting an instrumental approach to environmental sustainability. The research emphasizes the management of a technological response through technical systems or business process management, rather than recognizing the substantive problems in reconciling the needs of a growth economy with increasing consumption by a larger number of humans living in a closed and resource-finite system. Such an approach may serve to slow the rate of increase in resource consumption and ecosystem and environmental degradation. But a reframing of the problem will result in a deeper engagement with the potential contribution of IS to issues of sustaining the collective environment, not only the viability of the individual organization. We have suggested three ways in which the IS community is uniquely suited to contributing to ongoing efforts in IS environmental sustainability research that correspond to matters of scale, measurements and impacts, and designing adaptive management systems:

- IS research can create new entry points which consider the political and regulatory levels of analysis, in addition to individual consumers and individual organizations. The IS expertise in the creation, maintenance, and analysis of networks is critical in coordinating actions and in re-envisioning the scales at which people act and are acted upon. Similarly, the application of spatial analysis will be transformational in our understanding of how we as a species inhabit the world, and of our impacts on ecosystems and the natural environment. This may involve changing the social logic of consumerism and re-evaluating the definition of prosperity. It is also necessary to start recognizing the need for limits, particularly the limits of environmental exploitation.

- In addition to design of the technological artifacts to collect, store, analyze, and present environmental information, IS research can serve as a trans-disciplinary nexus for development of impact measures and reconciliation of target measures for environmental sustainability. Spatial information from geographic information systems will enable a much greater comprehension of the extent and temporal characteristics of a wide range of environmental impacts and organizational relationships. Utilization of the coevolutionary interactions of the environment and related ecosystem services and organizations provide a backdrop to understand possibilities and constraints within regional and global systems over time.
- The design research expertise of IS research can be applied to the innovation of adaptive management systems which enable organizations to learn from the management outcomes of environmental initiatives and responses to emerging threats. Organizational, political and regulatory responses must react to the nature of environmental sustainability challenges rather than assume that a given set of innovations or business processes will remain effective in a dynamic environment. Combining the build/evaluate approach with environmental adaptive management principles will enable both business goals and environmental values to be open to revision in the face of increasing experience.

As IS research seeks to contribute to the challenges of environmental sustainability, it is important that we not merely export the concepts of IS into a trans-disciplinary domain without careful reflection and appreciation of context. Senge et al.'s (2008) challenge to ground paradigmatic change in new ways of thinking and perceiving requires that IS researchers not recapitulate the business status quo which, in part, created the current environmental problems. By explicitly recognizing that people's actions, the impacts of organizations, and the environment are intertwined in a complex and evolving system, IS research can expand and shape the ongoing debate and contribute to the changes in fundamental values, beliefs, and models that will be required for humans to achieve a sustainable society.

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Part II
Tools and Methods

Advancing Business Process Technology for Humanity: Opportunities and Challenges of Green BPM for Sustainable Business Activities

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Abstract The sustainability of organizations' business activities is currently an intensely discussed issue which is gaining increasing importance. The research field of Green Information Systems (Green IS) is concerned with designing and investigating innovative methods and techniques supporting a better sustainability of business activities based on information systems (IS). According to the IEEE tagline *Advancing Technology for Humanity,* IS can contribute to a more sustainable business world and thus to a betterment of humanity. In our contribution, we argue that techniques and methods from the field of Business Process Management (BPM) can considerably support the preservation of the environment while performing business activities and thus contribute to a betterment of human living conditions. Organizational as well as technological opportunities and challenges of Green BPM are investigated and demonstrated by means of exemplary application scenarios from different organizational contexts. In order to delineate the technological potential of Green BPM, a semi-automated approach for process sustainability improvement is presented by means of a further application scenario.

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1 Introduction

The sustainability of business activities is currently an intensely discussed topic in research and practice. Taking resource scarceness, increasing pollution and the debate on global warming into consideration, more and more organizations recognize the upcoming need to improve the sustainability of their business activities. The matter gains increasing importance in the business context and drives organizations to put more effort into enhancing resource efficiency and reducing the production of waste materials in the context of their business activities.

Besides enterprises' growing interest in the topic, sustainability related issues gain more and more importance in the context of the Information Systems (IS) research discipline as IS offer considerable potential for the improvement of business activities' sustainability. In this context, the current research field of Green IS investigates sustainability issues from several different perspectives (Watson, Boudreau, & Chen, 2010). Not only the sustainability of technological components of IS are addressed, which is the focus of Green IT research, but also topics like business processes, people and culture. Recently, first research agendas for Green IS have been developed and the relevance and potential of innovative IS research results for sustainability enhancement and the preservation of the natural environment have been stressed (Melville, 2010). This idea has also been formulated on a general level in the IEEE tagline *Advancing Technology for Humanity* which accentuates the potential of technological change for the betterment of humanity including environment protection (IEEE, 2010).

In the following, we argue that and investigate how the methods and techniques of Business Process Management (BPM) can support the sustainability of business activities referring to this tagline. BPM has become one of the most intensively discussed topics in the IS discipline. Besides the growing maturity of BPM concepts, methods and techniques, the field of research has gained tremendous importance in research as well as in organizational practice (Fettke, 2009). It provides adequate techniques for the design, execution, controlling as well as the analysis of business processes in order to improve value creation within single organizations as well as in inter-organizational value networks (van der Aalst, ter Hofstede, & Weske, 2003). In order to improve the sustainability of business activities, the techniques and tools of BPM have to be adapted to dedicated requirements (Pernici, Ardagna, & Cappiello, 2008). In this article these techniques and tools are summarized under the term "Green BPM" as an intersection of approaches and ideas from the fields of BPM and Green IS, as is shown in Fig. 1.

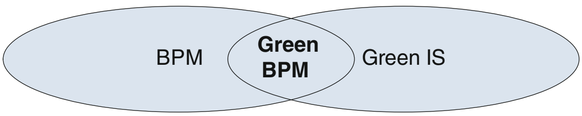

Fig. 1 Green BPM as the intersection of approaches and ideas from BPM and Green IS

First approaches and scientific publications on the topic of Green BPM already exist, e.g. (Ghose, Hoesch-Klohe, Hinsche, & Le, 2009; Hoesch-Klohe, Ghose, & Lê, 2010). Furthermore, a dedicated workshop on the topic was conducted at the 8th International Conference on Business Process Management (BPM 2010) in Hoboken, NJ (*1st International Workshop on Business Process Management and Sustainability, SusBPM 2010*) which focused on the investigation of the potential of BPM concerning business sustainability, e.g. (Houy, Reiter, Fettke, & Loos, 2011). However, the discussions on Green BPM methods are still in the early stages and so far only a few approaches exist. The contribution of our paper is a deeper going assessment and demonstration of both organizational and technological opportunities and challenges of Green BPM for the improvement of the sustainability of business activities. The paper is based on conceptual considerations and the investigation of several different Green BPM application scenarios.

The article is structured as follows: in the second section, underlying concepts and the idea of Green BPM are briefly introduced. The third section presents the potential of Green BPM by means of two exemplary application scenarios from different organizational contexts. Furthermore, an approach for semi-automated process sustainability improvement, the Abnoba framework, is presented and illustrated by a further application scenario. Thereafter, opportunities and challenges of Green BPM are derived from the findings before the article is summarized and concluded.

2 Sustainability Through Green BPM

Green IS initiatives generally focus on designing, building and operating sustainable IS in order to improve the sustainability of organizations. In our contribution the term organizational sustainability is understood according to the common definition. It is defined as an organization's ability to realize profits, to regard social needs and to sustain the environment at the same time (Wikström, 2010) in order to consider the needs of future generations (World Commission on Environment and Development, 1987). In our article, special attention is paid to the environmental and economic dimension of sustainability which can be improved by applying BPM methods and techniques. A better sustainability can be supported by higher efficiency of resource consumption; e.g. of IT infrastructures, or a lower level of fuel consumption of a transport medium in a business process. Furthermore, sustainability can be improved by a reduction of waste materials, greenhouse gases or noise produced by a business activity.

Business Process Management represents an approach which supports organizations in sustaining their competitive advantage (Hung, 2006). It comprises methods, techniques and tools for the design, enactment, control and analysis of business processes in order to facilitate an optimized value creation (van der Aalst et al., 2003). Today BPM is commonly understood as a continuous improvement process throughout the life cycle of business processes (Scheer & Brabänder, 2010) which comprises several phases visualized in Fig. 2 (Houy, Fettke, & Loos, 2010).

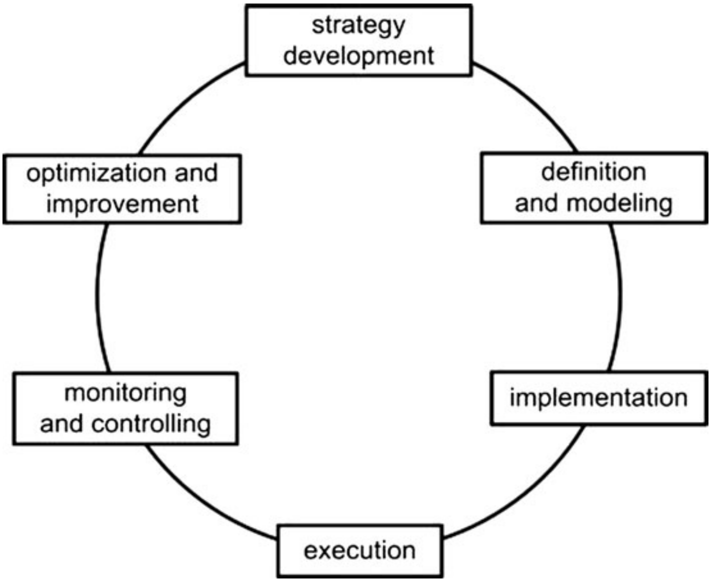

Fig. 2 BPM life cycle for continuous process improvement (Houy et al., 2010)

In this article the BPM life cycle will serve as a reference framework for the description of opportunities and challenges of Green BPM.

Green BPM is supposed to provide techniques for the design, execution, controlling as well as the analysis of sustainable processes in many different application areas. Common BPM techniques and tools can support the sustainability of dedicated Green IT initiatives like IT Service Management (ITSM) to a certain extent; e.g. by simplifying IT service processes. However, most common BPM techniques and tools are designed to support the efficiency of business processes focusing on costs and time. As already mentioned, these methods and techniques have to be adapted and extended in order to fully support sustainability initiatives concerning business processes.

The discussions on Green BPM techniques for modeling, implementing, executing and monitoring sustainable business processes are still in their early stages and so far only a few approaches exist. Ghose et al. (2009) have presented an approach for modeling and controlling the carbon dioxide (CO_2) emission in business processes. This approach aims at a process-based measurement of the carbon footprint of business activities. In recent publications, the understanding of Green BPM has been widened and the potential of Green BPM for improving the production of waste materials and the consumption of other, partly limited resources like water or fossil fuels, has also been considered (Hoesch-Klohe et al., 2010; Houy et al., 2011).

In Green BPM every business activity in a process model can be annotated with an adequate ratio representing the consumption of resources and the production of waste materials. Model annotation is possible for different modeling methods, like

Event-driven Process Chains (EPC) or the Business Process Modeling Notation (BPMN), which will also be demonstrated in our contribution. By accumulating the annotated values, the total consumption of needed resources or the total production of waste materials in a process can be measured and controlled. This method facilitates an optimized organization of activities in a process and the controlling of the ecological impact of its execution. In order to investigate the organizational as well as technological opportunities of Green BPM, the two following sections present exemplary application scenarios as well as a semi-automated approach for process sustainability improvement.

3 Application Scenarios for Green BPM

At first, the *organizational* opportunities of Green BPM are delineated by means of two application scenarios. The first scenario is concerned with sustainable process management for typical IT services. The second scenario broadens the perspective and deals with business processes in general.

3.1 Sustainable IT Service Management Processes

IT services, like web or application services, are mainly produced in data centers. The concept of *Cloud Computing* represents one of the latest developments in the IT service provision context. The concept covers the provision of services based on IT resources which are distributed among several production sites, allowing for a dynamic adaption of capacities. Cloud computing intensifies the concentration of IT service production into data centers. Thus, data centers can be regarded as the hot spots of IT-related energy consumption. In order to produce IT services in a professional way, the application of management best practices and standards is obligatory. The corresponding ITSM standards refer to the principles of BPM. Most steps and procedures applied in ITSM are based on defined process models. Furthermore, both concepts are based on "Plan, Do, Check, Act" lifecycle approaches including strategy formulation, execution, controlling and continuous improvement. Moreover, ITSM standards include descriptions of the service offering portfolio, guidelines for successful service operations and the definition of service quality, typically described as Service Level Agreements (SLAs) which are commonly monitored and reported.

An established best practice supporting these services is the comprehensive IT infrastructure library (ITIL) framework which is widely accepted and applied in professional IT service organizations. ITIL describes standardized processes in the context of Service Delivery, e.g. Service Level Management or Capacity Management, as well as processes for Service Support, Incident Management or Change Management. However, the ITIL framework does not have a special focus on the sustainability of ITSM processes. In this context, Green BPM can provide an approach for closing this gap and complementing the ITIL framework by sustainability concepts.

Interesting opportunities become obvious when Green BPM methods are used in the context of incident management. Incidents are usually defined as unplanned interruptions of IT services or as a reduction of IT service quality which require immediate reaction. According to our idea, this definition can be extended taking sustainability considerations into account. Thereby, incidents would not only be triggered if a deviation in terms of continuity and quality in service production can be stated. An incident should also be triggered if significant deviations in terms of a system's resource and energy consumption occur. If a system consumes too much energy after a reconfiguration, an incident can be triggered and the corresponding incident management process should be started.

An essential part of the extension of the incident management concept lies in the definition of *Green Service Level Agreements (gSLAs)*. It is necessary to introduce new indicators which define thresholds for energy consumption per transaction, total energy consumption or peak energy consumption within a certain period (e.g. *"service may not consume more than 10 kWh per 10,000 transactions."*). These new key indicators should be regarded as a precondition to operate an application system in a sustainable fashion. Nevertheless, they are an extension and may not replace, but complement traditional SLAs (Fig. 3).

Overall, defining Green Incidents and Green SLAs is an appropriate measure to implement the idea of sustainable IT operations into the concept of IT Service Management. It creates awareness for resource efficiency and supports management decisions in data centers. Nevertheless, resource efficiency and classical constraints such as reaction time, availability and downtime need to be balanced carefully.

Another example can be taken from capacity management which covers the planning and provision of physical capacities necessary for service delivery. Based on sales forecasts (e.g. *"100,000 online shop users next year"*), the process of capacity management defines the required physical hardware, as well as space and energy-related facilities in a data center. In this context, it is necessary to precisely forecast the required capacities. If the forecast is too low, additional capacities need to be installed on short notice. If the forecast is too high, overcapacities are installed, resulting in unnecessary capital expenditures and inefficiencies in

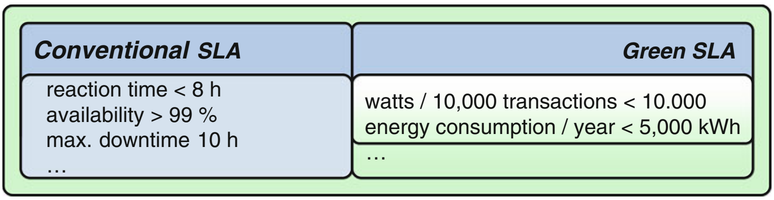

Fig. 3 Extension of the SLA concept by sustainability indicators

the use of resources. Furthermore, capacity management should drive the procurement of energy efficient equipment and support decision makers in avoiding the creation of overcapacities. It needs to create awareness for the effects of business decisions on necessary resources and should incorporate incentive mechanisms which reward the avoidance of capacity extensions (if this can be aligned with business objectives). In the future, *Green Business Capacity Management* can be established as a means to control the demand for IT capacity, taking both business objectives and sustainability considerations into account.

Additionally, the implementation quality of the IT service management processes themselves may have different levels depending on the company implementing them. In some cases, an individual company may have implemented ITSM processes in a very resource-intensive way, using physical meetings with high travel efforts or printing all process-relevant documents on paper. Although this is a general fault in process design, a careful examination of IT service process implementations with regard to such common mistakes should be considered. Thus, the resource efficiency and sustainability of ITSM processes can be further improved.

3.2 Sustainable Business Processes

Not only can the sustainability of ITSM processes be improved by using appropriate ratios. This approach can also be applied in order to enhance the sustainability of business processes in general. For every activity in a business process, relevant values concerning the consumption of resources or the production of waste materials can be considered. Figure 4 shows a typical sales process represented by an EPC (Scheer, 1994). In this process model, different activities are annotated with exemplary values of resource consumption. The sustainability can be optimized by planning and improving the process in a way that these values are reduced. Although, the controlling of actual values is only possible to a certain extent, processes can be designed in a more sustainable way taking these values into consideration.

It can be assumed that the application of this approach has the largest effects in inter-organizational business processes, especially in supply chain management (SCM) scenarios as SCM processes often come with a high resources consumption mainly related to the transportation of goods (Piotrowicz & Cuthbertson, 2009). Thereby, a better alignment of inter-organizational supply chain processes based on production forecasts and process sustainability analyses can significantly improve the emission of CO_2 produced during the transportation of goods. However, the individual situation of every partner in the supply chain has to be considered and the coordination of the different individual interests of each partner appears to be problematic. Therefore, adequate solutions are needed in order to be able to align these needs and to improve the sustainability of the whole supply chain.

Regarding the common BPM life cycle, the cooperating business partners can appoint a corporate sustainability *strategy* as a basis for their Green BPM initiative.

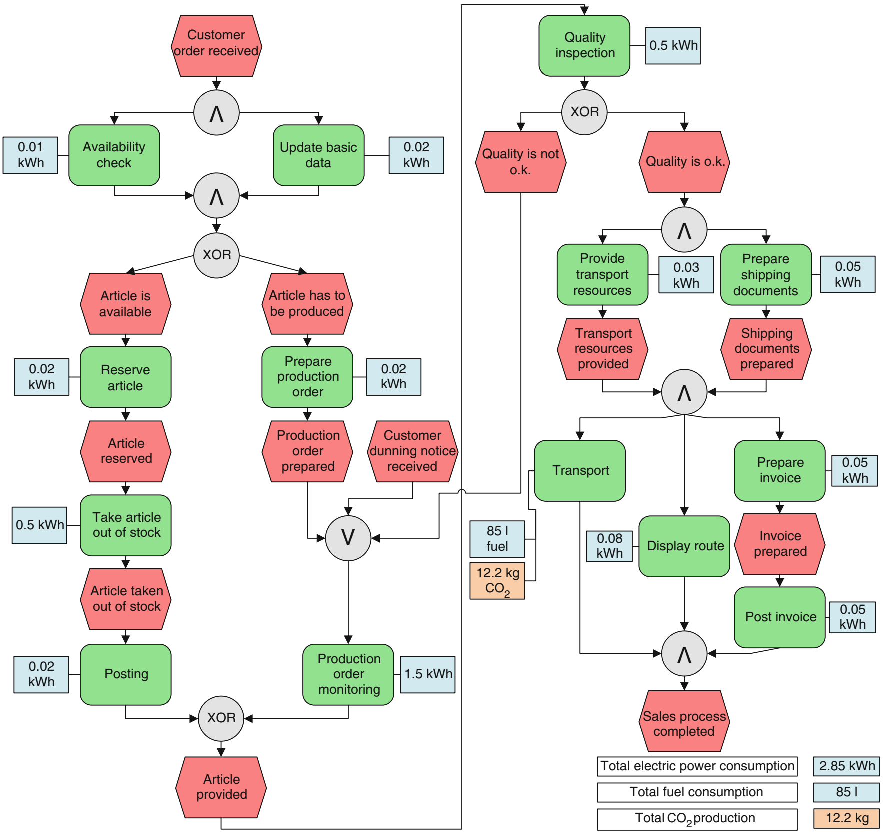

Fig. 4 Sales process (EPC) annotated with relevant sustainability ratios, based on Scheer (1994)

If every partner in the supply chain is interested in improving the process sustainability, sustainability ratios can be appointed as target values which should be achieved during the execution of the whole process. Based on that, the business processes can be *modeled* using ratios for the consumption of resources and the production of waste materials of each process step. The accumulation of these values represents the total effects of a whole process as shown in Fig. 4. The partners could for instance stipulate that the execution of a certain transport process should not consume more than a certain amount of fuel in total. The modeled processes are then *executed* and *controlled* comparing the planned ratios with the actual values provided by a monitoring system. In the improvement phase of the BPM life cycle, the process models could then be enhanced on the basis of monitoring values. Furthermore, different process design alternatives could be derived from executed model instances and then combined in a more sustainable way, which will be demonstrated in the next section. Thus, an optimization of the process's resource and cost efficiency can be achieved.

Based on these considerations, Green BPM could contribute to a more resource efficient supply chain management enhancing environmental performance by minimizing waste; this does not only effect the corporate image, but also the competitive advantages based on cost savings (Rao & Holt, 2005). However, appropriate techniques, tools and also organizational concepts are needed in order to coordinate Green BPM initiatives in inter-organizational contexts. Expanding the presented organizational possibilities, the next section presents exemplary technological opportunities. The Abnoba framework for semi-automated business process sustainability improvement is presented and further illustrated by means of application example.

4 An Approach for Environmentally Aware Process Improvement

Environmentally aware business process re-design/improvement has been identified as one of the key aspects of Green BPM. In an environmentally aware process improvement exercise, we seek to identify process design alternatives with the same desired functional properties, but with a more favorable environmental impact.

In practice, an environmental aware process improvement exercise poses various challenges. (1) To be able to discriminate between a set of process designs, we must be able to order them according to their environmental performance. Therefore, how can we assess the environmental performance of a process during design time? (2) Committing to a process, re-design can have a fatal impact on the organization, if the design is not aligned with the operational functional objectives. Therefore, does a suggested business process design have the desired functional outcomes, as required by a correlated operational objective? This question can be further extended by asking: is the process (re-)design compliant with given regulations; and can it be provisioned by the resource context of the organization? Overall, how can we ensure that the process (re-)design is "fitting" into the enterprise context? (3) Finding process improvements is a challenging task due to the need of the human analyst to explore a fast space of potentially applicable process designs and ensure a fit with the existing enterprise structure. The complexity of such an exercise might on the one hand result in *overlooked process designs* (with many desired environmental properties) and on the other hand result in *overlooked design mistakes*. Both cases can threaten the efficiency of organizations operations.

In this section, we provide a summary of the Abnoba framework for Green BPM (Ghose et al., 2009; Hoesch-Klohe & Ghose, 2010a, 2010b; Hoesch-Klohe et al., 2010) which seeks to provide methodological and tool supported decision support machinery to assist the process analyst in an environmentally aware process improvement exercise and the described challenges. The following elaboration focuses on the latter two challenges, viz. how we ensure that a process (re-)design fits into the organizational context (we emphasize the alignment with the operational objectives) and how we can support the analyst in identifying process re-design candidates. A detailed exploration on how to assess the environmental performance of a process design is omitted. However, we point the interested reader to the work of Recker, Rosemann, and Roohi Gohar (2011) who analyze various top-down, bottom-up and mixed approaches for assessing the environmental performance of a process design. In addition, Hoesch-Klohe et al. (2010) suggest deriving the environmental performance of a process design by correlating it with resource models. Each activity of the process design is annotated with the resources it requires, how it intends to use the resource and with which intensity. Based on this information and the information given by the resource models, the environmental performance of an activity can be dynamically derived during design time.

4.1 Is a Process Aligned with Operational Objectives?

In this sub-section we summarize how to (automatically) determine and ensure that the outcome of a potential to-be process (given by its process design) can realize correlated objectives. This is done by modeling the objectives of an organization. Objectives can be formulated at different levels of abstraction ranging from strategies to further refined operational objectives. A rich body of knowledge on goal representation, modeling and reasoning can be found in the goal-oriented requirements engineering literature; Yu and Mylopoulos (1995) and van Lamsweerde (2001) provide a good starting point for interested readers. For this elaboration, we assume that there exists a set of operational objectives. To be able to provide automated reasoning support the goals are presented (in natural language and) by a formal language like First-Order Logic. For example, in its simplest form a goal can be formally represented by a single literal α, where α could correspond to the sentence (in natural language) "The package safely arrived at destination". Hence, our goal is to make α true – to have the package at desired destination.

A process design will realize a correlated goal if its (cumulative) effects entail the goal. The cumulative effect of a process design is determined by the immediate effects of each activity of the process design. An immediate effect describes the outcome of executing a given activity in a formal language. For example, given a process design with a single activity with the effect α and β (the activity makes α and β true), this process design realizes a goal that is represented by α (because α is derivable from α and β – in fact α would be derivable from α alone). For process designs with more than one activity, immediate effects are accumulated across a process design using the Process SEER (detailed information in Hinge, Ghose, & Koliadis, 2009). In summary, the machinery allows us to point at any point in the process design and answer the question, what would have happened if the process design were executed up to this point. We omit a description on how to handle multiple paths through the process design and refer the reader to Hinge et al. (2009).

4.2 Semi-automated Environmentally Aware Process Improvement

The process improvement machinery of the Abnoba framework (Hoesch-Klohe & Ghose, 2010a) uses a library of best practice process fragments (snippets) to replace fragments of an "as-is design" with (more environmentally friendly) fragments drawn from the library. For each resulting process re-design candidate it is ensured that (1) the functional requirements are met (all correlated goals are realized), (2) the process design can be provisioned by the resource context of the organisation, (3) the process design is compliant with regulatory restrictions, and (4) the process design has a more preferred environmental profile. The majority of the existing process improvement frameworks (Reijers & Mansar, 2005 provide a survey) focus on optimizing the cycle time of a business process, by exploring possibilities for parallelizing activities. However, the resulting process re-designs are not necessarily superior with respect to their environmental performance. Nevertheless, the ability to search for and replace alternative fragments with parts of the as-is design allows for environmentally aware improvement. This approach has many parallels with the adaption of reference models (Fettke & Loos, 2007). Figure 5 provides a conceptual overview over the various steps to be described in more detail below.

- *Given an as-is process design it is disassembled into all its process fragments.* A process fragment is a (sub-)process graph with a single entry and a single exit point. For example, in Fig. 6 the fragment labeled with (1) can be disassembled into the fragments (2), (3), (4), and (5). Splitting a process design into all

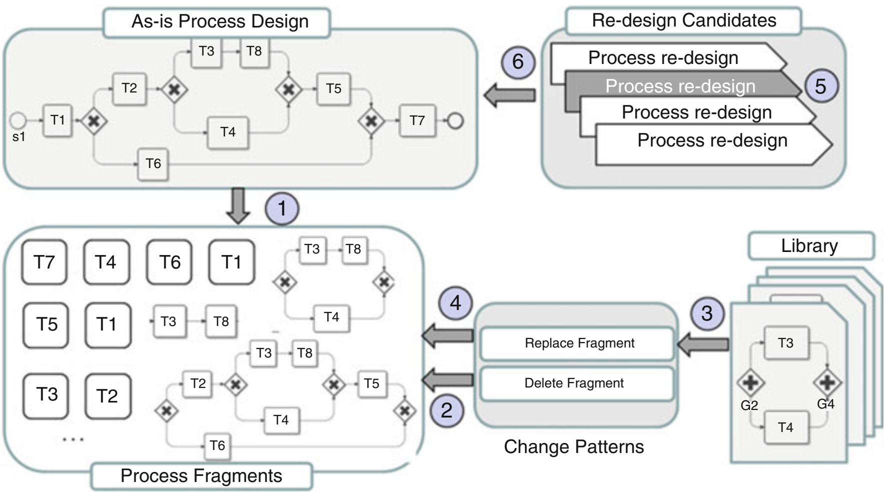

Fig. 5 An overview of the process improvement machinery (Hoesch-Klohe & Ghose, 2010b)

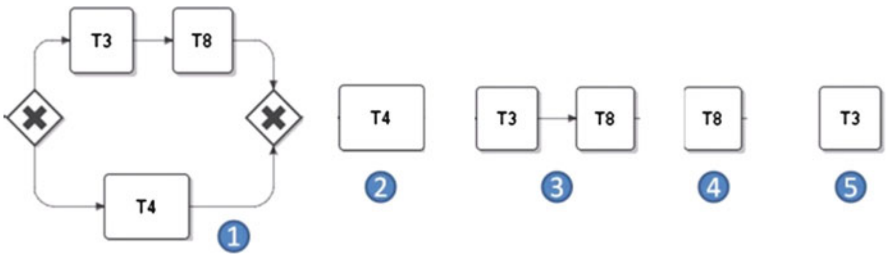

Fig. 6 Process fragment examples

its process fragments allows us to isolate functionality for fragment deletion or replacement with fragments possessing similar functionality (at least the functionality of the fragment to be replaced) in the library.

- *All obsolete fragments are removed from the as-is design.* Process designs evolve over time and hence might include functionality which has become superfluous. We identify obsolete fragments, by checking for each identified process fragment whether it can be deleted from the design, so that the resulting re-design remains to satisfy the correlated goals and is compliant. Note that due to the nature of a process fragment (single entry, single exit point) we can delete (and replace) fragments without impacting the correctness of the process syntax.
- *A capability library is used to search for substitutable fragments.* The capability library constitutes a set of effect-annotated process fragments. The library can be populated with past revisions of a process's design, with fragments from external "best practice" business processes and services (which can be treated as complex activities) derived from a service broker. Given such a library, for each fragment of the as-is process design we search for a substitutable fragment in the library. A process fragment p′ is a potential substitute for another process fragment p, if p′ has at least the functionality of p (every terminal effect scenario of p is entailed by some terminal effect scenario of p′).
- *Replace substitutable fragments.* All substitutable fragments, identified in the previous step, are replaced. Each replacement results in a process re-design candidate. For each candidate it is checked whether it is compliant (a machinery for compliance checking can be found in (Ghose & Koliadis, 2008)), can be provisioned by the resource context and achieves the desired functional outcome. The latter has to be checked because a new fragment drawn from the library can introduce additional functionality, which might cause inconsistencies. All valid process re-designs are added to a list of final process re-design suggestions.
- *Ordered process re-designs according to their environmental impact.* Given the final list of process re-design suggestions, their cumulative environmental impact is determined (Ghose et al., 2009; Hoesch-Klohe & Ghose, 2010b), the list respectively ordered, and finally presented to the analyst.

4.3 Process Sustainability Improvement: An Application Scenario

In the following we provide an application scenario showing a potential usage of the elaborated machinery. An obvious application scenario is a scenario in which a process fragment of the as-is design is replaced by a service, drawn from the library, which has a more preferred environmental profile – the functionality is outsourced to the respective service provider. In this scenario, the library is populated with services (or rather service descriptions). These services could be derived (in an automatic manner) from a service broker. The services in the library are matched against the fragments of the as-is design using their respective post-conditions (this requires the services to be formally represented using either the same ontology or a translator between the applied ontologies). The overall idea of this scenario is that functionality denoted by its process design fragment is outsourced to a service provider who has the means to operate more environmentally friendly.

However, a less obvious application scenario describes the case in which an old design version of a business process is used in the design of a to-be process. We use the BPMN to model an as-is "Handle Job Application" business process in an HR department. The process design is given in Fig. 7.

The business process is triggered by the arrival of a job application. The receipt of the application is confirmed and the strength and the correctness of the application are examined and verified before a decision is made. Finally, the applicant is informed about the outcome of his application. The given as-is *process design can be disassembled* into 23 *possible* process fragments. Due to space constraints we cannot show all these fragments, but Fig. 8 shows one of the 23 fragments.

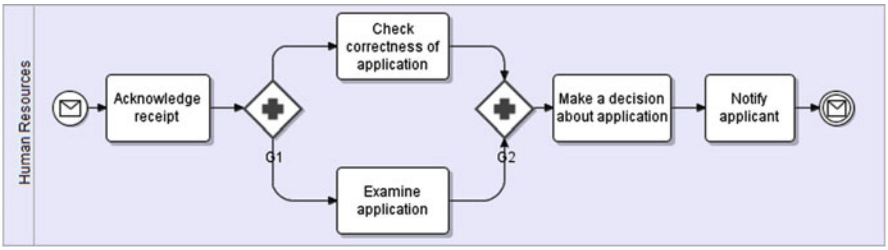

Fig. 7 As-is "Handle Job Application" business process

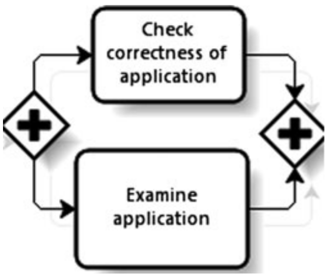

Fig. 8 A fragments from the as-is design

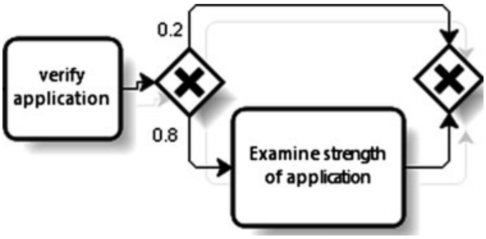

Fig. 9 Fragment from a past version of the "Handle Job Application" process design

Searching through the library reveals the process fragment shown in Fig. 9 which is a fragment from a past revision of the "Handle Job Application". In the fragment shown in Fig. 9 the activity "verify application" is executed before either the activity "examine strength of application" is performed (in the case the verification was positive) or the activity is skipped. Note that such a fragment is not identified based on the labels of the activities, but rather on the effects annotated of both fragments (we omit details for brevity). This fact is denoted by distinctly labeled activities in both fragments.

Note that the fragment shown in Fig. 9 might have been changed to the fragment shown in Fig. 8 to optimize the cycle time of the business process (activities are parallelized). However, new Quality of Service (QoS) requirements, reflecting the recent trend in industry towards more sustainable operations might make the past fragment more applicable (if environmental performance is ordered more important than cycle time).

A process re-design candidate is created by replacing the fragment given in Fig. 8 with the fragment given in Fig. 9. The candidate is then checked for compliance and goal realization. Given this check is successful the candidate is suggested to the analyst as a process re-design. The amount of e.g. carbon dioxide emission saved depends on probability of the positive or negative outcome of the "verify application" – in other words how often the execution of "examine strength of application" can be skipped.

In this section, we highlighted some challenges an analyst might face in an environmentally aware process improvement exercise. Based on the highlighted challenges, we summarized the Abnoba framework for Green BPM. The summary focused on how an automated machinery can be devised for improving a business process design and how it can be checked whether a process re-design fits into the organizational context. The former has been exemplified by an application scenario.

5 Opportunities and Challenges of Green BPM

The application scenarios and the description of the Abnoba framework have demonstrated opportunities and challenges of Green BPM for internal and inter-organizational business processes both from the organizational as well as from the technological side. These opportunities are systematized by means of the BPM life cycle (Fig. 10).

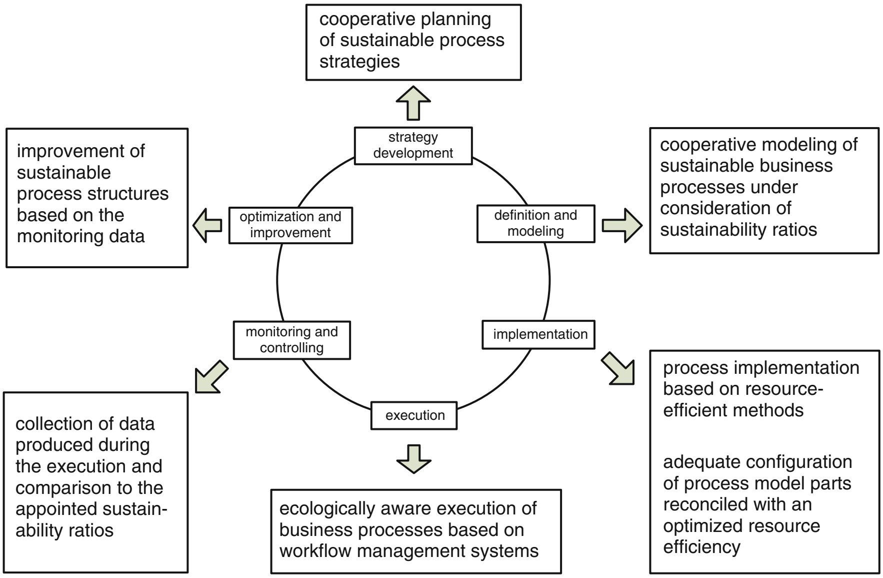

Fig. 10 Potentials and challenges of Green BPM (Based on Houy et al., 2011)

- Strategy development: In the phase of strategy development, a single organization or cooperating partners plan and appoint a sustainable corporate business process strategy. The objectives which should be achieved can be documented in a corporate Sustainability Balanced Scorecard (SBSC) with different sustainability ratios (Schmidt, Erek, Kolbe, & Zarnekow, 2009).
- Definition and modeling: In the phase of process modeling, models are developed considering the actual production of waste materials and the consumption of resources in order to create awareness of the problem. The individual sub-processes of the participating departments can then be defined in a more sustainable and resource efficient way in order to meet appointed ratios.
- Implementation: During the implementation phase, the several sub-processes have to be adequately configured in order to achieve an improvement of resource efficiency. In the context of configuring the sub-processes, the partners in cooperative scenarios should be supported by IT-based communication, e.g. video conferencing which is commonly more efficient than travelling.
- Execution: A more ecologically aware execution of business processes can be facilitated by inter-organizational workflow management systems driving the defined sustainable processes. In this context, electronic documents are often used in order to support the reduction of paper consumption.
- Monitoring and controlling: In this phase, the actual ratios of the process execution are measured for controlling purposes and can then be compared to the appointed sustainability ratios.

- Optimization and improvement: Based on this comparison in the preceding phase, weaker points and problems of process execution can be identified and considered during the improvement. Based on the process execution data, more sustainable process alternatives can be derived and combined, which is also supported by the presented Abnoba framework.

Nevertheless, there are also challenges which have to be faced in order to tap the full potential of Green BPM. In the first place, adequate and measurable sustainability ratios have to be identified and developed as these ratios provide the basis for process implementation, controlling and improvement. In some cases, the actual consumption of resources can only be estimated and is not exactly measurable.

Sustainability has become an important factor for many organizations. However, cost efficiency usually is the more important factor. In many cases, resource efficiency and an environmentally friendly economic activity go along with reduced costs; e.g. in the case of an optimized route for a travelling sales man. In other cases, cost-conscious business activities on globalized markets accompany high ecological costs; e.g. in the case when simple goods are transported far away to different countries in order to save personnel costs for further processing. Moreover, sometimes business processes have to be executed within a certain time limit producing higher ecological costs. In such a scenario further Green BPM tools are needed to support flexible and situational adaption of business process models for single process instances in order to facilitate an agile BPM fitting the needs of different emerging situations. Under certain circumstances, an optimization of time efficiency can be more important for the achievement of a business goal than resource efficiency (Ghose et al., 2009). Green BPM research has to examine whether existing tools can be adapted or new ones have to be developed.

In addition, further experience with the application of sustainability ratios in Green BPM is needed. Based on this experience, adequate green reference process models can be developed in order to document best practices for improving process sustainability in different business domains (Fettke & Loos, 2007).

6 Conclusion and Outlook

Green BPM is of relevance for both research and practice and offers considerable opportunities for the improvement of enterprises' sustainability. Our contribution has illuminated and discussed organizational as well as technological opportunities and challenges of Green BPM. At first, the topic was motivated by the actual debate on global warming and the need for better sustainability of business activities. Then, our understanding of Green BPM was explained and exemplified in the context of two application scenarios. Furthermore, the Abnoba framework as a current approach for semi-automated business process sustainability improvement has been presented. The opportunities and challenges of Green BPM were thereafter demonstrated and discussed based on the BPM life cycle.

The presented considerations as well as the application scenarios show that Green BPM can significantly contribute to more environmentally friendly business operations. It can be assumed that a lot of sustainability potential can be identified and realized in business processes of many different industries. Realizing these opportunities can significantly support more sustainable business activities and contribute to a betterment of humanity.

Future research should further develop concepts for Green BPM; e.g. in the form of green reference process models or procedure models for the implementation of green processes. Furthermore, adequate techniques and tools for the realization of Green BPM potentials in inter-organizational scenarios throughout the whole business process life cycle can considerably contribute to more sustainable business activities.

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Modeling and Analyzing the Carbon Footprint of Business Processes

Jan Recker, Michael Rosemann, Anders Hjalmarsson, and Mikael Lind

Abstract Many corporations and individuals realize that environmental sustainability is an urgent problem to address. In this chapter, we contribute to the emerging academic discussion by proposing two innovative approaches for engaging in the development of environmentally sustainable business processes. Specifically, we describe an extended process modeling approach for capturing and documenting the dioxide emissions produced during the execution of a business process. For illustration, we apply this approach to the case of a governmental Shared Services provider. Second, we then introduce an analysis method for measuring the carbon dioxide emissions produced during the execution of a business process. To illustrative this approach, we apply it in the real-life case of an European airport and show how this information can be leveraged in the re-design of "green" business processes.

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1 Introduction

The increasing awareness for the necessity of sustainability in living and working has put "green" or "sustainable" practices on the radar screen of organizations. Environmental constraints are increasingly imposed on organizations, and demand new levels of operational compliance.

In this context, colloquial terms such as Green IT (Poniatowski, 2009) have emerged to acknowledge information systems and the surrounding business processes as contributors to environmental problems as well as potential enablers of green, sustainable solutions. Yet, while organizations around the globe increasingly realize the demand and potential of the transformative power of information systems (Watson, Boudreau, & Chen, 2010), to date, few examples of such approaches have been reported in studies.

In this chapter, we contribute to the emerging body of research on sustainability in two ways:

- We describe an approach for documenting the carbon footprint of business processes in an extended business process model.
- We describe an approach for measuring the carbon footprint of business processes in an extended activity-based costing model.

With these two approaches, we extend the current body of knowledge in Green Business Process Management specifically in two stages of the process lifecycle, viz., modeling and analysis. This way, we set a platform for future contributions that can (a) extend our work to other stages of the business process lifecycle (e.g., improvement and implementation), or (b) work on the integration of the approaches (e.g., how the extended models can be leveraged in process analysis or improvement).

We proceed as follows: Following this introduction, we review existing research on sustainability and briefly discuss existing approaches to measuring carbon footprints in organizations. Next, we describe specific extensions to process modeling notations to allow for the documentation of carbon footprint information in a process model. We then apply our modeling approach to the case of a Direct Invoicing process at an Australian Corporate Services provider. Then, we introduce a method for measuring the carbon footprints of business processes. We apply our measurement approach to the case of a European airport. Finally, we conclude this chapter with a review of contributions, limitations and implications.

2 Background

Sustainability is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p. 43). Our interest specifically is on environmental aspects of sustainability. The most important environmental sustainability challenge is known as the problem of *global warming*, the increase in the average temperature of Earth's near-surface air and oceans. Global warming is primarily caused by greenhouse gas (GHG) emissions, in particular through Carbon Dioxide produced collaterally through human-triggered actions, such as business travels, paper production, manufacturing and others. Therefore, these actions are manifested also in the execution of organizational business processes.

Of course, we are not the first to examine environmental issues and organizational performance. Contributions on environmental quality, lean production, regulatory mechanisms, environmentally benevolent activities, and sustainable initiatives have been made in operations research, organizational science, behavioral psychology or econometrics, to name just a few. Yet, few contributions exist that examine the contribution of an organization's business processes to environmental sustainability.

We believe that Business Process Management can assist in the endeavor to extend our perspective on processes and the wider organizational performance. This is because Business Process Management tools and techniques assist organizations in their efforts to (re-) design the organizational processes in light of compliance regulations, operational agility, or other business imperatives such as time, quality or costs (Reijers & Mansar, 2005). The dedication of BPM approaches to eliminate waste under the "paperless office" paradigm indicates its potential for making processes more environmentally sustainable. We believe that it is possible to extend and adopt Business Process Management tools such that they also allow organizations to manage and improve the organizational processes in light of environmental considerations.

This work is an important move forward because, nowadays, global warming has raised attention about so-called eco-friendly business activities, defined as those processes that produce less carbon dioxide as a main cause of global warming. In this context, it is often referred to the *carbon footprint of business processes* as a measure for the carbon dioxide production alongside organizational operations such as paper-intensive processes (e.g., a bank's mortgage process), fuel consuming processes (e.g., business travels) or a process that produces waste materials and unnecessary power sources (e.g., defect processes, quality rectification processes).

Carbon footprint is commonly understood as the amount of carbon dioxide (CO_2) emitted through the combustion of fossil fuels during daily activities – in the case of a business organization, the amount of carbon dioxide emitted either directly or indirectly as a result of its everyday process operations. It is expressed as grams of CO_2 equivalent per kilowatt-hour of generation (g CO_2 eq/kWh), which accounts for the different global warming effects of other greenhouse gases.

To facilitate the improvement of the carbon footprint of business processes, appropriate steps have to be taken alongside the complete business process lifecycle (Mendling, 2008), viz., in the stages design, implementation, enactment and evaluation. Because within this lifecycle, the design and evaluation phases are important because they allow for the development of (green) business processes as well as for their analysis, we will concentrate our discussion on these two stages. To that end, in the following we firstly describe an approach to facilitate the documentation of the carbon dioxide emissions alongside a business process.

3 Modeling the Carbon Footprint of Business Processes

3.1 An Extended BPMN Notation

Process modeling is one of the key tools used within Business Process Management to describe the activities, tasks, and processes of an enterprise (Mendling, Reijers, & Recker, 2010). Process modeling is essentially a cognitive design tool, and the role of process modeling is to understand what you do now, and what you might want to do in the future. Because process modeling encompasses IT systems, information, activities, actors and business rules and other documentation, it appears an adequate tool in designing sustainable processes (Seidel, Recker, Pimmer, & vom Brocke, 2010), especially since resource consuming activities can be captured.

Process models are designed using so-called process modeling languages (sometimes called notations or techniques), i.e., sets of graphical constructs and rules how to combine these constructs. At present, the Business Process Modeling Notation (BPMN) denotes the industry standard for process modeling (Seidel et al., 2010), and it is this standard that we now seek to extend to present appropriate modeling constructs to capture carbon footprint information relevant to a business process.

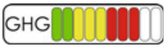
BPMN can help to gain better understanding of which activities that produce green house gases, most importantly carbon dioxide (CO_2). By defining an extended notation to indicate the activities which impact on the process emission of CO_2, a BPMN process map can be used to design processes on basis of sustainability considerations.

Activities that produce CO_2 can be characterized by the base of their *emission source* and their *method of producing* CO_2. For instance, paper, electricity or fuel can be defined as main source of CO_2 production in a business. Furthermore, activities such as unnecessary business travels, or redundant tasks may accumulate superfluous CO_2 on basis of these emission sources. The same level of concern can also be directed towards alternative means for reaching the same goal, such as alternative modes of transportation or similar measures.

Therefore, to allow for process design decisions that incorporate carbon footprint information as an important design consideration, we introduce the following BPMN notation extensions to capture activities, carbon dioxide emission sources, and flow of CO_2 in a BPMN process model (see Table 1).

Figure 1 gives an example of how these notation extensions can be used in conjunction with the BPMN specification. In the example, activities are characterized by defining which activity falls into which resource consumption group (e.g., fuel, paper). By calculating the amount of GHG emission for each activity, the example also displays the overall GHG emission levels. The indicator notation elements assign to each activity the exact amount of produced GHG, which allows calculating the GHG emissions per pool, and subsequently for the overall process.

Table 1 Suggested BPMN notation extensions

Construct	Notation	Specification
Fuel consuming activity		This notation is attached to an activity that produces CO_2 by using fuel as main source. Examples include business travels, transportation, and others
Paper consuming activity		This notation is attached to an activity that produces CO_2 by using paper. Examples include creating paper invoice, filing paper report, and others
GHG emission indicators	 or 	These notation constructs can be assigned to each pool or swim lane to indicate the level of GHG (mainly CO_2) emission in the relevant (part of the) process. Color coding can be used to display the overall level of GHG emission in the process. Else, the precise amount of GHG emission produced can be specified
GHG flow		The GHG flow construct is used to show the flow of GHG in a process and to connect emission producing activities to the GHG emission indicators

With these simple notation extensions, processes can be documented in light of their contribution to the carbon footprint of an organization. Such modeling enables process designers to identify on an appropriate level of detail the sources and main drivers of carbon emission alongside the value chain of an organization, and to use this information in the design or re-design of organizational processes that comply with environmental considerations or legislator demands.

3.2 *Case Study: The Direct Invoicing Process*

We applied our modelling approach in a case study with Seamless Service Provision (SSP), an Australia-based organization that offers financial and human

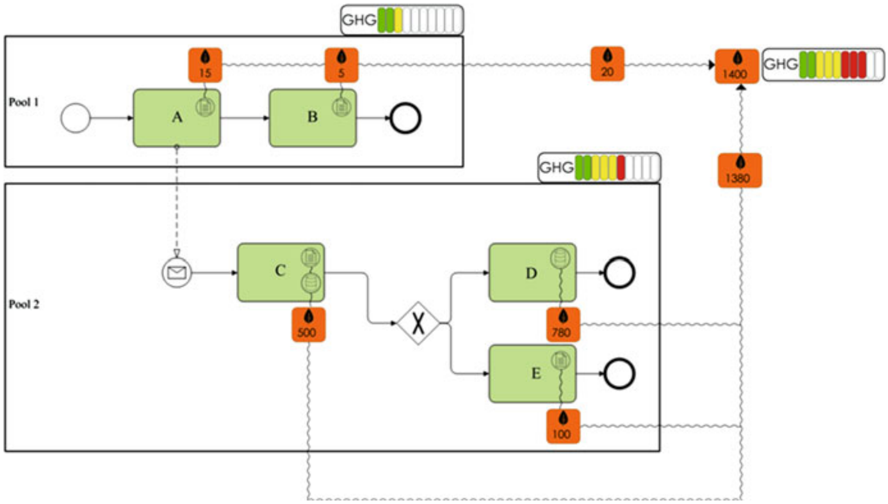


Fig. 1 Sample extended BPMN model including carbon footprint notation elements

resource services to organizations in the private and public sector. One of these services is the payment of so-called direct invoices for its clients. A direct invoice is an invoice without a corresponding purchase order.

SSP receives between 15,000 and 25,000 paper-based invoices per month. The invoices arrive in the incoming mail centre in the city centre (Office 1). Invoices are screened, entered into a system and then forwarded to Data Entry Officers at Office 2 in the north of the city (10 km distance from Office 1). Incomplete or incompliant invoices (10% of all invoices) are sent back to the client via postal mail with the request to complete the invoice.

The data entry officers then manually attach vendor master records to the invoices. The internal mail collects these forms and takes them to the master data entry department. The master data entry department creates SAP master data (takes 1–5 days) and then the invoice is ready to be entered in the SAP system by Data Entry Officers.

Validation Officers sort the invoices and print 10-page reports per 100 invoices (60 min for a batch of 100 invoices). Invoices are now ready for payment. The Payment Office runs a payment process every week. This is a highly automated process, at the end of which a report is generated. This report will be sent via mail to the individual clients to inform them about the successful payment of the invoice. Also, it will be sent to SSP's Accounts Receivable Department at Office 3 located 3 km away from Office 2. This department generates monthly invoices for SSP's clients. Third, the payment report will be sent to the Registry (same building). The employee in the Registry selects the paper-based invoices that have been paid and archives the invoices. Sometimes, vendors or clients have an issue with the payment and in these cases it is required to track down the original paper-based invoice together with all information on the invoice entry form. Such requests occur about five to ten times per month.

On the basis of this information, we were able create an extended process model of the process, modelled in BPMN (Recker, Rosemann, Indulska, & Green, 2009) together with our notation extensions. The model details the process in terms of 43 individual activities, ten involved departments within SSP, plus required data, paper, forms and other inputs to, and outputs from, the process. While we omit details about the modelling process due to space limitations, we show the final extended BPMN model in Fig. 2. Note how this model, in addition to the regular process flow, captures and illustrates the flow of CO_2 accumulations along the process.

We note that one of the main challenges in modelling an extended BPMN model is, obviously, the collection of adequate and reliable data about CO_2 accumulations during the execution of the process. Still, this data gathering challenge is not dissimilar to the traditional requirements gathering challenges in process design, and there is ample literature on methodologies and guidelines that readers can refer to, e.g., (Davies, 1982; Gulla & Brasethvik, 2000; Lauesen & Vinter, 2001; Nuseibeh & Easterbrook, 2000).

Having modelled the process in the extended BPMN notation, we posit that a visual inspection of the process model now guides an environmentally-focused analysis in at least three ways:

- It graphically visualizes the total CO_2 accumulations alongside a business process, thereby integrating quantitative data from a process analysis in the graphic representation of a process.
- It pinpoints graphically the key CO_2 emission drivers within a business process, thereby providing a scoping focus for a root-cause analysis.
- It visualizes graphically the activity-individual and overall extent to which a process can be considered green (through the GHG emission indicators), thereby allowing for simple judgment of the need for environmentally-oriented process change.

4 Measuring the Carbon Footprint of Business Processes

Of course, documenting the carbon footprint of business processes through extended process modeling is but one step of making process sustainable. Indeed, the modeling extensions introduced in Sect. 3 above are predominantly of interest to the lifecycle stage of process design. For holistic and comprehensive sustainable (re-) design of business processes, however, the (re-) design of business processes should be preceded by appropriate analyses of the “greenness” of the existing (or future) business processes. Specifically, we believe an analysis should be able to provide measurements of *carbon emissions*, and *carbon emission drivers*. To that end, we describe in the following an approach to measuring the carbon footprint of business processes.

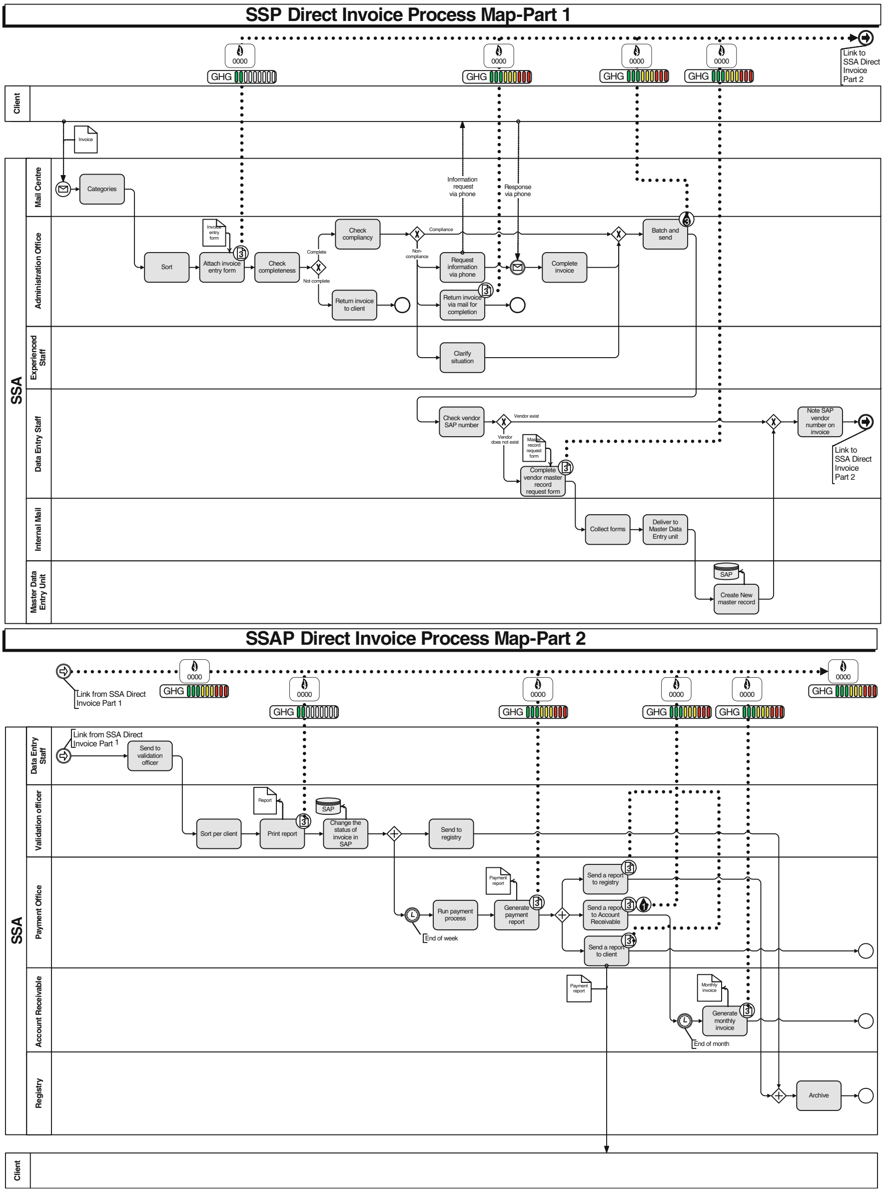


Fig. 2 Extended BPMN model of the direct invoicing process

Carbon footprint measurement is not a new topic. In fact, it has become a topic of interest to many business organizations, and has led to the development of several measurement approaches to calculate the footprint of a business as an organizational entity (see, for instance, http://www.carbonfootprint.com/).

Traditionally, calculating the carbon footprint of an organization can be done via three approaches (Hendrickson, Horvath, Joshi, & Lave, 1998): bottom-up – based on Process Analysis (PA) (Smith Cooper & Fava, 2006), top-down – based on an Environmental Input–output (EIO) analysis (Pan & Kraines, 2001), or through a combination of both (Heijungs & Suh, 2006). Still, these approach are focused on understanding input–output relations on either a system (Smith Cooper & Fava) or a broader institutional (Heijungs & Suh) or economical level (Pan & Kraines). We argue, therefore, that an understanding of carbon emissions on a *business process level* would create further opportunities on a meso and micro level to make quick and effective adjustments to an organization with a direct impact on its environmental image.

Our argument rests on a tight linkage between carbon emission measurement and Business Process Management (vom Brocke & Rosemann, 2010), through which an organization can create competent processes that function cost efficiently, with greater precision, reduced errors, and improved flexibility. While typically, process management has focused on the documentation, analysis and improvement of performance objectives such as cost, time, quality or flexibility (Reijers & Mansar, 2005), we will in the following extend a typical process management tool, namely *Activity-Based Costing* (Bromwich & Hong, 1999), towards the inclusion of environmental measures.

4.1 Activity-Based Emission (ABE) Analysis

Activity-Based Costing (ABC) is a collection of financial and operational performance information dealing with significant activities of the business (Bromwich & Hong, 1999). Key to this approach is the consideration of actual usage of equipment and resources (e.g. machinery and human resources) in the activities that constitute a business process. This approach takes a stance, therefore, on the operational level of a business process, which, through multi-level process architectures, thereby allowing for composition of the measures to a meso- or macro-organizational level.

Originally, ABC describes a costing model that identifies activities in an organization and assigns the cost of each activity resource to all products and services according to the actual consumption by each: it assigns more indirect costs (overhead) into direct costs (Kaplan & Bruns, 1987). In this way, an organization can precisely estimate the cost of individual processes (for both products and services) so they can identify and eliminate those that are unprofitable and lower the costing and pricing of those processes that are overpriced.

In ABC analysis, direct labor and materials are relatively easy to trace directly to processes, but it is more difficult to directly allocate indirect costs to organizational processes. Where processes use common resources differently (e.g., rooms, common machinery, resources involved in multiple processes), some sort of weighting is needed in the cost allocation process. The *cost driver* is a factor that creates or drives the cost of the activity (Ray & Gupt, 1992). For example, the cost of the activity of bank tellers can be ascribed to each process by measuring how long each process' transactions (cost driver) takes at the counter and then by measuring the number of each type of transaction.

ABC analysis is a key analysis tool in process management and has enjoyed considerable uptake (Innes & Falconer, 1995), also in complementary use with graphical process models (Tornberg, Jämsen, & Paranko, 2002). Therefore, following the basic premises of ABC Analysis, we argue that *Activity-Based Emission (ABE) Analysis* can be conducted for a process to determine the emission of CO_2 for each activity as well as the overall process. We believe that ABE allows the calculation of CO_2 emission more accurate than PA or EIO approaches by focusing on every step of a business process, by identifying the so-called *emission drivers* (the equivalent to a regular cost driver) and by considering the impact of alternative resources that facilitate the process execution. In fact, estimating and measuring the CO_2 outturn of each activity, the CO_2 emission of all services and products across all business processes of an organization can be calculated. In turn, ABE analysis can provide a more precise and specific insight into the actual processes, activities and resources within, that directly contribution, positively or negatively, to the carbon emission of an organization. This is because ABE helps to distinguish operations and resources based on their CO_2 emissions, and thus allows embedding an environmental view in the decision-making related to process (re-) design.

Further benefits from an ABE approach include that it can also be used within other business analysis tools such as Pareto analyses, to further examine the relation between cost, time and emission of CO_2 for a business. We foresee the combination of ABE with other analysis tools as a key step in defining organizational areas which require an improvement in light of sustainability considerations.

4.2 Stage Model

Similarly to a regular ABC analysis (Cooper & Kaplan, 1991), an ABE can be conducted within five main steps:

- Identify the product or service process to be considered. This step is typically supported through process modeling activities. At this stage, analysts may use an extended (or even regular) BPMN model of the process under consideration.
- Determine all the resources and processes that are required to create the product or deliver the service, and their respective CO^2 accumulation. To that end, typically, semi-formal graphical models of the business process are considered as documentations of the tasks that have to be performed, the actors and other resources that are involved in the execution of these tasks, relevant data and sources (transportation means, papers, forms, systems and technology) of the data, and the business rule logic that describes the logical and temporal order in which tasks are to be performed (Recker et al., 2009).

- Determine the "emission drivers" for each resource. In analogy to a cost driver (Ray & Gupt, 1992), an emission driver is any activity that causes a GHG emission to accumulate. A regular BPMN model, for example, details all tasks to be performed in a process (activities), all human and organizational resources involved (swimlanes and pools). An extended BPMN model using our notation extensions, additionally, would identify and document emission drivers for CO_2 accumulation – under the assumption that this information was properly identified prior to modeling.

  - *Scope1: direct GHG emissions* – emissions that occur from sources that are owned or controlled by the company. Examples include emissions from boilers, vehicles, electric generators and so forth.
  - *Scope2: electricity indirect emissions* – emissions that originate from consuming electricity, heat or steam purchased by the company.
  - *Scope3: other indirect GHG emissions* – emissions that are the results of the activities of the company but arise from sources not owned or controlled by the company. These include emissions from product materials produced by suppliers (newsprint/paper, ink, etc.), contractor delivery vehicles, employee commuting to/from work and business air travel.

  To measure the CO_2 accumulations, data will have to be collected, at least, about three important CO_2 emission types, *consumed electricity, consumed paper,* and *consumed fuel.* Arguably, there could be other emission types that could also be taken into consideration when identifying emission drivers.

  In identifying emission drivers, we draw upon recommendations from the Greenhouse Gas Protocol (GHG Protocol) for Sustainable Development (www.ghgprotocol.org), develop in late 1997 by the World Resources Institute and the World Business Council. The GHG Protocol is providing series of accounting tools to understand measure and manage green house gas emissions. In this protocol, three scope levels are defined to define organizational boundaries to enable differentiating between GHG emitting activities (the emission drivers) that are owned by organizations, and those that are not. These scope boundaries categories owned emitting activities in to three different scopes which is distinguishes between direct and in direct GHG emitting activities:
- Calculate CO2 emission for each activity by gathering Activity Data for each process and resource and define the emission type for each Activity Data. The GHG Protocol enables the calculation of the CO_2 emissions for each defined source of emission (the emission driver) in step 3 through GHG Protocol calculation tools. Examples for the three selected types of emissions include the following:

  - *Fuel (scope3):* For calculating the CO_2 emission of scope3 activities (e.g., business travel between two offices), the GHG protocol provides the formula*: Distance travelled* $\times$ *emissions factor incorporating default fuel efficiency value* $=$ *CO_2 emission*

  - *Paper (scope3):* For calculating the CO_2 emission of scope3 activities (e.g., transporting paper forms between two offices), the GHG protocol provides the formula*: Weight of paper × emissions factor for manufacture of paper = CO_2 equivalent emissions*
  - *Electricity (scope2):* CO_2 emission of purchased electricity can be calculated by using the GHG Protocol calculation tool for purchased electricity, which is based on the formula*: KWh of electricity used by organization × emission factor = CO_2 emissions*

- Use the data to calculate the overall CO^2 emission of the process. This is achieved by summing up all CO_2 emissions across all activities and scope levels. This analysis will then enable a sixth step (out of scope for this paper) – the actual act of making eco-aware process re-design decisions, and selecting those process and resource variants that help to reduce the carbon footprint during run-time execution.

4.3 Case Study: The Taxi Process to and from the Airport

4.3.1 Case Description

In this case study we applied our ABE approach to the taxi processes at a major airport in northern Europe. National environmental regulations force this airport to keep track of, and limit themselves to, a certain level of the CO_2 emissions that the airport is directly and indirectly responsible for. A direct emission is an emission created by operations within the airport an indirect emission is an emission created by a process that moves people or goods to and from the airport. All emissions from these activities are summarised into a total that may not exceed the emission roof determined by the national environmental agency.

The airport has approximately 17 million air passengers a year. Some of these passengers are passengers in transit who use the airport as a transit to reach a final destination. Buses, trains, and cars transport passengers to and from the airport. On average 2.2 million taxi trips are required each year in order to transport passengers and visitors to and from the airport.

The selected service process in this case is transport by taxi from and to the airport (see step 1 above). In order to reduce the environmental impact from taxis, the airport introduced the concept of eco-taxis in the middle of 2005. Specifically, a separate queue for eco-taxis was established in front of the ordinary taxi queue, promoting this eco-friendly transportation option to travellers. This way, the number of eco-taxis increased at the airport from 1% in 2005 to more than 80% in 2010.

In March 2010 a new system was introduced for coordinating taxi movements at the airport. This new Dispatch System uses a sophisticated algorithm to priorities the taxi's in the queue based on the emission level that each of the taxis have. The more eco-friendly a taxi is the more points it is awarded and hence prioritized in the dispatch queue. The system also gives prioritization points to taxis that have dropped off passengers at the airport upon arrival and assign waiting points to the taxis in the taxi remote so that taxis do not leave the airport without passengers from the airport. Taxi companies that serve the airport must register their taxis in the system in order to be able to pick up passengers from the airport. As a fourth step in this eco-based development related to taxi transportation, the airport has declared that only eco-taxis are allowed to operate from the airport by July 2011. This will change the requirements for the taxi operators radically and is also intended to reduce the CO_2 emissions from the taxi processes radically. As base for an evaluation of the impact we were allowed to perform an ABE Analysis on the taxi processes at the airport.

4.3.2 Case Analysis

To calculate the carbon footprint of the taxi trips at the airport, we created processes models of the flow of taxis to and from the airport, modeled in the extended BPMN notation. The models detail the process in terms of 29 individual activities, two involved actors (the taxi company and the passenger), information flows and other inputs to, and outputs from, the process. This information was important to step 1 of our ABE analysis, viz., the identification of important activities, as well as to step 2 (identifying the involved human and organizational resources relevant to the execution of the process). We omit the model from this chapter due to space limitations.

In the third step, we selected fuel as a CO_2 emission type of the process as it propels the resources in these processes (the taxis) and divided it in to the five most common types of engines propelling taxis at the airport:

- Petrol: 206 g/km (non-eco taxi).
- Eco-diesel: 120 g/km (eco taxi)
- Biogas: 77 g/km (eco taxi)
- Ethanol: 81 g/km (eco taxi)
- Hybrid: 104 g/km (eco taxi)

With these types of emissions, we were able to identify the five most common sub-types of resources acting as emission drivers in the taxi processes at the airport. These emission drivers are to be seen as scope 3 types of emissions as per the GHG protocol. In the fourth step (see above), we identified the sources (the data) for the emission. Emissions depend on traveled distance as well as the volume of taxi moments for each type of trip (eco trip vs. non-eco trip). In this forth step, we collected data from the new Dispatch System: the volume of taxi movements to and from the airport, in total for 2010 2,156,412 trips (1,149,819 trips from the airport and 1,006,593 trips to the airport). A total of 792,600 trips *from* the airport were made by eco taxis (i.e., with a car either propelled by Eco-diesel, Biogas, Ethanol or Hybrid). Similarly, 658,498 trips *to* the airport were carried out by eco taxis. We also collected data about the total volume of non-eco taxis and eco taxis, as well as eco taxis divided on different engines in order to break down the eco resources used in these two processes. In addition, we used the average distance for taxi travelers generated from a survey that the airport does every year with approx. 100,000 passengers. The average distance for taxi travelers was reported to be 43 km.

In the fifth step, we calculated the CO_2 emissions alongside the process for each type of trip (non-eco taxi trip vs. eco-taxi trip to and from the airport). In the calculation we assumed that the proportion of eco-trips divided on eco-resources equal the proportion of different types of eco-resources. We also used the emission factors provided by the National Environmental Protection Agency in the country where the airport is located. The reason for this is that the airport uses these factors for measuring the CO_2 emissions for land bound vehicles and emissions factors from GHG for calculating CO_2 emissions for airplanes. With this data we calculated the overall CO_2 emission of the Taxi Process at the airport, as described in Table 2. The data was calculated using the calculation schemes described in Sect. 4.2, and perusing the calculation tools defined and provided by the GHG protocol (www.ghgprotocol.org).

To summarize, the service processes transporting travelers by taxi from and to the airport has been selected (step 1). This process has been described in terms of traveler related activities (emission drivers) as well as involved actors (taxi companies) and resources (especially different kinds of taxi vehicles) used for

Table 2 ABE analysis of taxi trips to and from the airport in 2010

Type of taxi trip		Description	Number of trips per year	CO_2 emission per trip (kg, rounded)	CO_2 emission per year (kg)
Non-eco taxi trips from airport		31% of all taxi trips from the airport are non-eco taxi	357,219	**8.858**	3,164,245.90
Non-eco taxi trips to airport		35% of all taxi trips to the airport are non-eco taxi	348,095	**8.858**	3,083,425.51
Eco taxi trips from airport		69% of all taxi trips from the airport are eco taxi			
	Eco-diesel	0.6%	5,130	**5.160**	26,471.33
	Ethanol	21.1%	166,961	**3.483**	581,526.35
	Biogas	55.3%	438,157	**3.311**	1,450,737.59
	Hybrid	23%	182,352	**4.472**	815,476.48
Eco taxi trips to airport		65% of all taxi trips to the airport are eco taxi			
	Eco-diesel	0.6%	4,262	**5.160**	21,992.55
	Ethanol	21.1%	138,713	**3.483**	483,136.44
	Biogas	55.3%	364,024	**3.311**	1,205,283.63
	Hybrid	23%	151,499	**4.472**	677,503.97
Total emission per year (kg) from the taxi process					**11,509,799.75**

realizing these service processes (step 2). Emission drivers have been identified for each variant of resource utilized in the activities where other indirect GHG emissions (scope 3) has been characterized for each type of engine powering the taxi vehicles transporting the traveler (step 3). These different types of engines were then used to calculate the CO_2 emission divided into two different types of taxi rides (non-eco taxi trips vs. eco-taxi trips) (step 4), which then formed the basis for calculating the overall CO_2 emission for the selected processes (step 5). Since two processes (taxi to and from the airport) were selected this also gave rise to comparison.

5 Conclusion

In this chapter, we described two important steps forward towards the eco-friendly management of business processes. Specifically, we introduced two approaches relevant to two distinct stages of the business process lifecycle, viz., modeling and analysis.

By being able to *document* or *measure* the environmental impact of a business process, analysts and managers are empowered to account for environmental information in their decisions to execute or change business processes. Our documentation and measurement approaches both work for as-is (as in our service provider case) as well as for to-be scenarios (as in our Airport case) and can therefore be used to make informed decisions about "green" processes and the improvement of the processes towards environmental as well as classical business objectives. Specifically, the airport case demonstrates how the ABE analysis can be a useful tool to monitor and evaluate several incremental steps in the development towards sustainable to-be processes (here: more eco-friendly transportation system using taxis).

Our work surrounding the two approaches contains some limitations. Notably, we focused on two distinct stages of the business process lifecycle, and only sketched how the two approaches – extended modeling and ABE analysis – can be integrated. We showed how an extended BPMN model serves as a useful data input to step 1 of the ABE analysis; but still, theoretically, it is possible to conduct an ABE analysis without modeling the process beforehand.

Second, in our case studies we focused on selected emission drivers and emission sources and acknowledge that a different focus on other emission drivers or sources could yield different results. Nonetheless, our ambition was to demonstrate how existing analysis tools for organizational management could be adapted to allow for inclusion of sustainability considerations. Such work, and its application in practice, can be an important move towards "green" organizations and "green" value chains.

Following our work, future work could be carried out to develop or extend approaches for 'green' process implementation or enactment, to complete the stages of the business process lifecycle. Other work could examine the integration and complementary use of the approaches across all stages of the lifecycle. Empirical work, finally, could be carried out to examine the utility of such approaches in actual sustainability initiatives.

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Managing Process Performance to Enable Corporate Sustainability: A Capability Maturity Model

Anne Cleven, Robert Winter, and Felix Wortmann

Abstract Sustainability is among the key issues that organisations face today. Sustainability is frequently defined as economic activity that meets the needs of the present generation without compromising the ability of future generations to meet theirs. Despite being intensely discussed, however, the concept of sustainability is not as clear cut as is commonly believed. Likewise, neither kind nor scope of the capabilities organisations need to develop in order to become truly sustainable are currently well understood. This chapter proposes that process performance management (PPM) is a vital approach that organisations can use to address their sustainability concerns. Using a quantitative, questionnaire-based approach, the Rasch algorithm, we develop a capability maturity model that allows organisations to determine their current PPM maturity level and to identify required improvements regarding their process performance. The chapter concludes with a detailed discussion of the use of PPM to incorporate corporate sustainability in day-to-day operations.

1 Introduction

Many companies—in particular multinationals with a significant impact on both employment and the economy in general—periodically report their internal and external sustainability results in order to testify their sustainability performance (Baumgartner & Ebner, 2010, p. 87; Pojasek, 2009, p. 76; Wikström, 2010, p. 100). This reporting habit is achieving growing approval and is adopted by an increasing number of organisations. A considerable number of companies, however, is only vaguely convinced about both their overall objectives and their capabilities in sustainability concerns (Baumgartner & Ebner, p. 76). Even after more than

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30 years of discussion on the concept, the business community does not seem to have agreed upon reasonable and practical approaches for an efficient implementation of sustainability issues (Labuschagne, Brent, & van Erck, 2005). As a consequence many companies feel left in suspense and are fishing in murky waters.

The term *sustainability* gained great popularity with the definition provided by the Brundtland report, ‘Our Common Future’, in 1987. The report defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1991, p. 43). Based on this definition, the term *triple bottom line* (TBL) was coined, which refers to the three fundamental pillars of corporate sustainability (Savitz & Weber, 2006):

- The economic bottom line,
- The social bottom line, and
- The environmental bottom line.

Up to today, the required capabilities for achieving sustainability—particularly the necessary competencies in day-to-day operations—have not yet been consolidated and agreed upon. Part of the problem may be that some organisations show their commitment to being sustainable merely by changing their rhetoric and pursuing green-washing (Laufer, 2003; Stiller & Daub, 2007). Another part of the problem, however, is that organisations simply do not know *what* actions and measures to take or *how* to make sustainability part of their business routines and strategies (Baumgartner & Ebner, 2010, p. 77). Most of the guidelines developed by governments, research institutions, and organisations like the Global Reporting Initiative (GRI) provide instructions on how to measure and report organisational sustainability performance (AG, 2000; GRI, 2006; SGX, 2010), but these guidelines lack advice on how to achieve sustainability in the first place (Isaksson, 2006).

We propose that one of the most intuitive approaches to making manageable the giant challenge of sustainability and incorporating it into daily operations entails taking a process perspective and that the concept of process performance management (PPM) provides a valuable basis for establishing and maintaining sustainable business processes. This chapter illuminates the capabilities required to measure and manage performance on a process level. Using a quantitative approach, we develop a capability maturity model (CMM) that allows organisations to evaluate their current positions and to identify required improvements with respect to their PPM capabilities.

The remainder of this chapter is structured as follows. Section 2 provides the conceptual background for our research by introducing the concepts of business process management (BPM) and PPM. This section establishes the fundamentals of maturity models (MMs) and maturity model (MM) development, as well as our conceptualisation of maturity for PPM. The subsequent section sketches out the methodology applied in developing MMs, including data collection and data analysis. The CMM itself is presented in detail in Sect. 4. Section 5 then discusses how organisations can benefit from using the proposed model when striving for a comprehensive approach to measuring and managing corporate sustainability.

The concluding section summarizes our work and names limitations, along with implications for theory and practice.

2 Foundations and Conceptual Background

2.1 Measuring and Managing Process Performance

Analyzing and improving organisational processes has been recognized as key to achieving organisational performance and has been discussed under the acronym BPM for roughly three decades in the business community (Armistead, Pritchard, & Machin, 1999; Lee & Dale, 1998; Smith & Fingar, 2003). However, since BPM still represents a young field of research and a number of organisations are only beginning to analyze, genuinely understand, and intentionally (re-)design their work practices (Bandara, Indulska, Chong, & Sadiq, 2007), available approaches to BPM often focus on the early phases of the BPM lifecycle. However, once organisations have increased their level of BPM maturity, they need "to begin measuring processes and their outputs, and to continually refine their designs" (Davenport & Beers, 1995, p. 60). Up to now, though, there is only little guidance on how to address performance management issues in the context of BPM (Kueng, 2000; Vergidis, Turner, & Tiwari, 2008).

One quite recent, but very promising approach addressing this gap is called PPM. As was the case for BPM at one time (Smart, Maddern, & Maull, 2009), PPM has generated enormous practitioner interest, so the most elaborate conceptions of PPM have been provided by practitioners. The Association of Business Process Management Professionals (ABPMP), one of the premier not-for-profit practitioner organisations in the field of BPM, defines the measurement of process performance as "the formal, planned monitoring of process execution and the tracing of results to determine the effectiveness and efficiency of the process" (ABPMP, 2009, p. 22). The information gained in the measurement process is thereafter "used to make decisions for improving or retiring existing processes and/or introducing new processes in order to meet the strategic objectives of the organisation" (ABPMP, 2009, p. 22). Concepts that have been identified as contributing to either of the two components include defining performance metrics; monitoring, controlling, and simulating processes; and aligning process and enterprise performance (Davamanirajan, Kauffman, Kriebel, & Mukhopadhyay, 2006; Kueng, 2000, p. 69).

2.2 Maturity Assessments and MM Development

The popularity of MMs has increased largely in the fields of information systems (IS) and management science (Mettler & Rohner, 2009). Since the initial introduction of the concept in the 1970s (C. F. Gibson & Nolan, 1974), myriad MMs have been developed in both theory and practice (e.g. Crawford, 2006; Khaiata & Zualkernan, 2009; Scott, 2007). MMs are a valuable instrument for systematically documenting and guiding the development of organisations based on anticipated, desired, or archetypal evolution paths. A MM consists of a sequence of maturity levels for a class of objects (Becker, Knackstadt, & Pöppelbuß, 2009, p. 213; Klimko, 2001, p. 271). Maturity in this context is understood as a "measure to evaluate the capabilities of an organisation" (de Bruin & Rosemann, 2005, p. 1), while the term *capability* is understood as the ability to achieve a predefined goal (van Steenbergen, Bos, Brinkkemper, van de Weerd, & Bekkers, 2010, p. 317). MM are applied as both an evaluative and comparative basis for self or third party assessment (Chrissis, Konrad, & Shrum, 2007; de Bruin & Rosemann; Hakes, 1996) and an informed approach to achieving continuous improvement (Ahern, Clouse, & Turner, 2004). Table 1 provides a brief overview of the most important characteristics of MMs.

While MMs are seeing increasing prominence, they are also the subject of some criticism: In particular, the rapid development of large numbers of MMs—de Bruin et al. identify over a hundred different MMs in their extensive review

Table 1 Characteristics of MMs

Characteristic	Description
Object of maturity assessment	MMs allow for the assessment of the maturity of a variety of objects. Most frequently assessed objects are technologies/systems (Popovic, Coelho, & Jaklič 2009; Zumpe & Ihme, 2006), processes (Chrissis et al., 2007; Paulk, Curtis, Chrissis, & Weber, 1993), people/workforce (Curtis, Hefley, & Miller, 2010). and management capabilities, such as project or knowledge management (Crawford, 2006; Paulzen, Doumi, Perc, & Cereijo-Roibas, 2002)
Dimension	Dimensions are specific capability areas that describe aspects of the object of maturity assessment. Dimensions should be both exhaustive and distinct (Mettler & Rohner, 2009). Each dimension of a MM is further specified by several characteristics (practices, measures, or activities) at each level (Fraser, Moultrie, & Gregory, 2002)
Level	Levels are archetypal states of maturity of the object that is assessed. Each level should have a set of distinct characteristics (practices, measures, or activities per dimension) that are empirically testable (Nolan, 1973)
Maturity principle	MMs can be continuous or staged. While continuous models allow characteristics to be scored at several levels, staged models require all the elements of one distinct level to be achieved (Fraser et al., 2002). Hence, in continuous MMs, a maturity rank may be determined as either the (weighted) sum of the individual scores or the sum of the individual levels in several dimensions. By contrast, staged MMs clearly specify a set of goals and key practices to be implemented in order to reach a certain level
Assessment	Either qualitative (e.g., interviews) or quantitative approaches (e.g., questionnaires with Likert scales) may be used to pursue a maturity assessment

(de Bruin & Rosemann, 2005)—has led to a certain arbitrariness and negligence with respect to the development or design process of MMs (Becker et al., 2009; Mettler & Rohner, 2009). In addressing this grievance, de Bruin et al. suggest a MM lifecycle model that consists of six phases: scope, design, populate, test, deploy, and maintain (de Bruin & Rosemann). Regarding the design phase in particular, Mettler and Rohner further suggest a top-down and a bottom-up approach. While the top-down approach specifies that levels be defined first and thereafter completed with characteristics that describe the different dimensions, the bottom-up approach prescribes that dimensions and characteristics be derived first and then assigned to different maturity levels. Several methods have been proposed for the derivation of characteristics, dimensions, and levels. The most frequently mentioned qualitative methods are literature analysis, Delphi studies, case studies, expert interviews, and focus groups (Becker et al.; de Bruin & Rosemann). Quantitative methods are used less often, as they require a theoretical foundation, and many existing MMs lack a theoretical foundation (Lahrmann, Marx, Winter, & Wortmann, 2011). However, an explicated theoretical foundation—that is, a rigorous derivation of the underlying maturity concept—serves to deepen the understanding of the relationships and mutual impacts between parts of the model and should be carefully considered.

The next section presents the conceptualisation of maturity that builds the theoretical foundation of our PPM CMM.

2.3 Conceptualising PPM Maturity

Soanes and Stevenson define maturity as a “state of being complete, perfect, or ready” or the “fullness of development” (Soanes & Stevenson, 2008, p. 906). We argue that depicting this appreciation of maturity in MMs requires not only the consideration of causes (such as, in this context, “processes have defined process owners”) but also that of effects (such as, in this context, “process flows are consistent and transparent beyond functional borders”). MMs that contain only effects do not provide guidance on how to improve the object whose maturity is to be measured, whereas MMs that incorporate only causes do not offer insights into the impact that is to be achieved. Building on this argumentation, we deploy IS success models and their underlying theory to conceptualise our MM (DeLone & McLean, 2003; Gable, Sedera, & Chan, 2008; Petter, DeLone, & McLean, 2008). In so doing, we intend to complement the relevance of MMs with the rigour of theory.

The purpose of IS success models is to explain which variables or components (causes) positively affect IS success (effect). IS success is conceptualized as being based on “IS use”—that is, the intention to use, as well as the actual use, which drives “IS impact,” or the ultimate IS net benefits. “IS use” itself is influenced by “IS deployment,” or the quality of the IS system deployed. According

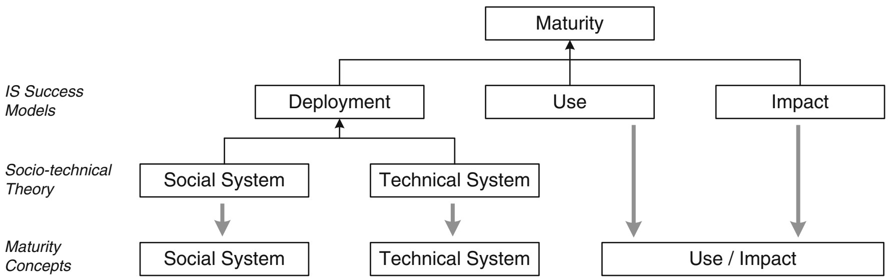

Fig. 1 Concepts that represent maturity

to socio-technical theory (Bostrom & Heinen, 1977) (STT) "IS deployment" may be understood as a compound of different pieces of information technology (IT) and as an interplay of IT, people, methodological capabilities, and organisational practices. STT postulates that the social and the technical subsystems of an IS are interdependent and that they should work with each other in order to maximise the system's benefits.

In line with common research practice (e.g. Gable et al., 2008), our analysis focuses on the causes of IS success, rather than on the success itself, so we collapse "IS use" and "IS impact" into one concept. Thus, the conceptual basis for our MM is formed by the three concepts: "social system", "technical system", and "use/ impact" (cf. Fig. 1).

Having outlined the conceptual focus of our MM, we proceed with the domain focus and scope of the content we chose. PPM whose maturity we aim to measure has been defined as the bipartite approach of process performance measurement—in other words, the planned monitoring of process execution and logging of results to determine the effectiveness and efficiency of a process—and improvement—i.e., the use of this information to make improvement decisions in line with the strategic objectives of the organisation (cf. Sect. 2.1). Elbashir, Collier, and Davern (2008) propose that effectively and sustainably managing performance on a process level requires bringing together BPM and business intelligence (BI) capabilities and techniques. Therefore, we propose that, in order to capture and depict PPM maturity comprehensively, we must use a compound of three dimensions: BPM as the business-related foundation for PPM, BI as the information-technological basis or enabler of PPM, and PPM itself to cover process-specific measurement and improvement capabilities.

In developing the questionnaire, we built upon the two outlined perspectives. On the one hand our work was guided by the conceptual results we derived from the IS success model and SST ("social system", "technical system", "use/impact"). On the other hand we brought together key insights from the BPM, BI and PPM domain. Table 2 shows the references that were used for the questionnaire development.

The next section introduces the research methodology employed and describes the data collection and analysis.

Table 2 References for questionnaire development

Source	Conceptual focus			Domain focus		
	Socio	Tech.	Use/imp.	BPM	PPM	BI
(Bandara et al., 2007), (Paim, Caulliraux, & Cardoso, 2008)	x			x		
(Alibabaei, Bandara, & Aghdasi, 2009)			x	x		
(Elbashir et al., 2008)	x				x	
(Ko, Lee, & Lee, 2009), (Mutschler, Reichert, & Bumiller, 2008)		X			x	
(Elbashir et al., 2008), (Kueng, 2000)			x		x	
(Davenport, 2010), (Wixom & Watson, 2010)	x					x
(Watson, 2009)		X				x
(Williams & Williams, 2007), (Gibson, Arnott, & Jagielska, 2004), (Lönnqvist & Pirttiäki, 2006)			x			x

3 Research Methodology

3.1 Using the Rasch Algorithm for MM Development

The Rasch algorithm has proven a viable approach to building empirically grounded MMs (Dekleva & Drehmer, 1997). By counting the answers that indicate the presence of capabilities, the algorithm calculates two scores: one for the difficulty of items and one for the ability of the surveyed entities. Both scores are measured on the same interval scale.[1]

In the context of MM construction, the measurement of item difficulty supports the inductive allocation of items onto maturity levels, and the capability of participants supports the assessment of organisations. In order to tailor the Rasch algorithm for MM development, the basic model has been modified slightly in three areas: (1) Because rating scales have a stronger expressive power, five-tired Likert scales are employed instead of the originally proposed dichotomous scales. (2) A MM helps its users determine where to improve their capabilities, so both current and desired degrees of realisation per item and per organisation are surveyed and analysed. The difficulty of an item for an organisation is then determined by the delta value, where a high positive gap expresses a difficult and desired item, and negative gaps and values on the threshold represent easy items. (3) The Rasch algorithm yields only a single ordinal scale that represents the logit measure of each item and organisation, but not distinct maturity levels. In order to overcome subjectivity in defining maturity levels, a cluster analysis based on the item logits is

[1] Details of the mathematical and conceptual foundations of the dichotomous Rasch model can be found in (Rasch, 1980).

performed. The purpose of clustering is the “unsupervised classification of patterns (observations, data items, or feature vectors) into groups (clusters)” (Jain, Murty, & Flynn, 1999, p. 264). Since most MMs use five maturity levels (Becker, Niehaves, Pöppelbuß, & Simons, 2010), the anticipated number of clusters is set to five.

3.2 Data Collection

The data was collected using a written questionnaire that was distributed at a practitioner event on BI and business analytics held in October 2009. The participants were specialists and executives working as performance analysts, business developers, controllers, and BI specialists on both the business and the IT side, so they had the knowledge and information required to answer the questions (Czaja & Blair, 1996). The questionnaire was designed to assess both the current and the future desired state of PPM in the participating organisations. The selection of items was guided by the relevant literature in BPM, performance management, and BI, as described in the preceding chapter. The first version of the questionnaire was pretested with regard to wording, coherency, and ease of interpretation with three academics with adequate expertise, and the instrument was revised according to their feedback. Before being distributed, the questionnaire was pre-tested again with three practitioners with regard to consistency, understandability, and adequacy of item sequence. The final questionnaire presented 40 items that relate to the research phenomenon PPM.

Respondents were asked to indicate the current and the desired degree of realisation in their organisations for each of the 40 items using a five-tiered Likert scale. Forty-nine questionnaires representing 49 different organisations were returned. The surveyed organisations are primarily large and medium-sized companies from the German-speaking countries. Sixty percent have more than 1,000 employees, and another 22% have more than 100 employees. The main sectors represented were professional services (40%); banking, finance and insurance (29%); high tech (11%); manufacturing and consumer goods (7%); media and telecommunication (5%); and others (8%).

3.3 Data Analysis

The BIGSTEPS software, Version 2.82 (Linacre & Wright, 1998) was used to obtain the Rasch item calibration. Important output statistics are the measure of difficulty, the standard error, and a set of standardized fit statistics (infit and outfit) for each item. Infit is sensitive to unexpected behaviour affecting responses to items that indicate capabilities near the organisation’s ability level. Infit is approximately normally distributed with an expectation of zero and a standard deviation of one. Outfit is sensitive to unexpected behaviour by organisations on items that indicate capabilities far from the organisation's ability level. It is also approximately normally distributed. If the data conforms to the model, infits and outfits greater than 2 should not occur in more than 5% of the items (Dekleva & Drehmer, 1997). Our data set meets this quality criterion. Table 3 show the results of applying the Rasch algorithm ordered by the levels achieved by means of the subsequent cluster analysis.

The next section explains the deduction of the MM and introduces the model.

Table 3 Results of applying the Rasch algorithm ordered level (cluster)

Meas.	Error	Infit	Outfit	Level	Item
1.06	0.37	−1.91	0.56	5	PPM is part of the Corporate Performance Management (CPM)
1.35	0.37	0.50	0.9	5	PPM is deployed for all processes of the organisation
0.57	0.3	0.70	1.06	4	Defined BI governance responsibilities and processes are in place
0.70	0.35	1.89	1.68	4	A central integrated database is in place (e.g., an Enterprise Data Warehouse [DWH])
0.70	0.35	−1.07	0.73	4	Processes have defined process owners
0.57	0.35	−0.8	0.76	4	BI systems, such as dashboards, are used for the presentation of process performance indicators
0.57	0.35	−2.44	1.06	4	Cycle time is measured for processes
0.70	0.35	−0.67	0.83	4	Process costs are measured for processes
0.82	0.36	−0.41	0.86	4	Quality is measured for processes
0.57	0.35	−0.92	0.81	4	Resource utilisation is measured for processes
0.57	0.35	0.96	1.11	4	PPM is deployed for production processes
0.57	0.35	1.42	1.12	4	PPM is deployed for other administration processes (e.g., HR)
0.20	0.35	0.26	0.91	3	Defined BI deployment and use processes are in place
0.20	0.35	0.53	0.99	3	A defined BI architecture with distinct guidelines (standards and principles) is in place
0.08	0.35	0.91	1.06	3	The embedding of BI into operational processes is appropriate
0.08	0.35	−1.09	0.78	3	The use of information takes place across all organisational units
0.45	0.35	−2.22	0.61	3	Process flows are consistent and transparent beyond system borders
0.35	0.35	0.84	1.15	3	PPM is centrally coordinated and implemented
0.33	0.35	1.26	1.08	3	A central data warehouse is used for analytically editing process performance indicators
0.20	0.35	−1.75	0.68	3	Operating rates are measured for processes
0.33	0.35	−0.67	0.97	3	Adherence to schedules is measured for processes
0.80	0.35	0.55	0.96	3	PPM is deployed for accounting processes
−0.17	0.36	0.30	1.09	3	Data quality is consistently high
−0.70	0.38	−0.92	0.70	2	The system performance and availability that is provided meets the factual requirements
−0.43	0.36	0.17	0.91	2	The supply of information from corporate management through BI is appropriate

(continued)

Table 3 (continued)

Meas.	Error	Infit	Outfit	Level	Item
−0.17	0.36	−0.87	0.73	2	The supply of information from middle management through BI is appropriate
−0.17	0.36	0.35	1.04	2	An organisational unit is specifically responsible for the strategic management of business processes (e.g., decisions on standards and tools and/or the organisational integration of BPM)
−0.04	0.35	−0.31	0.84	2	Processes are consistently documented and/or modelled
−0.04	0.35	−1.23	0.79	2	Process flows are consistent and transparent beyond functional borders (organisational units, divisions, departments)
−0.25	0.37	0.97	1.19	2	PPM lies within the responsibility of the process owners
−0.04	0.35	−1.07	0.72	2	PPM is deployed for sales processes
−0.64	0.39	1.19	1.23	2	PPM is utilised to improve cross-functional cooperation
−0.09	0.37	1.65	1.24	2	PPM is utilised to avoid local performance optima
−1.29	0.42	−0.91	0.60	1	Timely provision of information is ensured
−1.00	0.39	1.78	1.71	1	Process orientation is a central paradigm
−1.12	0.40	−1.53	0.51	1	Process owners have sufficient decision-making authority to take on process design and process execution control
−1.69	0.45	−0.58	0.86	1	Source systems for process data are transactional systems (e.g., ERP, CRM, SCM)
−1.00	0.39	0.09	1.09	1	PPM is deployed for the core processes of the organisation
−1.24	0.42	1.22	1.62	1	PPM is utilised for periodic process analysis and continuous improvement (ex post)
−1.01	0.40	1.11	1.54	1	PPM is utilised for planning, such as planning for capacities (ex ante)

4 Deriving a CMM for PPM

The CMM is built based on the results of the Rasch algorithm and the succeeding cluster analysis. Along the dimensions that form the theoretical and domain-related basis of our maturity concept, the items are assigned to the levels as they were determined by applying the algorithms. Table 4 shows the resulting impact-oriented PPM CMM.

Various terms have been used in prior MM development efforts to describe the distinct levels of maturity that can be achieved. The well-known Capability Maturity Model Integration (CMMI) developed at Carnegie Mellon contains five maturity levels termed “Initial”, “Managed”, “Defined”, “Quantitatively Managed”, and “Optimizing” (Chrissis et al., 2007). The BI MM proposed by The Data Warehouse Institute (TDWI) offers six maturity levels labelled “Prenatal”, “Infant”, “Child”, “Teenager”, “Adult”, and “Sage” (Eckerson, 2010). In denominating the levels of the model proposed here, we adopt the levels of the BI MM, leaving out the “Prenatal” level.

Level 1 of the PPM CMM, titled “PPM Infant”, is characterised by a corporate-wide commitment to BPM and the intention to adopt process orientation as a central

Table 4 PPM CMM

		Level 1 PPM infant	Level 2 PPM child	Level 3 PPM teenager	Level 4 PPM adult	Level 5 PPM sage
Socio	BPM	Empowered process owners	Central coordination		Clear ownership	
	PPM		Empowered process owners	Central coordination		PPM is part of CPM
	BI			Standardised systems and processes	Defined governance	
Technical	PPM	Transactional sources		DWH-based integration	BI-based presentation	
	BI	Low latency in infrastructure	High-quality infrastructure		Central DWH	
Use/Impact	BPM		Cross-functional integration	Cross-system integration		
	PPM	Core processes	Sales processes	Accounting processes	Production and administrative processes	All processes
		Ex post and ex ante analyses	Cross-functional integration			
				Fundamental KPI set	Advanced KPI set	
	BI		Selected management	All staff		

paradigm. The existing organisational structure is enriched when the process owners are assigned adequate decision-making authority to accomplish process (re-)designs. From a technical point of view, the BI infrastructure is sufficiently mature as to ensure a timely provision of analytical data. However, source systems for process monitoring and controlling are mainly transactional at this stage and have not yet been properly integrated. In the infant stage of PPM maturity, the scope of process performance measurement is limited to the organisation's core processes, which are primarily measured for improvement (ex post) and planning (ex ante) purposes.

Organisations at level 2, called "PPM Child", have an organisational unit in place that is dedicated to the strategic management and central coordination of business processes. This unit determines the standards, tools, mechanisms, and techniques to be used to integrate and anchor process orientation in the organisation. The selection of adequate instruments and frameworks is guided by the overall business strategy, so it is fully aligned with the organisation's strategic objectives. At level 2 the functional scope for process owners is extended, as they are entrusted with the full responsibility for PPM tasks. Consequently, at level 2 they become fully accountable not only for the initial design but also for the continuous measurement and improvement of the processes they own. The BI infrastructure at this level is of consistently high quality as it relates to both data and system performance. The centralisation of BPM coordination and the availability of a high-quality BI infrastructure support the reliable integration of processes across organisational functions. Moreover, the broadened use of process performance data facilitates cross-functional cooperation and avoids local performance optima. The scope of process performance analyses is extended to cover not only core processes but also sales processes, and results of the analyses are used for decision making by middle and upper management.

When they reach level 3, termed "PPM Teenager", organisations have centralised the PPM function and have put into effect both standardised BI deployment routines and a defined BI architecture. A DWH is in place for the diagnostic analysis and enrichment of process performance indicators. Enhanced system integration enables process consistency across functional and system borders, allowing for the continuous measurement of processes from one end to the other. A fundamental set of process-related key performance indicators (KPIs), including operation rates and adherence to schedule, has been defined and is continuously measured. Finally, the integration of BI into operational processes makes process performance data available to all staff levels.

Level 4 of the PPM CMM, named "PPM Adult", is characterised by a further manifestation of the process paradigm in which process ownerships have become prevalent. At this stage, process ownership is not just a role but an established organisational entity with significant authority. The existing BI landscape has further matured and is now supplemented by a set of defined governance guidelines. The technical capabilities have improved so as to enable a BI-based presentation of process performance data on dashboards. All transactional data, including process data, that is meant to be analysed by means of the acquired BI capabilities is integrated in one enterprise DWH, and decision makers employ an advanced set of KPIs for process performance measurement. This set of indicators, which includes KPIs like cycle time, process quality, process costs, and resource utilisation, enables the organisation to monitor and control its performance actively as it relates to process results but particularly to process execution.

Attaining the highest level of PPM maturity, the level termed “PPM Sage” aligns and integrates PPM initiatives with the CPM approach so as to directly reflect the overall organisational goals and translate them into immediate action. At this stage, process performance measurement and improvement are established over the entire landscape of the organisation’s processes, facilitating a comprehensive assessment of overall operational performance.

The next section discusses the application of PPM and the proposed CMM to support the measurement and management of corporate sustainability.

5 PPM as an Enabler of Corporate Sustainability

In striving for sustainability, organisations search for the “sweet spot” of sustainability in which injurious social and environmental impacts are minimized while an adequate rate of return is preserved (Nguyen & Slater, 2010). Establishing and maintaining this balance is a key challenge for organisations (Hessami, Hus, & Jahankhani, 2009, p. 76). The sustainable development or macro-level of sustainability defines the context in which organisations follow the “process of creating, testing, and maintaining opportunity” (Holling, 2001, p. 390). Uncontrollable factors like uncertainty, rapid environmental changes, and a high degree of complexity (Hessami et al.) affect an organisation’s ability to foster its adaptive capabilities and create opportunities, just as external influences like legal and societal requirements do (Baumgartner & Ebner, 2010). To conceptualise and realise corporate sustainability, a company must derive a “consensus on what to sustain” (Wikström, 2010, p. 100), analyse external and internal influences, and decide what steps to take and for how long. Figure 2, which provides an overview of the components of and influences on corporate sustainability, shows that, in order to assess TBL performance comprehensively, each of its dimensions should be measured.

How does PPM contribute to achieving sustainability? The answer, according to Nguyen and her colleague, is that for sustainability holds true what is valid for any other business initiative, “If you can’t measure it, you can’t manage it” (Nguyen & Slater, 2010, p. 10). Traditional performance management approaches tend to overemphasize the measurement of outcomes (e.g., profitability, liquidity, and solvency ratios) at the expense of execution quality. The same applies for sustainability management approaches: Pojasek states that many organisations still believe that measuring sustainability results provides “a strong indication of [. . .] sustainability performance” (Pojasek, 2009, p. 78). However, in order to measure both sustainability and performance in an immediate and direct way,

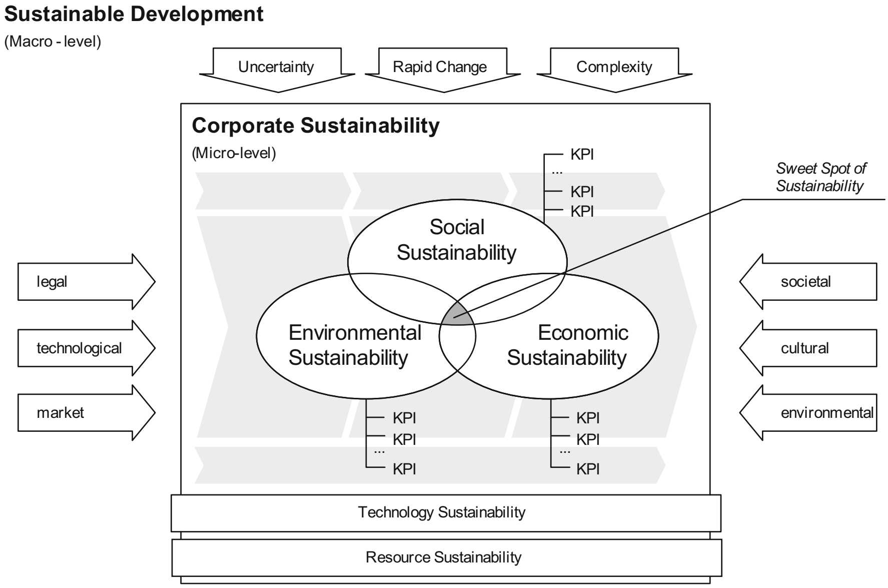

Fig. 2 The concept of sustainability (Based on Baumgartner & Ebner, 2010; Hessami et al., 2009; Nguyen & Slater, 2010)

measurement must not be limited to *process results* but should also—and in particular—focus on the effectiveness, efficiency and quality of *process execution* itself.

The PPM CMM introduced in this chapter is a valuable instrument with which to take the first step in this direction. It identifies the necessary organisational and technical competencies for establishing a sound process-based sustainability management approach. Besides the organisational (e.g., central coordination of PPM issues, level 3) and technical (e.g., DWH-based integration, level 3) prerequisites, the model illuminates the resulting capabilities that manifest in a positive business impact (e.g., use of fundamental set of KPIs available to all staff, level 3). In order to build sustainability into the proposed model, the model must be enriched with a set of KPIs that reflect all three aspects of the TBL. Of these three aspects, the economic dimension—often termed the baseline of corporate sustainability (Wikström, 2010)—is the most widely discussed. Aiming at sustainable profits, high productivity, and long-term business growth, the economic dimension is seen as a prerequisite of "focus on environmental and social issues" (Isaksson, 2006, p. 632). Several renowned IS researchers also advocate integrating sustainability measures into daily operations and innovating IT in order to support the sustainable conduct of business. Melville (2010) suggests a set of environmental data sources and metrics that support the assessment of an organisation's impact on the natural environment, while Elliot (2011) complements existing research by illuminating the main environmental challenges and suggesting the adoption of a multi-perspective approach to measuring sustainability.

In practice, too, increased efforts are put into measuring and improving sustainability performance. One prominent organisation that has committed to a rigorous measurement of sustainability performance is SAP. Their sustainability report (SAP, 2011) discloses their economic performance—measured through revenue, operating margin, and customer satisfaction—and their social performance—measured through employee turnover, employee health, employee engagement, and the percentage of women in top management. Environmental sustainability is assessed using the KPIs greenhouse gas footprint, total energy consumed, percentage of renewable energy, and data center energy. These metrics may serve as first examples to be integrated into the model proposed here.

6 Conclusion and Future Work

MMs have become an established means in the IS community to document capabilities systematically and guide organisations in their efforts to improve them. This chapter proposes a theoretically founded MM for assessing and evaluating competencies in the field of PPM. Our theoretical understanding of maturity embraces technical and social competencies that are required for the deployment of PPM, as well as the effects of a good deployment in terms of resulting business impacts. Because the model incorporates both causes and effects, it is expected to find broad practitioner approval.

Compared to MM development processes described elsewhere (e.g. Becker et al., 2009; de Bruin & Rosemann, 2005), the combined approach of behavioural and design research methods applied in developing the MM proposed here is unconventional and innovative. In particular, this approach avoids the arbitrariness in assigning capabilities to different maturity levels that is inherent in other development methods. The study will be of interest to other researchers engaged in the field of MM development, and we look forward to further lively discussion and progression in all directions of study.

We consider PPM a powerful concept for use in breaking the sustainability challenge into a set of manageable tasks that can be straightforwardly implemented, controlled, and continuously improved. It is our hope that our MM will support organisations in evaluating their current capabilities and identifying the competencies they must develop in order to improve. However, in its present form, our model provides only suggestions on necessary organisational and technical capabilities for incorporating sustainability into an organisation's day-to-day business. In order to cover all three aspects of the TBL comprehensively, the model will have to be enriched with KPIs that directly measure economic, ecological, and social performance on a process level. Therefore, while the proposed model does provide answers to the question of *how* to measure and manage sustainability, it does not emphasize *what* exactly needs to be controlled. Measurement frameworks suggesting effective metrics are thus discussed in detail the following chapter.

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Measurement Systems for Sustainability

Evaluation and Extension of Common Measurement Systems with Regard to Sustainability

Nicole Zeise, Marco Link, and Erich Ortner

Abstract To control the performance of companies in a sustainable way, it is necessary, in a first step, to clarify the fundamental dimensions of sustainability. In the next step, this paper aims at deriving criteria to examine common performance measurement systems –PMS– whether they are suitable to measure performance of companies with regard to sustainability. According to these criteria, selected potential method extensions are evaluated in order to integrate sustainability into the performance measurement systems and management systems.

1 Introduction

The term sustainability is often used in several contexts, including marketing phrases, generational justice and concerning business goals. The term is relative to the focused scope: from targeting a global environmental sustainability through to taking a local view with regards to a certain organization, a wide range of companies are, in most cases, mainly driven by the economical aspect; they are concerned with their own sustainability (generating profits and reinvesting them into the company). Other forces, such as governmental regulations or market pressures, are able to expand the sustainability scope of single organizations. To cover and to manage such internal and external requirements concerning sustainability, specific instruments are needed. It is obvious to take systems which measure a company's performance into consideration. The question is: "Is it possible to use existing PMS to integrate sustainability and what are the main features to improve them concerning the topic sustainability?"

This paper is discussing a selection of measurement systems and methods which can, with regard to their ability, manage a company in a sustainable way. Section 2

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shows underlying assumptions concerning the concept “sustainability”, an entrepreneurial framework and the concept “PMS”. The next Sect. 3 defines evaluation criteria’s, with which in Sect. 4 selected PMS were conducted. To sum up, Sect. 5 sets the evaluation within the overall context and presents a final outlook.

2 Fundamentals of Measuring Sustainability

2.1 The Concept Sustainability

Sustainability is currently regarded within various contexts and discussed controversially. There are a great number of concepts and definitions of sustainability. The following three aspects have become widely accepted as the main dimensions of examination, also in the context of the key term “Triple Bottom Line” (cf. Fauzi, Svensson, & Rahman, 2010):

- Environmental sustainability,
- Social sustainability and
- Economic sustainability.

Some approaches add further ideas to these aspects, e.g. those presented by Herzig, Kleiber, Klinke, Müller, and Schaltegger (2007) or Jörissen, Kopfmüller, Brandl, and Paetau (1999). Key terms and ideas which are being widely used include, among others, “Corporate Social Performance” (Fauzi et al., 2010) or “Corporate Social Responsibility” (EG Commission, 2001), the latter often being considered a synonym of the former. These concepts describe responsible entrepreneurship that goes beyond legal obligations. The United Nations World Commission on Environment and Development defines the term “sustainable development” as follows: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UN World Commission on Environment and Development, 2010).

Organizations as part of the economic system aim to create value and to satisfy needs through the production of goods or through services. The superior function of the economy is permitting the use of scarce goods at the lowest possible cost through the highest possible value creation (Deutscher Bundestag, 1998). The available resources of manpower and natural productivity are to be employed in such a way that the best possible provision of the population with goods and services can be achieved. All existing production factors shall be directed towards their most productive use (Deutscher Bundestag). But taking into account, that there are successful companies from industries such as the tobacco, liquor or arms industries it can be asserted that sustainability as we understand it today does not seem to warrant long-term entrepreneurial success.

Thereby the time scale of sustainability has so far been rarely discussed, even though we assume that “sustainability” will often be as associated with the passing of time. Assessments of sustainability will change by changing the time period also with regard to intergenerational justice. So it has to be clarified how many years and how many generations the time scale should concern (cf. Bell & Morse, 2010).

2.2 Entrepreneurial Framework

Looking at businesses with regard to sustainability, numerous aspects play an important role. Some of these aspects will, in this paper, also be used as structuring features. In principle, we can differentiate between an internal and an external business perspective. Internally, as shown course-granularly in Fig. 1, management control systems use a number of different controlling tools. These tools are interrelated with strategic and operative business actions as well as with external stakeholders and the obligations that arise from their demands on the organization.

In the information systems sector, a tool is defined as an implemented method which comprises a language together with a certain procedure (Lehmann, 1999).

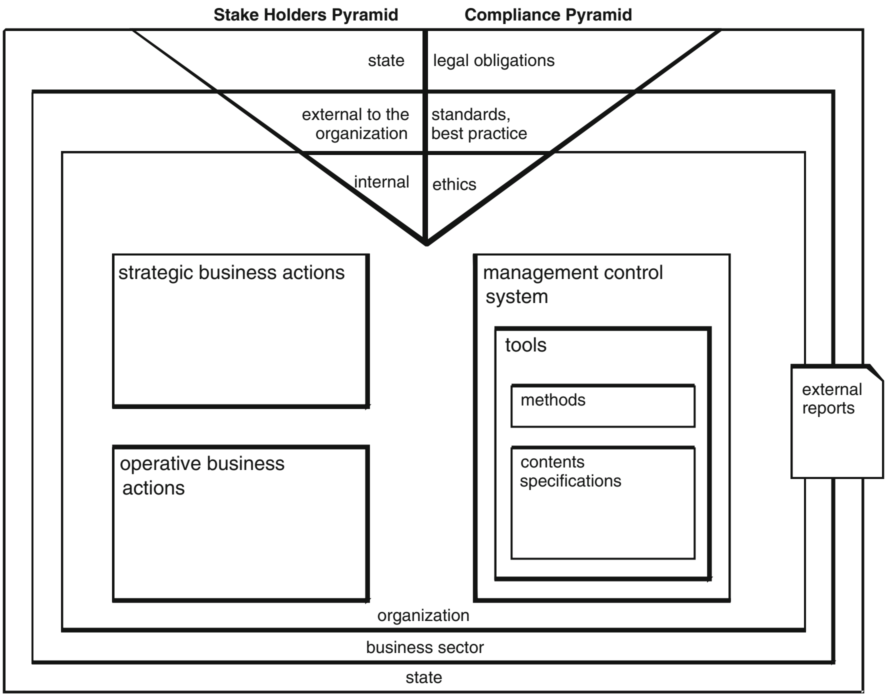

Fig. 1 Organizational relations and obligations

Additionally, to be able to use such a method, specific contents are needed, which can in turn be deduced from content specifications or content standards.

The external business perspective as shown in Fig. 1 is characterized by a stakeholders and compliance pyramid (cf. Behringer, 2010). Stakeholders could be internal (e.g. employees) or external (e.g. customers, suppliers, shareholders) target groups as well as a national state. The latter is represented by legal and other obligations which businesses must heed (e.g. accounting regulations). So-called best practices or standards within certain business sectors are not binding obligations, but may have to be complied with when stakeholders (like major customers) pressure an organization to do so. In the compliance pyramid, the ethics aspect has less influence on a business as it represents voluntary actions.

In the course of this paper, we will narrow these general ideas down to the sustainability approach as defined above. Legal obligations could concern reduction on CO_2 emissions, for instance, which are, on a national level, made more flexible through emission trading schemes. Following the objectives of the Kyoto Protocol, these reduction obligations were codified into German law according to the EU Directive 2003/87/EC (The European Parliament and the Council of the European Union, 2009).

2.3 Performance Measurement System (PMS) Basics

Performance measurement systems represent a form of management and control tool to support the decision-making process and form the basis of the communication on the decisions thus made (Amaratunga & Baldry, 2002). They are models which describe activities and outputs as well as their correlations, using indicators that focus on the various stakeholders (Neely, Gregory, & Platts, 1995). PMS can either be available in a standardised form through pre-defined systems of indicators (e.g. ROI), or as management systems with indicators specifically developed to meet the organization's needs (e.g. balanced scorecard) (Ghalayini & Noble, 1996).

> In order for an organization to make effective use of its performance measurement outcomes, it must be able to make the transition from measurement to management (Amaratunga & Baldry, 2002).

Thereby the differentiation between management and measurement systems leads to holistic discussions of advantages and disadvantages of these systems (Ghalayini & Noble, 1996), which should not be discussed within this paper. Traditional performance measures comprise operative elements such as profit or loss, and net current assets. Although concrete measurements systems and their implementation within a business have a very strong, traditionally economic basis (Gates & Germain, 2010), both types of indicators – monetary and non-monetary – are suitable to measure performance of a company. Performance potential measures stands for strategic results like creating or securing success potentials (Prammer, 2010).

Performance measurement systems provide indicators related by cause and effect chains, which are separated into key performance indicators and key result indicators (Parmenter, 2010). They are also called outcome measures and measures which drive future performance (Kaplan & Norton, 2009).

> To enable dynamic reactions, both forms of indicators and forms of control are important. Result–indicators to help to learn about past performance (feedback loops) and performance-indicators are useful to feed-forward loops. (Zeise, Link, & Ortner, 2010)

To establish performance management on the basis of performance measurement it becomes necessary to provide a framework to act in the sense of continuous improvement (Amaratunga & Baldry, 2002; Neely, 2002). With this regard many management systems were developed in the last years (e.g. EFQM, Quality Management, and Balanced Scorecard). They provide a set of guidelines to implement these systems in a way which leads a company to continuous improvement of strategy, processes and structures.

3 Evaluation Criteria for PMS in the Sustainability Context

In order to display and measure sustainable development and to audit objectives, performance and performance potential of a business have to be evaluated with regard to the basic sustainability aspects. Therefore combination of the fundamentals on sustainability, the entrepreneur framework and PMS of Sect. 2, lead us to the following criteria. These criteria make no claim to be complete, but primarily serve the analysis in this paper.

The three widely accepted dimensions of sustainability (as showed in Sect. 1) should be regarded by each respective PMS (Table 1: criteria 1.1, 1.2, 1.3). Additionally the interdependences between the three dimensions of sustainability play an important role to act sustainable. Economic success is on one hand a requirement to implement environmental and social actions and on the other hand the implementation of environmental and social actions can gain additional economic success (Schaltegger & Synnestvedt, 2002) which should be measured. Bell discusses this integrating aspect according to two forms of choosing sustainable actions (by considering economical aspects "weak sustainability" and by non considering economical aspects "strong sustainability") (Bell & Morse, 2010). Additionally, Ingebrigtsen and Jakobsen (2006) discuss this integrating aspect with regard to "a change in paradigm, from a mechanistic to an organic world

Table 1 Criteria to evaluate aspects regarding the analysis of sustainability

Number	Criteria description
1.1	Economy issues
1.2	Environmental issues
1.3	Social issues
1.4	Correlations of these dimensions

view”. Therefore we have chosen the description of the correlations of the different dimensions as another criterion to evaluate the PMS (Table 1: criterion 1.4), if it is suitable to measure sustainable performance.

Regarding the fact that sustainability is discussed in economical and political contexts (EG Commission, 2001; Jörissen et al., 1999; UN World Commission on Environment and Development, 2010), our idea is that to act sustainable, rules and guidelines (Hardi & Zdan, 1997; Jörissen et al.) should be given to any company to implement sustainability. Therefore the PMS to measure sustainability should contain details and definitions of the concept sustainability in form of guidelines, goals and indicators (Table 2: criterion 2.1). Such details and definitions could be specified in general or more detailed with regard to a specified business sector (Table 2: criterion 2.2). With regard to comparability between several companies by indicators (benchmark) the calculation schema of the indicators should be presented by the PMS (Table 2: criterion 2.3).

To support analyses of indicator (values) to control the sustainable performance of a company, it is necessary to connect the measurement concepts or rather their underlying systems with the different processes of a company and the company’s strategy (see Sect. 2.3). Therefore, the above criteria describe the connect ability of definable objectives and business procedures. By connecting indicators and business processes, target/actual analyses can be approached through operational management actions (Table 3: criterion 2.1). In addition, it may be necessary to look at measurable performance from the viewpoint of different stakeholders (Epstein, 2006) (Table 3: criterion 2.2).

The application of the ideas described above can –as shown in Sect. 2– be motivated by different general conditions. The first criterion (Table 4: criterion 2.1)

Table 2 Criteria to evaluate content specifications and standards for sustainability objectives and sustainability indicators

Number	Criteria description
2.1	Specifications for standard goals and indicators
2.2	Specifications for goals and indicators within a specific business sector
2.3	Rules to calculate indicators – benchmarking opportunities (comparability with other companies)

Table 3 Criteria to evaluate interaction and connectivity requirements

Number	Criteria description
3.1	Definitions of goals as a function of business procedures and strategies
3.2	Description of performance from the perspective of different stakeholders

Table 4 Criteria to evaluate the level of compliance

Number	Criteria description
4.1	Implementation because of voluntary or external (non-legally binding) pressure
4.2	Fitness for the integration of legal obligations

Table 5 Criteria to evaluate the system type

Number	Criteria description
5.1	Procedural specifications (implementation)
5.2	Procedural specifications (improvement and advancement)

combines steps 2 and 3 of the compliance pyramid (best practice and ethics). While there is no legal obligation for the implementation of these concepts, involved parties within the value creation chain and other stakeholders can push an organization towards compliance. As in the case of emissions trading (The European Parliament and the Council of the European Union, 2009), a number of issues are legally obliging and should therefore –where applicable– be integrated into the measurement concepts. The second criterion describes the possibilities of this integration (Table 4: criterion 2.2).

To manage an organization by a performance measurement system it is important to have a framework which supports the organization by implementation as well as by improvement of the management system (as showed in Sect. 2.3). Therefore certain procedures can be defined which, on the one hand, make specifications about the implementation of a system (Table 5: criterion 2.1) and, on the other, make specifications about the improvement and advancement of these systems (Table 5: criterion 2.2).

For each concept and criterion, the evaluation is condensed to “fully applicable” (A), “partially applicable” (B), and “not applicable” (C). The sustainability measurement systems described in detail in the next section will be evaluated through the above given five sets of criteria.

4 Analysis and Evaluation of Selected Approaches for the Measurement of Sustainability

To examine specific sustainable performance measurement systems a database search was conducted. The search was performed with various combinations of key words: “performance measurement sustainability”, “performance management sustainability”, “sustainable indicator systems” and “measure sustainability”. This search leads to certain amplifications and redevelopments of PMS which specifically focus on sustainability. In the following sections we evaluate selected PMS distinguished by standardised systems with pre-defined indicators on one hand and management systems which focus on developing individual indicators to meet the organization’s needs on the other hand. This differentiation comes through relevant literature as shown in Sect. 2.3.

4.1 Standardised Systems with Pre-defined Indicators

4.1.1 GRI Framework

The Global Reporting Initiative (GRI) is an international network-based organization, initiated by investor groups, environmental organizations and other groups of public interest. The GRI offers a reporting framework on sustainability that companies can use on a voluntary basis (4.1, A).[1] Deutsche Börse, The Coca Cola Company or Royal Dutch Shell are among those companies that adopt the GRI Framework (GRI, 2011a).

In essence, the framework's guidelines comprise two parts: The first part offers an in-depth description of the principles of reporting, e.g. the scope and comprehensiveness as well as rules for the compilation of the report (5.1, A). The second part deals with the standards a sustainability report should comply with. This includes information about the business strategy and profile, about the management approach that has been chosen as well as about the performance indicators. The reporting framework as such contains goals and indicators (based on concrete evaluation rules), which are in turn described with respect to social, environmental, and economic sustainability (1.1, A; 1.2, A; 1.3, A; 2.1, A). However, the correlations between these dimensions are not explicitly described by cause-effect relations (1.4, B). There are guidelines for specific industries and countries, too, which address tailor-made issues in addition to the general guidelines (2.2, A) (cf. GRI, 2011b).

By means of extensive standardisation of the reports, companies are offered a tool which allows them to draw comparisons with other businesses (2.3, A). At the same time this standardisation hinders the integration of individual endeavours and definitions concerning sustainability because a general reporting frame is set. A reporting of measures as to the single objectives could be conducive to the addition of individual requirements on the internal management of sustainability in organizations (3.1, B). However, this does not constitute a method for the integration of legal obligations (4.2, C). In addition, the reporting only contains dimensions regarding sustainability, while dimensions that arise from demands made by certain stakeholders (e.g. customers, staff, procedures, etc.) are neglected. But these demands are implicitly taken into account by developing the report, through the inclusion of all stakeholders (3.2, B). The framework does not present a management approach on sustainability, but a reporting standard, which means that choosing procedures for the improvement and advancement of the framework is left to the company itself (5.2, C).

[1] The evaluation of the respective concept with regard to a specific evaluation criterion is given in brackets: (no. of criterion, evaluation), both defined in Sect. 2.1.

4.1.2 Composite Sustainable Development Index (CSDI) Approach

This approach that was introduced by Krajnc and Glavič (2005) describes a method to calculate a top key index with reference to sustainability. Here, all sustainability dimensions (1.1, A; 1.2, A; 1.3, A) are analysed by quantifying and normalising single indicators and combining them to sub-indexes. Interdependencies of, or correlations between the dimensions are not considered, though (1.4, C). The underlying indicators are extracted from other systems such as the GRI Framework (2.1, C; 2.2, C). This means that no rules are given about how to calculate the single indicators, but there are regulations on how to calculate the normalisation and aggregation so that inter-company comparability can be achieved (2.3, B). Basically the CSDI approach is a calculation method (3.1, C; 3.2, C) that describes procedures to determine a composite, business-specific sustainability indicator (5.1, A; 5.2, C). Such a method can be applied to compare companies (of a specific business sector) with regard to their sustainability (4.1, A; 4.2, C).

4.1.3 Extensions of Traditional Financial Calculation Schemes

Monetary indicators have been developed, based on the scientific fundament of business economics in general and of accounting and controlling in particular. These systems are characteristically one-dimensional, i.e. they include merely financial data in their analysis and condense the individual parameters to financial top key indicators. These serve an enterprise as a voluntary basis for the calculation of investors' financial demands (4.1, A), presenting financial objectives (3.2, B). Their functional orientation makes it difficult to integrate the measurement of more extensive legal demands (4.2, C).

For these systems there exist extensions for the measurement of sustainability, too, which shall be evaluated consecutively. Indicators of sustainability are added to the original indicator systems, but not with details about specific business sectors (2.1, A; 2.2, C). This one-dimensional perspective on sustainability enables an evaluation of the current situation in view of certain aspects in comparison with competitors. However, these systems assume that the sustainability criteria "environmental" and "society" can be financially quantified, which poses a great challenge for the systems' execution (Chousa & Castro, 2006) (2.3, B). In the financial literature, exist procedures for the implementation of the original systems; yet extensions to these systems base on scientific findings which means that concrete procedures for said extensions remain to be introduced (5.1, B; 5.2, C).

Figge and Hahn (2004) have developed the so-called *Sustainable Value Added (SVA)* approach, following the Economic Value Added approach. From the perspective of opportunity costs, the SVA approach considers environmental, economic, and social aspects of sustainability (1.1, A; 1.2, A; 1.3, A) (Figge & Hahn). This method offers a benchmark for the comparison and evaluation of different organizations. As an abstract method it is peculiar in so far as it takes efficiency criteria as well as effectiveness criteria (1.4, A) into account. Contrary to many other models, the SVA explicitly offers the possibility to calculate with quantifiable data and to compare these.

Chousa & Castro (2006) describes the process of integrating sustainability –with all relevant aspects– into traditional financial analysis (Integrating Sustainability into traditional Financial Analysis approach, ISFA, finally including a DuPont ratio scheme). To achieve this integration, a ratio analysis is selected. In view of sustainability, this comprises the well-known eco-efficiency and socio-efficiency indicators as a ratio of economic, environmental and socially sustainable indicators (1.1, A; 1.2, A; 1.3, A). Chousa aims at developing a tool with the help of which it is possible to represent all relations of sustainability (1.4, A). In order to achieve this, the author develops ratio indicators and correlations between these indicators from an accounting point of view. The results were presented as a pyramid, following the original DuPont pyramid.

4.2 Management Systems

4.2.1 EFQM Model

The European Foundation for Quality Management (EFQM) model offers organizations the possibility to conduct a self-evaluation –either on a voluntary basis or because of requirements set by a supplier– on their way to business excellence (4.1, A). Focussing on sustainability aspects, the model was chiefly developed by the Sustainable Excellence Group in cooperation with the Deutsche Bundesstiftung Umwelt. In the year 2003, large parts of these specifications to sustainability were incorporated into the European Foundation for Quality Management standard model (SEG & DBU, 2005).

The model's framework consists of nine major categories, which are distinguished between enablers and results (enablers: "Leadership", "Strategy", "People", "Partnerships & Resources", "Processes, Products and Services", results: "Customer results", "People results", "Society results" and "Key results"). These categories are aligned with the company's stakeholders and thereby represent business performance from their point of view (3.2, A). The very EFQM sees sustainable development as the model's central theme; there are, however, no explicit descriptions of the individual aspects of sustainability. In the EFQM model, concrete reference to important elements of sustainability can only be found implied in the major categories (cf. Albrecht, 2008; EFQM, 2011) (1.2, B; 1.3, B; 1.4, B). Merely the economic aspects of business performance are examined from a key result perspective (1.1, A).

The EFQM model presents a list of questions, with the help of which a self-evaluation according to its topics can be conducted. This means that sustainability objectives are only given implicitly (2.1, B). The list of questions is rather general and doesn't differentiate between individual business sectors (2.2, C). Neither do there exist any indicator lists. However, the EFQM model's perspectives are evaluated by means of the radar model –through a defined method– and therefore permit comparison with other companies (2.3, B). This means that goals and indicators are tailored to the organization, and are thus also aligned with the organization's system of procedures (3.1, A). In addition, this individuality facilitates the integration of various other demands (e.g. legal demands) (4.2, A). In general, with the help of this model a comparable basis can be established for different companies, which allows adjustments for the individual company, too.

As a management approach, the EFQM model contains, at the same time, procedures for the implementation as well as the improvement and advancement of the system (5.1, A; 5.2, A). These procedures don't explicitly focus on sustainability but are helpful for the development of the system as a whole (Zink, Kötter, Longmuß, & Thul, 2009).

4.2.2 ISO 14000 Environmental Management Standards

With the ISO 14000 family, the International Organization for Standardization (ISO) has developed management standards which companies can implement on a voluntary basis or when asked to do so by a supplier (4.1, A). The most important member of this family is the ISO 14000:2004 standard. In analogy to the ISO 9001 quality management standard, it formulates specifications for environmental management systems (cf. Edwards, 2004).

The environmental aspects of sustainability are the main focus of the ISO 14000 family (1.2, A). As the underlying system is a predefined procedural system, some economic aspects as well as the correlation of economy and environmental are also included (1.1, B; 1.3, C; 1.4, B). Similarly to the EFQM model, the ISO 14000 standard contains guidelines for a general management approach which defines procedural standards on the basis of general demands towards an organization (2.1, B). Here, too, no demands specific to certain business sectors are presented (2.2, C). Neither do there exist any indicator lists for the company to select from. The general specifications from the environmental field can be examined and adapted by the organization with respect to procedural specifics. Thereby it is possible to integrate wider legal obligations, too (4.2, A).

The environmental process model takes into account the demands from the company's various groups of stakeholders (3.2, A), but doesn't permit a comparison with other businesses as it lacks an evaluation method. The resulting measuring system is merely applicable to the individual company (2.3, C). As a management approach, this model contains, at the same time, procedures for the implementation as well as improvement and advancement of the system (5.1, A; 5.2, A).

4.2.3 BSC Extension to Meet Sustainability Demands

The original concept of the balanced scorecard (BSC) goes back to publications by Kaplan and Norton from the 1990s (Kaplan & Norton, 2009) and permits the implementation of entrepreneurial strategies (4.1, A). Already existing strategic goals of a company or organization form the basis of the BSC. In its initial form, the BSC comprises four perspectives (finance, customers, procedures, learning & innovation) that can be adapted or advanced to meet the specific demands of the company (3.2, A). Within each of the four perspectives, business strategies are specified by means of goals and indicators (3.1, A). Every organization can define their own set of goals and indicators, which means that the indicators are individually set yet not suitable for comparison (2.3, C). However, in the initial BSC concept there do exist basic remarks with respect to the compilation of goals and indicators as well as to the advancement and re-development of the system (5.1, A; 5.2, A).

As a modular system that can easily be adjusted to the specific requirements, the BSC is also suitable for the integration of more extensive legal demands (4.2, A) and regarding sustainability demands, too. Encompassing aspects of sustainability, however, poses a challenge for the BSC, because originally the model didn't contain a sustainability perspective. Therefore, compiling specific contents lies entirely in the hands of the individual company. As a result, we evaluate the approaches mentioned in all aspects of criterion 2 with C.

Because the concept permits such a liberal approach, adjustments with regard to sustainability vary greatly. Two BSC varieties which take sustainability into account will be described and evaluated in detail:

The most prominent feature about the *Sustainability Balanced Scorecard (SBSC)* (Engelhardt et al., 2006) is the fact that the original financial perspective is exchanged with the sustainability perspective. This means that the tree columns are not analysed individually but are regarded from a general point of view (1.1, B; 1.2, B; 1.3, B). Interrelations with the company's other objectives are described, while interrelations with sustainability objectives are not (1.4, B).

The *Sustainable and Systemic Balanced Scorecard (SSBSC)* (Ammon, Becke, Göllinger, Heupel, & Weber, 2002) incorporates not only financial but also environmental and sociological perspectives. The original perspectives –leading to the financial perspective– were adapted as the economic perspective. This means that the SSBSC generally caters for all sustainability aspects (1.1, A; 1.2, A; 1.3, A) and allows the description of interrelated individual goals (1.4, A).

4.3 Summary on Analysis and Evaluation of PMS

The following Fig. 2 presents an overview of the evaluation results of each individual system.

Nr.	criterion	GRI	CSDI	Extensions of traditional financial calculation schemes		EFQM	ISO14000	BSC extension	
				SVA	ISFA			SBSC	SSBSC
1	**Analysis of sustainability aspects through**								
1.1	economy issues	A	A	A	A	A	B	B	A
1.2	environmental issues	A	A	A	A	B	A	B	A
1.3	social issues	A	A	A	A	B	C	B	A
1.4	correlations of these dimensions	B	C	A	A	B	B	B	A
2	**Contents specifications and standards for sustainability objectives and sustainability indicators**								
2.1	specifications for standard goals and indicators	A	C	A	A	B	B	C	C
2.2	specifications for goals and indicators within a specific business sector	A	C	C	C	C	C	C	C
2.3	calculation rules for indicators - benchmarking opportunities	A	A	B	B	A	C	C	C
3	**Interaction and connecitivy requirements**								
3.1	definition of the objectives as a function of business procedures	B	C	C	C	A	A	A	A
3.2	stakeholders	B	C	B	B	A	A	A	A
4	**Level of compliance**								
4.1	implementation because of voluntary or non-legal pressure	A	A	A	A	A	A	A	A
4.2	fitness for the integration of legal obligations	C	C	C	C	A	A	B	B
5	**System type as regards the method**								
5.1	procedural specifications (implementation)	A	A	B	B	A	A	A	A
5.2	procedural specifications (improvement and advancement)	C	C	C	C	A	A	A	A

Fig. 2 Evaluation matrix

In general, the matrix shows that all systems –in their own manner– are suitable for the measurement of sustainability. Which measurement system needs to be chosen, depends strongly on the requirements of each individual organization. On one hand GRI Framework, CSDI and extensions of monetary indicator systems offer standardized systems or reporting frameworks, allowing the evaluation of individual sustainability aspects and of benchmarks. On the other hand management approaches such as the EFQM model, environmental management standards or sustainable BSC are of a more holistic nature, focussing on management of sustainability requirements.

EFQM model and environmental management systems provides factors of success of sustainability –even though these are not explicitly described in EFQM, and with focus on the ecologic factor in environmental management systems– these model define a frame of action towards sustainability, including general issues as well as concrete implementation issues. As an extra, the EFQM model also offers a framework for self-evaluation, presenting an evaluation standard and therefore permitting benchmarking. Within the GRI Framework, a concrete frame of measurements for sustainability exists through its definitions on sustainability. In contrast, the BSC extensions allow individual compilation of sustainability requirements, what leads to in-depth research activities in order to be able to define the company's frame of sustainability. Extensions of systems of monetary indicators form measurement tools, which hinder the compilation of a system of indicators simply because of the consistent monetary evaluation of sustainability aspects. But they do facilitate communication with shareholders.

By combining reporting frameworks (e.g. GRI) with managements systems (e.g. EFQM or BSC), more effective models for the implementation of and reporting on sustainability could be developed. Concrete demands on sustainability –with especially devised indicator systems– could be integrated into management systems, which would therefore gain a much better standing with respect to comparability and concreteness of contents. At the same time, indicator systems would be improved by concrete implementation guidelines and could reach another dimension with regard to the different stakeholder groups of an organization.

5 Conclusion, Limitations and Outlook

The debate on sustainability with its three dimensions –social, environmental and economic sustainability– is just emerging. The challenge is on the one hand, to set up feasible regulations that define tasks and obligations regarding economic sustainability in view of social and environmental sustainability, and on the other hand to present a frame of action like the ones established by Blazejczak and Edler (2004) or Grunwald, Kopfmüller, Grunwald and Kopfmüller (2006). These regulations focus on societies, states or national economies respectively. It is in this national economic context that sustainability needs to be examined (Stahlmann & Clausen, 2002), with the concrete perspective on the individual organization, too. Approaches that heed these requirements are presented, for instance, by the Global Reporting Initiative as well as –in the quality management sector– by the Sustainable Excellence Group.

On the whole, the research for the paper at hand has demonstrated that sustainability is currently discussed by a number of independent organizations (GRI, ISO, EFQM, etc.) and also on international and national levels. In order to compile requirements on sustainability and putting them into action globally, activities on a global scale are of central importance. These could create standards to ingrain the whole cosmos of sustainability in daily entrepreneurial tasks. Today, reporting on sustainability is largely voluntary still, apart from aspects that have already been regulated by law such as the emissions trading acts. To be able to practically establish sustainability objectives, it is essential to set up a frame of action with concrete requirements which encompasses all aspects of sustainability that are made compulsory for every enterprise. By means of sustainability reports –made obligatory by law– these could be established in business life similar to accounting standards. The road to sustainable development can only be paved when it has become legally binding for the economy to provide for all three aspects of sustainability: economy, environmental, and society.

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Energy Informatics: Initial Thoughts on Data and Process Management

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Abstract Energy Informatics is an emerging discipline concerned with using information systems to reduce energy consumption. The relationship between Energy Informatics and data and process management is examined. A new era of sensor network data is identified. Three aspects of business process management, case management, complex event processing, and key performance indicators are examined. The chapter shows how these three BPM technologies fit into an energy management systems general model.

1 A Long Partnership

Energy and information have long been the dual pillars of society. Darwin (2004) suggested that fire (a form of energy) and language (a form of information system) are the two most important human inventions. Information systems also have a binary basis. Information systems process data, and thus data and process management are core IS features. In this chapter, we examine the data and processing sides of Energy Informatics. First, we consider the partnership between energy and information. Then we introduce the Energy Informatics framework before considering the data and process management aspects of Energy Informatics (Fig. 1).

On the energy side, our use of fossil fuels took off with the Industrial Revolution, when mass industry emerged in Britain in the 1750s. Our ability to harness sources of energy, other than our muscles and domesticated animals, made the advancement of human civilization possible. Because of energy, we could grow more, make more, and trade over a wide range. Currently, society has acknowledged the detrimental impacts associated with energy consumption, pointing to CO_2 emissions that have reached a level that threatens extinction of many species and

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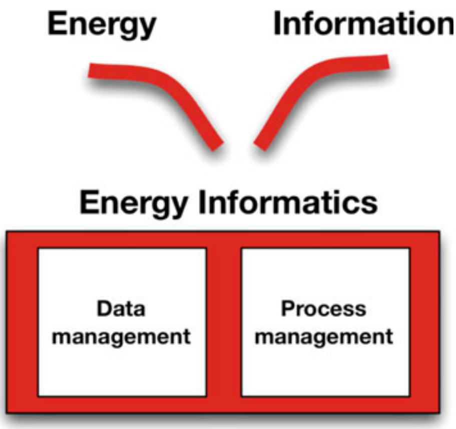

Fig. 1 The dualities of energy and information, and energy informatics

a mass loss of biodiversity. On the information side, information systems, in their many forms, have accumulated over the millennia. We started building rudimentary information systems when we learned to exchange information through gestures and actions. Since then, major breakthroughs (e.g., language, writing, printing, digitization, wireless telegraphy, etc.) have extended our ability to exchange, record, and process information.

When we trace the patterns over the millennia, the interconnection between energy and information systems is readily apparent. Thus, it is surprising that little scientific research directed at understanding this mutual relationship has been conducted. We suggest there is a need for a new discipline, Energy Informatics, which we have been developing over the last few years (Watson, Boudreau, Li, & Levis, 2010; Watson, Boudreau, & Chen, 2010). The Energy Informatics framework, which we explain and illustrate in this chapter, blends energy and information systems to guide research and practice that is socially responsible and ecologically necessary. The goal of Energy Informatics is to stimulate research aiming at reducing energy consumption through the development of practical solutions leveraging the transformative power of information systems.

2 The Energy Informatics Framework

The core idea underlying the Energy Informatics framework[1] can be expressed quite concisely:

Energy + Information < Energy

The Energy Informatics framework (Watson, Boudreau, & Chen, 2010), graphically represented in Fig. 2, emphasizes the interacting roles of supply and

[1] This framework would equally apply to other scarce natural resources, such as water.

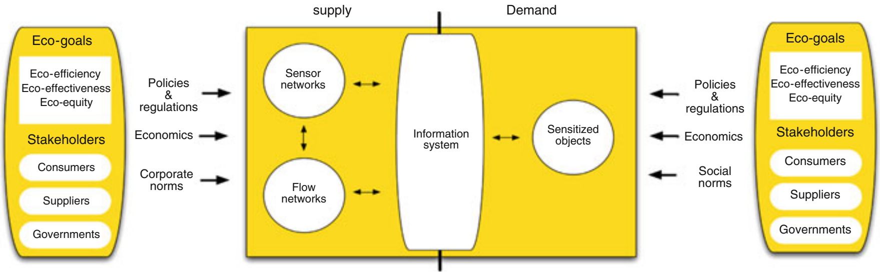

Fig. 2 Energy informatics framework (Source: Watson, Boudreau, & Chen, 2010)

demand in determining energy consuming practices. Briefly, some of the core concepts include three types of goals that are typically pursued by stakeholders aiming at minimizing energy consumption: eco-efficiency, eco-equity, and eco-effectiveness. In addition, three types of stakeholders are considered the most critical: the suppliers, consumers, and governments.

The supply side of the framework emphasizes the economic, regulatory, and normative forces that are likely to drive change. Flow networks (i.e., the set of connected transport components that supports the movement of continuous matter or discrete objects) and sensor networks (the set of spatially distributed devices that report the status of a physical item or environmental condition) are the key technologies of interest on the supply side.

In regard to demand, regulations and economic forces still constitute an influence on the energy consumer, but social norms constitute a new force at play. The key technology on the demand side is the sensitized object, which represents the physical good that an entity owns or manages that has the capability to sense and report data about its use. Supplying consumers with information about their energy usage is likely in some cases to lead to changes in usage patterns and decreases in overall consumption. For example, if consumers can get real time information about how much energy is used when doing laundry on a given Saturday morning (when many other consumers are using the same flow network, as detected by the sensor network), some might choose to postpone washing clothes to a time when there is less demand for electricity and it is possibly cheaper. Alternatively, the entire process might be automated so that some devices upon detecting high demand automatically switch themselves off or move to a lower energy consumption state.

Information systems integrate the supply and demand sides of the framework. The goal of such an integrated information system is to manage supply and demand to reduce total demand and maintain demand below established thresholds. These joint targets can ultimately be achieved only by a single system (e.g., EnerNOC's demand response system).

We contend that the problems emanating from over-consumption of fossil fuels can be ameliorated with accurate information about consumption practices. Precise and detailed information would enable and motivate economic and behaviorally driven solutions. Accordingly, information systems have a key role to play in reducing energy consumption, and thus CO2 emissions.

3 Energy Informatics and Data Management

An energy system cannot be optimized without detailed knowledge of the sources and sinks of energy and their key characteristics. The Energy Informatics framework specifically identifies the need for a sensor network to collect source data and sensitized objects to report sink data. The use of sensors is era shifting for the data management side of an IS, which we now consider (see Table 1).

In the first few decades of computer-based IS, most organizational data were captured during the processing of a transaction; such as sale, delivery of goods into inventory, and reservation of an airline seat. These transaction processing systems fed the databases that maintained the facts a company needed to remember (e.g., who owes me money) if it were to stay in a business and assisted making decisions (e.g., how much should we order of item Y) that would help it prosper. These transaction processing systems provided, and still do, the data for MIS, DSS, EIS, and other acronymic systems aimed at supporting enterprise management. Enterprise resource management (ERP) systems represent a culmination of these transaction-driven systems.

In the mid 1900s with the commercialization of the Internet, an entire new stream of data flowed into corporate data coffers. Customer interactions through a web site initially, and later through smart phones and tablets, created a torrent of data. Organizations realized that they could learn about their customers' preferences and needs by analyzing click stream data. The process of converting web site visits into sales (Berthon, Pitt, & Watson, 1996) spawned a new class of software, web metrics, and created the job of web analyst. As the Internet era took hold, customers went beyond simply using the Web for searching and buying. Product reviews, for example, became one of several major streams of customer originated data that organizations facilitated. A new class of customer-generated information systems emerged (DesAutels, 2011). These new systems resulted in an order of magnitude increase in the volume of data that organizations had to manage. The simple purchase transaction was now supplemented by data about the customer's visit to the web site.

As we enter the sustainability era, a new data stream will require management. As Fig. 2 indicates, sensor networks are a major component of an energy management system. These networks will provide the data for managing and optimizing

Table 1 Three eras of data management

Era	Source of data
Transaction	Business transactions
Network	Customer interactions
Sensor	Sensor network reporting

energy flows. The issues related to sensor network data management are considerably different from the prior eras on several dimensions, which we now discuss.

First, sensor networks will be deliberately designed, and data collection will be their prime purpose rather than a byproduct. Transaction data existed prior to computer-based information systems, and early data processing systems (the common name during the initial years of IS) converted paper records to electronic format and automated manual processes. The capture of customer-generated data followed the introduction of Web sites. Most organizations created a site, and then started to record some data, starting with counting visits to the site and then more elaborate metrics were implemented.

Second, sensor network designs require IS professionals to develop a new set of design skills. There are multiple parameters to consider in designing a sensor network, which include:

- Sensor density
- Sensor reporting frequency
- Sensor data capture capabilities

The granularity of input data has a direct connection of the quality of a systems optimization. For example, the design of city road network is likely to be more precise when it is based on 500 zones of hourly data than 10 zones of daily data. Of course, collecting the additional data points is expensive (1,200 times more data in this case), more costly to manage, and the optimization algorithm will taken more processing power.[2] Thus, the design of sensor networks poses questions about the value of information, which might be considered a core Information Systems issue.

4 Energy Informatics and Process Management

Although much progress has been made in defining the BPM management discipline and in implementing associated technology, few people would consider the field mature. Research efforts on a variety of fronts are in progress, but two particular strands stand out – both with clear benefits to Energy Informatics. The first (Case Management) involves management of the business and customer interactions for energy related projects. The second (Complex Event Processing) involves integrating sensor networks into BPM. Whereas Case management can serve global systems design, Complex Event Processing and key performance indicators (KPIs) are approaches that addresses operational efficiency. Both are represented in context, in Fig. 3, which incorporates BPM into a general information systems model for an energy management system (Watson & Boudreau, 2010). The general model has two parts: systems design and operational efficiency.

[2] Processing time is likely to be of the order of n^2, where n is the number of zones.

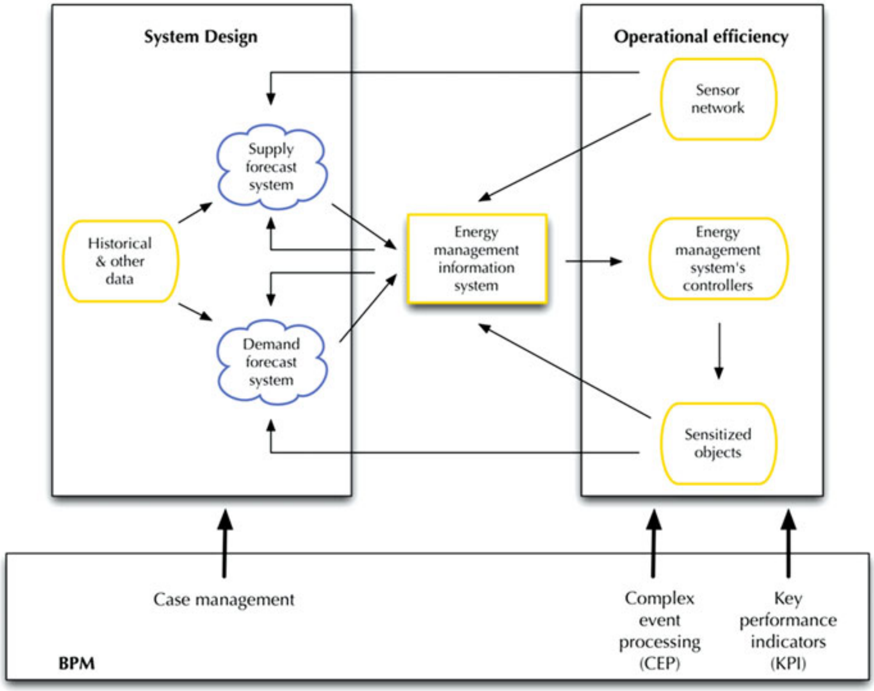

Fig. 3 Energy management system relationship between systems design and operational efficiency (Adapted from Watson & Boudreau, 2010)

Efficiency is typically a prominent goal when a system is planned, but design is a broad brush that works with averages and some reasonable range around them. Designers work with historical or predicted data. They can't anticipate all future possibilities, and thus when placed in a dynamic environment, any resulting system will be suboptimal most of the time. This is particularly of concern when there is a lack of capacity. Hence, there needs to be an operational efficiency element in place to collect current data about a system's usage in order to adjust parameters to better suit current conditions. We will now further discuss the relationship between these process management techniques and energy management.

4.1 Case Management

As is true for many active research areas, extensions to BPM go by many names. The terms Adaptive BPM, Dynamic BPM, and Case Management are roughly synonymous, and all deal with the problem of handling business processes that cannot be completely predefined. Such processes typically are long lived, involve collaboration, and require complex content to be accessed and created as work knowledge management. Such processes are very common in the service sector of advanced economies and constitute a large part of "knowledge work" today (Davenport, 2005). Although rules engines are becoming more sophisticated and widely used, they cannot handle such "ad hoc" structures since they rely, ultimately, on pre-determined processes. A new approach is needed, particularly for emerging fields, which are in themselves relatively undefined.

The situation is similar to the evolution of the process of software development. For many years the standard process model was nicknamed "the waterfall." A requirements definition was completely defined in detail before work was started on development. Once all the software was available, the process moved to testing and finally implementation. Over the last decade, a more adaptable methodology has been used by many companies: the "agile" approach stresses rapid implementation of small parts of the total system, using a minimum set of planning artifacts. In effect, project and process management are merging and becoming more adaptive to the particular circumstances of each situation.

A key distinction between "case management" processes and those managed by BPM technology today is the ability of a case manager to design and implement novel process fragments for individual process instances. For example, a university campus might have a long term goal of reducing energy use. This goal translates into a constantly changing set of specific projects involving particular buildings and more general initiatives that apply to the campus as a whole. All this activity needs to be centrally accessible, since the wide ranging projects may directly affect the more targeted programs; for instance, new sources of funding might dramatically accelerate existing projects and make new initiatives possible. In effect, the users of a BPM system need to be able to design and implement unique processes within the structure of the overall project.

A case structured process presupposes a case manager. The adaptive BPM environment leverages this person, allowing case managers to be more productive and providing clarity to all the participants in the process.

Demand for these kinds of extensions has led to the Open Modeling Group (the body that defines the BPMN modeling standard) issuing a request for "Letters of Interest" for the proposed CMPM (Case Management Process Modeling) standard.[3] It might take a few years, but if a standard modeling approach is approved, this could accelerate development and adoption of case management solutions. The application of Case Management to Energy Informatics involves business and customer interactions and, since it will potentially affect all case structured processes, the beneficial effects could be widespread.

An example involving innovation management concerns the development of special food plant varieties by a major research university. These food plant strains reflect more of the sun's energy than current varieties and are just as productive. Given the enormous acreage under cultivation with food crops, adoption of such an

[3] http://www.omg.org/schedule/.

invention could materially affect global warming by reflecting rather than absorbing the sun's energy. The university organization that handles the commercialization uses a paper-based case management system, which does not allow for the efficient processing of such inventions. Cases may be sidelined for long periods. A new research breakthrough may only make sense if tied to previous "dead ends" and the high "case load" per worker means that such connections can be lost. In this situation, leveraging the specialized case worker could affect the timing of such breakthroughs being utilized. Since the use of case management by knowledge workers is so widespread, there are many other possible examples.

Although it is natural to be skeptical of the rapid adoption of Case Management, Gartner Group, in its key predictions for BPM,[4] noted that:

> By 2012, 20 percent of customer-facing processes will be knowledge-adaptable and assembled just in time to meet the demands and preferences of each customer, assisted by BPM technologies [. . .] By 2013, dynamic BPM will be an imperative for companies seeking process efficiencies in increasingly chaotic environments.

4.2 Complex Event Processing

The second research area involves the incorporation of the "Internet of Things" into BPM. Many people are surprised to learn that the number of "things" communicating via networks is greater than the number of people doing so (Chui, Löffler, & Roberts, 2010). Current BPM practice uses instance information generated by the process to monitor performance; common examples being activity times and costs. There are, however, many sources of information originating outside the current process that may be relevant. The sensor networks described in the Energy Informatics framework could clearly be one such source.

Sensors emit event streams and the handling of these streams is usually described as Complex Event Processing (CEP) (Luckham, 2002). Event streams can potentially consist of very large amounts of low level information, so CEP must provide event abstraction using event hierarchies to be useful. In general, events can be processed as follows:

- Monitor real-time events – a single event could trigger action.
- Filter and/or aggregate these events.
- Correlate events with other events or business rules.
- Generate alerts or initiate processes as the result of individual events or correlations that are of business interest.
- Store events, which might be at the individual, filtered or aggregated level.
- Report against stored events.

[4] http://www.gartner.com/it/page.jsp?id=1278415.

While all this is possible in real time (as the process is running), an additional capability is the recognition of patterns of interest from historical information which can then be used to enhance business rules.

CEP is an active area of research in several universities and there are commercial products available. The most common implementation of CEP today is in the capital markets, but there are applications for "self-healing" networks, network security and others situations that require sophisticated pattern recognition that leads to recovery after component failure or traffic bottlenecks.

Applications of CEP in BPM involve the routing of events to a Business Activity Monitoring function, where along with process data, they are reviewed by process owners. It is not too far-fetched to imagine, however, that as in self-healing networks and algorithmic trading, the CEP results directly affect the process. In fact, the marriage of CEP and BPM has been given a name: EDBPM. i.e., Event-Driven Business Process Management. In order for EDBPM to become widely used, modeling and execution standards (BPMN and BPEL) would need to be extended to include complex events. With this accomplished, the applications discussed earlier for using sensor data in energy management should be possible.

An example of CEP involving Energy Informatics involves a vital on-going project being undertaken in Europe and the US. This is the so called Smart Grid. There is no efficient, scalable storage mechanism for electricity. This can lead to overproduction in one location at the same time that high demand exists in another. Transmission is critical and in some extreme cases, new wind farms have to shut down once they satisfy local demand due to lack of transmission capacity. Although the primary function of the Smart Grid is to extend the transmission and distribution networks, the management of these networks using CEP will be important. A more complex electricity producer sector, resulting from the diversification of energy sources, will benefit enormously from BPM by identifying (and eventually automatically reacting to) the grid sensor network.

4.3 Key Performance Indicators

When firms adopt a process orientation, they usually also decide on metrics to track their current and target levels of performance. Typically, such metrics have to do with efficiency (e.g., cycle time), costs (e.g., labor costs), and quality (e.g., number of complaints or defects).

Metrics can be at the activity level (e.g., in the "fill out form" activity, what is the percentage of forms that were filled without error?), at the process level (e.g., in the "fulfillment" process, what was the percentage of orders that were delivered on time?), or at the enterprise level (e.g., what percentage of current customers are repeats?). When enterprise level metrics are associated with strategic goals, they are often called Key Performance Indicators (KPIs). The Business Process Management Common Body of Knowledge (Antonucci et al., 2009) identifies some of the characteristics relevant to KPI metrics:

- Alignment. KPIs are always aligned with corporate strategies and objectives.
- Accountability. Every KPI is “owned” by an individual or group on the business side who is accountable for its outcome.
- Actionable. KPIs are populated with timely, actionable data so users can intervene to improve performance before it’s too late.
- Easy to understand. KPIs should be straightforward, not based on complex indexes that managers don’t know how to influence directly.
- Standardized. KPIs are generally more effective when based on standard definitions, rules, and calculations so they can be integrated across dashboards, throughout the organization, and used for benchmarking within and across industries.
- Few in number. KPIs should focus users on a few high value activities, or on the overall effectiveness of the process.
- Reinforced. The impact of KPIs may be enhanced by attaching compensation or incentives to them.

The sustainability era that we have now embarked upon calls for a new type of metrics that will leverage the massive amount of data collected through sensor networks. Sustainability metrics thus need to exist at the activity, process, and enterprise levels, and must be evaluated in conjunction with those related to a firm’s efficiency, costs, and quality of outputs. For many firms, considering sustainability metrics will not only require an overhaul of their systems to include sensors measuring flows, but also a shift in organizational culture and managerial practices.

4.4 Sustainability at Frito-Lay

One company that has embraced sustainability in both its culture and practices is Frito-Lay. Like its parent, Pepsico Inc., Frito-Lay has developed a reputation as a good environmental citizen, and accordingly has developed many sustainability metrics and is committed to diverse sustainability goals. In its company vision, Frito-Lay clearly states its goal to reduce its environmental footprint by conserving natural resources and harnessing renewable energy technology. Exemplifying this vision, Frito-Lay introduced a new packaging for its SunChips brand made of renewable, plant based materials that are designed to compost in about 14 weeks in the proper environment. Frito-Lay is also well known for using solar energy in some of its plants (e.g., Modesto, CA), distribution centers, and even in its headquarters (located in Plano, TX), which obtained a LEED Gold certification from the US Green Building Council in the summer of 2009. The many environmental awards Frito-Lay has collected over recent years are representative of the company’s strong environmental records, which often go beyond legal requirements. Around the country, many of its facilities have targeted challenging environmental goals.

One of these facilities is the West Valley Plant, located near Salt Lake City, Utah. It is a core facility (i.e., one that makes the core package of products: potato and tortilla chips) that was built in 1995. The plant has about 275 employees working with the business unit, manufacturing, warehouse, and distribution.

Since 2009, the Frito-Lay's West Valley plant has implemented a new program, called "Team 4ward."[5] The idea behind Team 4ward is simple: employees are assigned to teams that are empowered to act on a part of the business that they are passionate about. As long as this is aligned with one of the four pillars of the company's strategy – commitment to people, planet, partners, and products – and focuses on specific areas for execution (safety, water, electricity conservation, etc.), then employees have much leeway. Managers become servant leaders to employees volunteering on a Team 4ward team, making sure that they have access to the information and resources needed to deliver results.

The West Valley plant employees who care for the planet have to rely on sustainability metrics to assess the plant's performance in terms of environmental impact. This is how the plant addresses (or could address) each of the KPI characteristics presented earlier:

- Alignment. As many companies are now targeting a "triple-bottom line" (Elkington, 1997), where not only economic sustainability, but also social and environmental sustainability are strategically important (Dyllick & Hockerts, 2002), aligning sustainability KPIs with a firm's strategy or vision should still be of primary concern. At Frito-Lay, as mentioned earlier, it is part of the firm's vision to reduce its environmental footprint by conserving natural resources and harnessing renewable energy technology. This was also echoed by the West Valley plant.
- Accountability. At the West Valley Plant, Frito-Lay nominated an employee to monitor and act upon the sustainability metrics associated with its manufacturing processes (they refer to each of these employees as the "planet person"). Although the "planet person" is helped by a team of employees and a manager acting as a "servant leader," it is the planet person, ultimately, who is accountable for the planet metrics that are evaluated during a given shift.
- Actionable. The West Valley Plant seeks to reduce the gap between the availability of a metric and its corrective action (when necessary). To do this, the plant has outfitted its equipment with a greater number of sensors, and installed a monitor in its control room that displays all equipment used along with their consumption levels (in terms of water, natural gas, starch, etc.) for both the past 2–8 h. The employee who takes the role of the "planet person" monitors these consumption levels at the beginning of a shift, and then every 2 h. When a metric is in out-of-bounds, the planet person has the ability and authority to rectify a

[5] http://www.snacks.com/good_fun_fritolay/2009/09/team-4ward-generating-impoved-business-results.html.

problematic situation with little delay. Employees have indeed been trained to not only detect, but also fix, common problems within the plant.

- Easy to understand. Sustainability metrics created by the West Valley Plant employees are easy to understand. Indeed, metrics are represented in a spreadsheet, and are color-coded in green (if the value is within the target zone) or red (if the value is under or over a pre-determined limit).
- Standardized. Given that the West Valley plant is still at the early stage of deciding on which metrics to consider and measure, standards to be used across plants have not yet been established. The plant could be inspired by the Global Reporting Initiative (GRI), which suggests sustainability metrics that have gained global acceptance. The GRI's framework currently identifies 30 environmental indicators related to consumption of material, energy, and water; biodiversity; emissions, effluents, and waste; transports, and others. Given the increasing number of organizations relying on the GRI framework to report their sustainability performance, a firm need not be at a loss when trying to identify KPIs that will be meaningful to stakeholders.
- Few in number. Again, the GRI framework comes in handy for firms that need to select the few KPIs that are most relevant to their sector. GRI subdivides its environmental indicators in terms of "core" versus "additional" – thus distinguishing the most important to stakeholders versus those that represent emerging good practices. From the 30 environmental indicators it has established, only 17 are designated as core. Obviously, depending of its sector, an organization can only take focus on a subset of these 17. For example, whereas the West Valley Plant is very concerned with all indicators related to water consumption, the ones related to biodiversity are less relevant for the plant.
- Reinforced. The West Valley implemented a bonus structure that is aligned with the established objectives within each of its business areas, one of which being the "planet" area (i.e., sustainability metrics). Instead of being calculated on a yearly basis, the bonus is paid out quarterly, such that there is are opportunities for employees to fare better even if a particular quarter is not outstanding.

The West Valley plant, in sum, is putting considerable effort into making sure that its sustainability metrics will have an impact on improving its activities and processes, thus supporting its strategic goals. As organizations acknowledge the imperative to become more sustainable, they, like the West Valley plant, will need to give proper attention to the sustainability metrics they develop and monitor.

5 Future Directions

The connection between data and processes was recognized by IS professionals almost as soon as they started to deploy computers to solve business problems, which is why the field was called automated data processing (ADP) for some years.

IS, though not so called in the pioneering days, was about creating computer-based processes (programs) to handle organizational data. However, only recently did we recognize the critical connection between energy and information, and we now need to advance this awareness a step further by investigating the *ménage à trois* between Energy Informatics, data management, and process management. This chapter makes explicit the connection and gives a broad frame (Fig. 3) and some examples for understanding how some BPM technologies relate to energy management. The next step is to undertake the research to understand the deeper ramifications of this connection and to extend Energy Informatics thinking to go beyond its somewhat data-centric vision (e.g., sensor networks) to embrace process management and create a balance between the traditional pillars of IS.

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Change the Game: Sustainability in Projects and Project Management

Gilbert Silvius

Abstract Sustainability is one of the most important challenges of our time. How can we develop prosperity, without compromising the life of future generations? Companies are integrating ideas of sustainability in their marketing, corporate communications, annual reports and in their actions. Many of these actions are organized in projects. The project management world, however, fails to address the sustainability agenda (Eid, 2009). This chapter explores the concept of sustainability and its application to project management. It aims to identify the questions that surround the integration of sustainability in project management and to provide practical insights to this challenge. After a review of the relevant literature on sustainability, its leading elements are identified. Based on an analysis of the scarce literature on the application of these elements in project management we will raise questions on the scope and definition on sustainability in projects and project management.

1 Introduction

In the last 10–15 years, the concept of sustainability has grown in recognition and importance. The pressure on companies to broaden their reporting and accountability from economic performance for shareholders to sustainability performance for all stakeholders has increased (Visser, 2002). The recent world crises may even imply, that a strategy focused solely on shareholder value, is not longer viable (Kennedy, 2000). Following the success of Al Gore's 'inconvenient truth', awareness seems to be growing that a change of mindset is needed, both in consumer behavior as in corporate policies. How can we develop prosperity without compromising the life of future generations? Proactively or reactively, companies are

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looking for ways to integrate concepts of sustainability in their marketing, corporate communications, annual reports and in their business processes (Hedstrom, Poltorzycki, & Stroh, 1998; Holliday, 2001). Sustainability, in this context, being defined as "Adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future." (Deloitte & Touche, 1992).

The concerns about sustainability indicate that the current way of producing, organizing, consuming, living, etc. have or may have negative effects on the future. In fact, the World Commission on Environment and Development (Brundtland, 1987) stated that current business practices are not sustainable. This implies that also the current business processes of businesses are not sustainable. Therefore, these processes need to change. And they need to change in a sustainable way.

A frequently used way of realizing change in organizations is by creating temporary, result oriented organizations: projects (Lundin & Söderholm, 1995; Turner & Müller, 2003). Therefore it makes sense to link the concept of sustainability to project management (Gareis, Heumann, & Martinuzzi, 2009; Silvius, van der Brink, & Köhler, 2009). Association for Project Management (past-) chairman Tom Taylor recognizes that "the planet earth is in a perilous position with a range of fundamental sustainability threats" and "Project and Programme Managers are significantly placed to make contributions to Sustainable Management practices" (Association for Project Management, 2006). However, Eid concludes in his study on sustainable development and project management that the standards for project management "fail to seriously address the sustainability agenda" (Eid, 2009).

This chapter explores the concept of sustainability and its application to project and change management. It aims to identify the questions that surround the integration of sustainability in project management and to provide practical insights to this challenge.

After a review of the relevant literature on sustainability, we will identify its leading principles. Based on an analysis of the scarce literature on the application of these principles to project management we will identify the implications for the scope considered in of project management. The chapter will be concluded with a suggested definition of Sustainability in Projects and Project Management as a foundation for further research.

2 The Concepts of Sustainability

The balance between economic growth and social wellbeing has been around as a political and managerial challenge for over 150 years (Dyllick & Hockerts, 2002). Also the concern for the wise use of natural resources and our planet emerged already many decades ago, with Carson's book "Silent Spring" (Carson, 1962) as a launching hallmark. In 1972 the 'Club of Rome', an independent think tank, published its book “The Limits to Growth”. In the book, the authors concluded that if the world’s population and economy would continue to grow at their current speeds, our planet’s natural resources would approach depletion. The Limits to Growth fuelled a public debate, leading to installation of the UN ‘World Commission on Development and Environment’, named the Brundtland Commission after its chair. In their report “Our Common Future”, the Brundtland commission defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (1987). By stating that “In its broadest sense, sustainable development strategy aims at promoting harmony among human beings and between humanity and nature”, the report implies that sustainability requires also a social and an environmental perspective, next to the economical perspective, on development and performance.

The visions that none of the development goals of economic growth, social wellbeing and a wise use of natural resources, can be reached without considering and effecting the other two, got widely accepted (Keating, 1993). In his book “Cannibals with Forks: the Triple Bottom Line of twenty-first Century Business”, identifies John Elkington, this as the ‘triple bottom line’ or ‘Triple-P (People, Planet, Profit)’ concept: Sustainability is about the balance or harmony between economic sustainability, social sustainability and environmental sustainability (Elkington, 1997).

Based on the concepts and standards described above, a number of key elements, or principles, of sustainability can be derived. For example Dyllick and Hockerts (2002) identify three “key elements of corporate sustainability”: Integrating the economic, ecological and social aspects into the firm’s strategy, Integrating short-term and long-term aspects and Consuming the income and not the capital. Gareis et al. define sustainability with the following principles (Gareis, Huemann, & Martinuzzi, 2011): economic, social and ecologic orientation; short-, mid- and long-term orientation; local, regional and global orientation; value orientation. The ISO 26000 guideline on social responsibility mentions accountability, transparency, ethical behavior, respect for stakeholders’ interests, respect for rule of law, respect for international norms of behavior and respect for human rights as ‘principles’ of sustainability. After considering these sets of elements or principles we conclude six ‘principles of sustainability’ that will be our guiding principles in the integration of the concepts of sustainability in projects and project management.

The six principles of sustainability are:

Sustainability is about balancing or harmonizing social, environmental and economical interests

In order to contribute to sustainable development, a company should satisfy all ‘three pillars’ of sustainability: Social, Environmental and Economic (illustrated in Fig. 1). The dimensions are interrelated, i.e. they influence each other in various ways. One way of considering sustainability is to ‘balance’ social, economic and environmental aspects by trading off the negative effects of doing business for a somewhat lower profit. For example compensating CO2 emission by planting new trees or

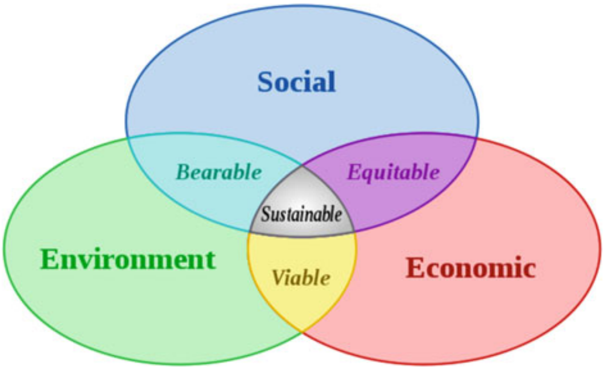


Fig. 1 The triple-P concept of sustainability

compensating unhealthy work pressure by higher salaries. A more proactive approach to sustainability looks at how organizations create a 'harmony' of social, environmental and economic aspects in their activities. This approach is not about compensating bad effects, but about creating good effects (Silvius & Schipper, 2010).

Sustainability is about both short term and long term orientation
A sustainable company should consider long-term consequences of their actions, and not only focus on short-term gains. Especially firms listed on the stock market have overemphasized the importance of short-term gains, trying to increase performance from quarterly report to quarterly report, and thereby loosing long-term vision. This element focuses the attention to the full lifespan of the matter at hand. An important notion in this aspect is that the economical perspective, because of discount rates, tends to value short term effects more than long term effects, whereas social impacts or environmental degradation may not occur before the long-term.

Sustainability is about local and global orientation
The increasing globalization of economies effect the geographical area that organizations influence. Whether intentionally or not, many organizations are influenced by international stakeholders whether these are competitors, suppliers or (potential) customers. The behavior and actions of organizations therefore have an effect on economical, social and environmental aspects, both locally and globally. "In order to efficiently address these nested and interlinked processes sustainable development has to be a coordinated effort playing out across several levels, ranging from the global to the regional and the local" (Gareis et al., 2011).

Sustainability is about consuming income, not capital
Sustainability implies that "the natural capital remains intact. This means that the source and sink functions of the environment should not be degraded. Therefore, the extraction of renewable resources should not exceed the rate at which they are renewed, and the absorptive capacity of the environment to assimilate waste, should

not be exceeded." (Gilbert, Stevenson, Girardet, & Stern, 1996). This principle is common knowledge in business from the economic perspective. Finance managers know that a company which does not use its income to pay for its costs, but instead uses its capital, will soon be insolvent. From a social or environmental perspective, however, the impact may not be visible in the short-term, causing degradation of resources in the long run. In order to be sustainable, companies have to manage not only their economic capital, but also their social and environmental capital.

Sustainability is about transparency and accountability
The principle of transparency implies that an organization is open about its policies, decisions and actions, including the environmental and social effects of those actions and policies. This implies that organizations provide timely, clear and relevant information to their stakeholders so that these stakeholders can evaluate the organization's actions and can address potential issues with these actions. The principle of accountability is logically connected to this. This principle implies that an organization is responsible for its policies, decisions and actions and the effect of these on environment and society. The principle also implies that an organization accepts this responsibility and is willing to be held accountable for these policies, decisions and actions.

Sustainability is also about personal values and ethics
As discussed earlier, a key element of sustainability is change. Change towards more sustainable (business) practices. As argued by Robinson (2004) and Martens (2006), sustainable development is inevitably a normative concept, reflecting values and ethical considerations of the society. Part of change needed for more a sustainable development, will therefore also be the implicit or explicit set of values that we as professionals, business leaders or consumers have and that influence or lead our behavior. GRI Deputy Director Nelmara Arbex puts it simple and clear: "In order to change the way we DO things, we need to change the way we VIEW things".

These sustainability principles provide guidance for the analysis of the impact of the concepts of sustainability in projects and project management in the following paragraphs.

3 Sustainability in Project and Project Management

The concepts of sustainability have only recently been linked to projects and project management (Gareis et al., 2009; Silvius et al., 2009). We consider projects as temporary organizations (Lundin & Söderholm 1995; Turner & Müller 2003) that deliver (any kind of) change to organizations, products, services, business processes, policies or assets. These project-organized changes, or simply projects, are characterized by:

- A temporary nature or temporary organization;
- Most often across organizational structures and boundaries;
- A defined deliverable or result, logically or preferably linked to the organization's strategy or goals;
- Specified resources and budget.

In this definition, projects are, as temporary organizations, related to a non-temporary 'permanent' organization, and realize changes that benefit the strategy or goals of this organization.

The permanent organization utilizes resources and assets in its operational business processes to deliver benefits or value to its customers and ultimately deliver business performance (e.g. profit, market share, return in capital, etc.) to the organisation and its stakeholders. Its activities are based on goals that are developed or set in a strategic management process. Figure 2 provides a high level illustration of this relationship between goal setting, the utilisation of assets and resources, operations, benefits and performance.

The strategic management of the organisation, however, not just includes setting goals. It also includes evaluating the business performance of the organisation against these goals. If the performance is satisfactory, the operations may continue. But if the performance is unsatisfactory, because of lack of performance or because of changing goals, there may be reason to change something in the organisation. In that case, a temporary organization, in the form of a project, is commonly used to create this change. The change may concern the resources, assets or business processes of the permanent organization, but also the products/services rendered or the internal policies and procedures. The selection of the 'right' changes for the organisation is usually part of a process called 'portfolio management'. Figure 3 illustrates this relationship between projects as temporary organisations and the permanent organisation.

Elaborating on the view of projects as instruments of change, it is evident that a (more) sustainable society requires projects to realize change. In fact, this connection between sustainability and projects was already established by the World Commission on Environment and Development (Brundtland, 1987). However, the conclusion of Eid's study mentioned earlier (Eid, 2009), illustrates that projects and sustainable development are probably not 'natural friends'. Given the temporary nature of projects this may not be surprising. Table 1 illustrates some of the 'natural' differences in the characteristics of the two concepts.

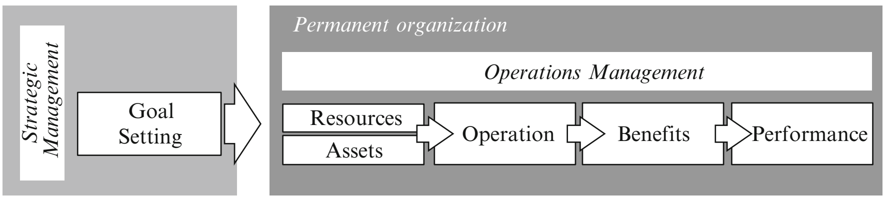


Fig. 2 Schematic overview of relationships within the permanent organization

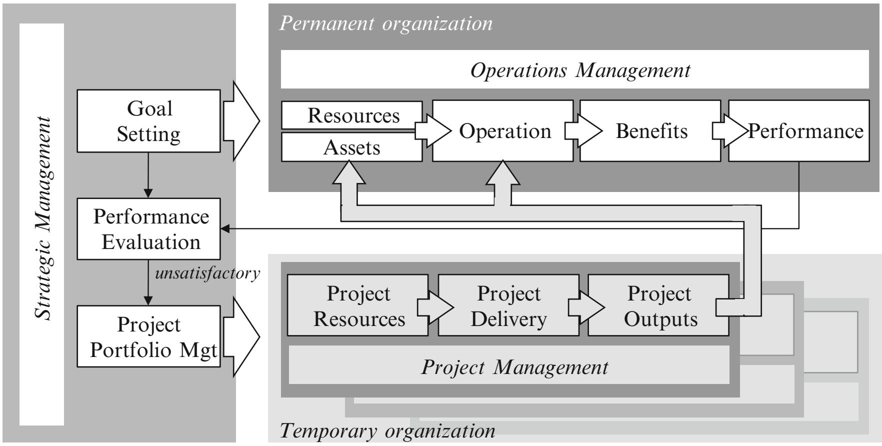


Fig. 3 Project as temporary organizations that deliver changes to the permanent organization

Table 1 The contrast between the concepts of sustainable development and projects

Sustainable development		Project management
Long term + short term oriented	⟷	Short term oriented
In the interest of this generation and future generations	⟷	In the interest of sponsor/ stakeholders
Life-cycle oriented	⟷	Deliverable/result oriented
People, planet, profit	⟷	Scope, time, budget
Increasing complexity	⟷	Reduced complexity

The relationship between sustainability and project management is still an emerging field of study (Gareis et al., 2009). Some first studies and ideas were published in recent years. And although the studies differ in approach and depth, a few conclusions can be drawn.

Conclusion 1: Sustainability is relevant to projects and project management.

As stated in the introduction of this chapter, APM's (past-)chairman Tom Taylor was one of the first to suggest the project management community to familiarize themselves with the issues of sustainability, recognizing that more should be done to contribute to a more sustainable society (Association for Project Management, 2006). This appeal was the output of a small working party in APM, that recognized that project managers were not well equipped to make a contribution to sustainable development and decided to investigate this issue.

On the 2008 European conference of the Project Management Institute (PMI), Jennifer Russell elaborated on what Corporate Social Responsibility means for project managers (Russell, 2008). She pointed out that a project manager, being in the frontline of new or changed activities within an organization, is perfectly positioned to influence the organization's operations towards greater sustainability.

Russell also argued that this position is not without responsibility, both for the organization as for the project manager. She concludes that "Corporate social responsibility is too big an issue to leave to someone else to address."

Conclusion 2: Integrating sustainability stretches the system boundaries of project management.

In some of the first publications on sustainability and project management, Carin Labuschagne and Alan Brent of the University of Pretoria link the principles of sustainable development to project life cycle management in the manufacturing industry (2006). They suggest that the future-orientation of sustainability implies that the full life cycle of a project, from its conception to its disposal, should be considered. Elaborating on this life cycle view, they argue that when considering sustainability in project management, not just the total life cycle of the project (e.g. initiation-development-execution-testing-launch) should be taken into account, but also of the 'result' the project produces, being a change in assets, systems, behaviour, etc. This result, in their words: the 'asset', should also be considered over its full life cycle, being something like design-develop-manufacture-operate-decommission-disposal. And taking the life cycle view even further, also the life cycle of the product or service that the asset produces should be considered. Figure 4 visualizes how these three life cycles, 'project life cycle', 'asset life cycle' and 'product life cycle', interact and relate to each other. Including sustainability considerations in projects therefore suggests that all three life cycles are considered.

Because Labuschagne and Brent include the result of the project, the asset, in their framework, it is sensitive to the context of the project. Their studies regarded the manufacturing sector in which projects generally realize assets that produce

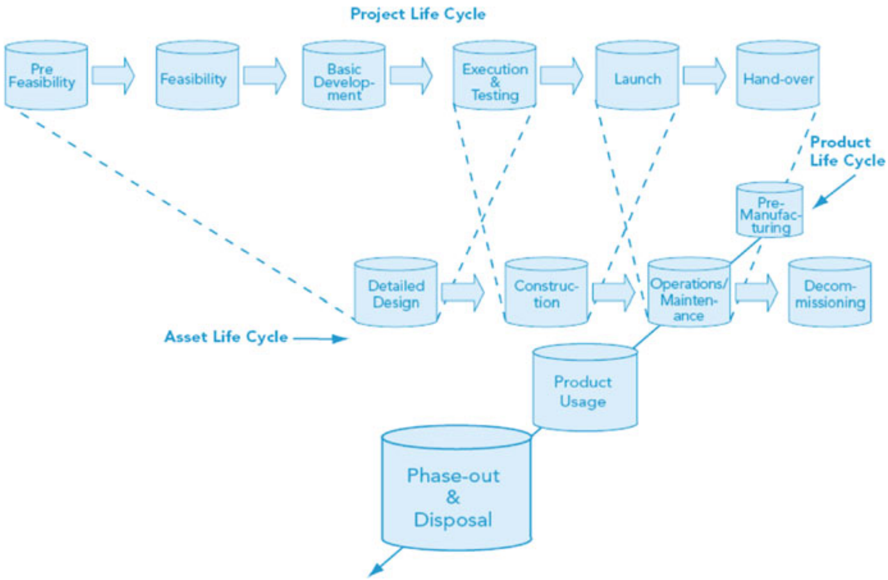


Fig. 4 Interrelating life-cycles (Based on Labuschagne & Brent, 2006; Silvius et al., 2009)

products. In other contexts, the result of a project may be not an asset, but an organizational change or a new policy. The general insight gained from their work, however, may be that integrating sustainability in projects should not be limited to just the project management processes. It suggests that also the 'supply chain' of the project is to be considered, including the life cycle of whatever result the project realizes and also the life cycle of the resources used in realizing the result. Integrating the concept of sustainability in project management may therefore very well stretch the 'systems boundaries' of project management.

Another view on the scope of integrating sustainability in to projects can be found in the 'Sust PM' research project (Gareis et al., 2009, 2011). This project focuses on integrating the concepts of sustainability specifically in project management processes and methods, and not the project management result or deliverable. This specific focus is motivated by the temporary character of projects, which causes the project management processes to be 'overlooked' in organizations, when striving for a more sustainable business. In the Sust PM study, the concept of sustainability is detailed in six characteristics: Economic-oriented, Ecologic-oriented, Social-oriented, Short, mid, long-term oriented, Local, regional, global-oriented and Value-oriented. Project management is subsequently confronted with these six characteristics in order to develop additions to the project management standards and methodologies.

Conclusion 3: Project management standards fail to address sustainability

This conclusion was most clearly drawn by Mohamed Eid in the 2009 book "Sustainable Development & Project Management" (Eid, 2009). Eid studied the integration of sustainable development in construction project management. Some conclusions from his study:

- Project management is an efficient vehicle to introduce a more profound change, not only to the construction industry's practice, but more importantly to the industry's culture.
- Project management processes and knowledge fall short of committing to a sustainable approach.
- Mapping sustainable development onto project management processes and knowledge areas, identifies opportunities for introducing sustainability guidelines in to all project management processes.

Eid also identified a number of 'leverage points' where sustainable development can connect into project management. These leverage points include the contribution to business strategy, the business justification, the procurement strategy, the readiness for service and the benefits evaluation of a project. The leverage points cover the whole life cycle of the project.

It should be mentioned, that 'help may be on its way' with regards to the integration of the concepts of sustainability into project management standards. For example, in the PMI sponsored 'Sust PM' research project, led by Austrian professor Roland Gareis, the focus is on integrating the concepts of sustainability specifically in project management processes and formats.

Other initiatives to develop 'tools' to integrate sustainability aspects into project management resulted in several checklists. For example, Taylor elaborated on his earlier appeal to the project management profession (Association for Project Management, 2006), by publishing 'A Sustainability Checklist for Managers of Projects' (Taylor, 2008). This checklist contains a list of suggested consideration for project managers, with which they can incorporate sustainability aspects in their projects. And although the checklist lacks a systematic approach to the concepts of sustainability. It is a meaningful attempt to translate the 'abstract' concepts of sustainability to the daily work of the project manager.

The 2010 IPMA Expert Seminar 'Survival and Sustainability as challenges for projects', featured several papers and discussions on the integration of sustainability in projects and project management (Knöpfel, 2010). An international group of experts[1] developed a checklist of sustainability aspects and mapped these aspects on project management processes, roles and responsibilities of project members and project management competencies.

The book "Green Project Management" by Richard Maltzman and David Shirley (2010) focuses on the integration of environmental sustainability in project management. It introduces the term 'greenality' as the merger of 'green' aspects and the 'quality' of the project. The book provides essential factual knowledge about environmental aspects and includes an extensive description of how project managers and sponsors can integrate these aspects into the different phases of a project.

A more thorough study into the operationalization of sustainability in projects was done by Iris Oehlman (2010). She developed the 'Sustainable Footprint Methodology' to analyze and determine the relevant social, environmental and economical impacts of a project. The framework confronts the life cycle of a project, consisting of three phases: project pre-phase, project execution and operation of the asset, with the three pillars of 'the triple bottom line': People, Planet and Profit. Each of the nine 'cells' of the resulting 3 by 3 matrix is detailed in a set of sustainability indicators relevant to the respective sustainability perspective and the phase in the project life-cycle.

Conclusion 4: The integration of sustainability may change the project management profession.

The conclusion of the 2010 IPMA Expert Seminar mentioned earlier was that the influence of the project manager on the sustainability aspects of his or hers project at hand is substantial, regardless whether he/she actually bears responsibility for these aspects. This conclusion may actually change the nature of the project management profession. From a managerial role aimed at realizing delegated tasks, it may need to develop into a more advisory role with autonomous professional responsibilities and aimed at the right organizational changes.

[1] The experts included APM past-president Tom Taylor, IPMA vice-president Hans Knöpfel, professor Rodney Turner and professor Gilbert Silvius.

The studies summarized above illustrate the current state of knowledge on sustainability in projects and project management. The current state of research on sustainability in projects and project management is mostly interpretive, giving meaning to how the concepts of sustainability could be interpreted in the context of projects, rather than prescriptive, prescribing how sustainability should be integrated into projects. Different authors pose different ideas and insights, containing many interesting suggestions about how project management should develop. However, most ideas and suggestions are of a rather conceptual nature and need elaboration to be of more practical value for the profession. The studies provide ingredients and provide questions, rather than answers. The first logical questions that should be answered are:

- Which system boundaries should be taken into account when considering sustainability in projects and project management?
- How can sustainability in projects and in project management be defined?

The final paragraphs of this chapter will explore these questions in order to develop a definition of sustainability in projects and project management.

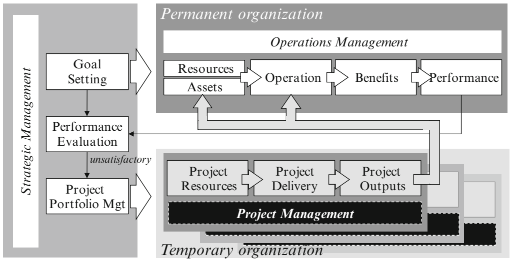
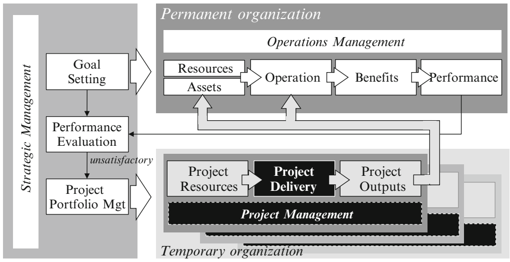
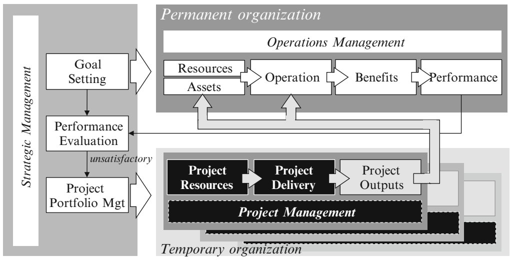
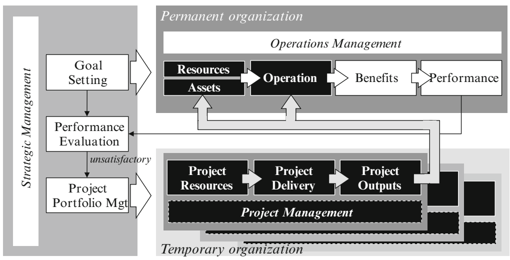
4 Scope of Sustainability in Projects and Project Management

From the discussion of the publications above, it became clear that the question what sustainability means for projects and project management, cannot be answered without discussing the scope or 'system boundaries' of projects and project management. What should be 'in scope' of projects and what not? These boundaries can be best illustrated in relationship to the context of a project as indicated in Fig. 3.

Understandably, this question creates debate amongst both researchers and practitioners. For example Labuschagne and Brent (2006) include in their views the consideration of sustainability aspects to the project, its result and its effect, thereby suggesting that integrating sustainability in project management cannot be limited to the project delivery processes as such. This view opposes the approach taken by Gareis et al. (2009) that limits the consideration of sustainability aspects to the project management processes. In order to clarify the different approaches to the scope of sustainability in projects and project management, Table 2 illustrates five approaches we deducted from literature and logical reasoning. We made an effort to provide logical names for the different approaches, but of course these are arbitrary. The different approaches are illustrated by indicating which processes are in scope in the different approaches (highlighted in black), on the overview provided in Fig. 3.

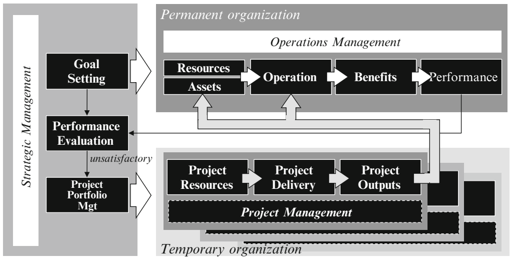
When the concepts of sustainability are considered only on the level of the project management processes, for example labour circumstances of project members or teleconferencing as alternative for travelling to meetings, we talk

Table 2 Different scopes of considering sustainability in project management

Approach	System boundaries
Sustainability in **project management processes**	
Sustainability in **project delivery**	
Sustainability in **project management**	
Sustainability in **the project**	

(continued)

Table 2 (continued)

Approach	System boundaries
Sustainability in **the project life cycle**	

about 'Sustainability in project management processes'. This approach can be found for example in the earlier mentioned Sust PM project.

The 'Sustainability in project delivery' approach also considers the sustainability aspects of the actual delivery of 'production' processes of the project. These processes can be of an informational nature, for example in software development projects, but also of a physical nature, for example in a project to produce gadgets or give-aways as part of a promotion campaign. The 'Sustainability in project management' approach includes also the resources and materials used in these project delivery processes as objects of consideration.

In the 'Sustainability in the project' approach, the aspects of sustainability are also applied to the result or deliverable of the project. As stated earlier, this result can be any kind of change in organizations, policies, products, services, processes, assets and/or resources. The 'Sustainability in the project life cycle' approach adopts the views taken by Labuschagne and Brent and expand the consideration of sustainability aspects to the project, its result and its effect.

Table 2 illustrates that different interpretations exist for the scope or system boundaries of considering sustainability in projects and project management. However, based on the 'Sustainability is about both short term and long term' principle of sustainability, it is inevitable to include the result of the project in the consideration of sustainability aspects. This points towards either the 'Sustainability in the project' or the 'Sustainability in the project life cycle' approach as most suitable.

5 Definition of Sustainability in Projects and Project Management

With the 'system boundaries' of 'sustainable project management' now defined, we can elaborate on what the integration of all six principles of sustainability may imply for projects and project management.

Sustainability is about balancing or harmonizing social, environmental and economical interests
Corresponding with the triple bottom line concept of sustainability, integrating sustainability in projects and project management requires the inclusion of 'People' and 'Planet' performance indicators in the management systems, formats and governance of projects (Silvius et al., 2009). In the current project management methodologies, the management of projects is dominated by the 'triple-constraint' variables time, cost and quality (Project Management Institute, 2008). And although the success of projects is most often defined in a more holistic perspective (Thomas & Fernandez, 2007), this broader set of criteria doesn't reflect on the way projects are managed. The triple-constraint variables clearly put emphasis on the profit 'P'. The social and environmental aspects may be included as aspects of the quality of the result, but they are bound to get less attention.

Sustainability is about both short term and long term orientation
As argued above, the inclusion of the long term orientation stretches the system boundaries of project management beyond what is currently considered as the domain of project management. In the integrated life cycles view demonstrated by Labuschagne and Brent, one could argue that the boundary between the temporary project organization and the permanent organization does not exist anymore. This conclusion, however, confuses managerial responsibility and scope of consideration. The temporary nature of any project organization implies that the managerial responsibility of the project manager is also temporary. This temporariness, however, does not imply a short term orientation. Since benefits of the project deliverable most likely occur after the project has been completed, a longer term orientation, longer than the project life cycle, is also irreversibly included in the scope of consideration of the project.

Sustainability is about local and global orientation
In an increasingly global business world, more and more projects also touch upon the geo-economical challenges we face. Part of the project team may be located in emerging economies like India or China. Suppliers may be all over the world. Or customers benefitting from the project's deliverable. It is clear that the globalizing business world also includes globalized projects and project management. The impact of this globalization trend effects how project teams are organized and managed. Topics like virtual organizations and differing cultures get increasing attention in publications and on seminars. However, the scopes of these publications seem to be limited to the process of performing the project. Within the project management community, the discussion about globalization aspects of the result or deliverable of the project, still has to emerge.

Sustainability is about consuming income, not capital
This aspect of sustainability refers to the principle that resources are not exhausted more or quicker then they may be regenerated. In projects this principle may apply to the use of materials, energy, water and other resources, both in the process of delivering the project or as included in or part of the deliverable of the project.

Since the temporary nature of projects can create an extraordinary pressure for project members, this principle may be explicitly applied to the human resources in the project. Their performance in the projects should not have a negative effect of their future ability to perform.

Sustainability is about transparency and accountability

The principle of accountability is already clearly present in project management. Project managers account for their actions and decisions in regular progress reports. These reports typically include the 'triple-constraint' variables time, cost and quality. Following the earlier mentioned triple bottom line concept, however, integrating sustainability implies that project managers are also accountable for the ecological and social aspects of their projects. This logically implies that project progress reports also include environmental and social indicators.

The principle of transparency is less obvious in project management. The principle of transparency suggests that project managers communicate potentially relevant events, considerations and decisions to (potential) stakeholders. In projects, however, it is common practice that a project manager controls the information flows from the project team to stakeholders (Project Management Institute, 2008), most often with the goal to influence or manipulate the stakeholder's perception of the project. From a stakeholder management perspective, this practice of influencing perceptions is quite logical and rational, but with an expanding set of potential stakeholders, the integration of sustainability would require a more transparent communication with all (potential) stakeholders.

Sustainability is also about personal values and ethics

As discussed earlier, our behaviour as professionals and consumers reflects the values and ethical considerations of our society and of ourselves. Projects and project managers are no strangers to this. Also projects have specific values, norms and rules (Gareis et al., 2009). These values are heavily influenced by the project context, but also by the project manager. For project managers, professional ethics and values are written down in professional 'codes of conduct'. PMI members receive the PMI Code of Ethics and Professional Conduct and most IPMA member associations also have a code of conduct for their members. The content of these codes most often relate to the relationship of the project manager and the project sponsor and the relationship of the project manager and the association that he or she is member of. Some codes, most prominently the PMI one, also mention a responsibility of the project manager towards the society in general. Article 2.2.1. of the PMI Code of Ethics and Professional Conduct states that "We make decisions and take actions based on the best interest of society, public safety, and the environment." The statement clearly connects ethics and professional conduct with the concepts of sustainability.

Considering the perspective of projects as an instrument of change, the holistic nature of the sustainability principles and the conclusion on the appropriate scope to be considered, we developed the following definition of 'Sustainability in Projects and Project Management'.

Sustainability in projects and project management is the development, delivery and management of project-organized change in policies, processes, resources, assets or organizations, with consideration of the six principles of sustainability, in the project, its result and its effect.

6 Conclusion

Projects can make a contribution to the sustainable change of organizations. It should therefore be expected that the concepts of sustainability are reflected in projects and project management. And although some aspects of sustainability are found in the various standards of project management, it has to be concluded that the integration of sustainability in projects and project management is not fully recognized yet. In exploring what sustainability means for projects and project management, this chapter raised a number of key questions on this issue. These questions were:

- Which system boundaries should be taken into account when considering sustainability in projects and project management?
- How can sustainability in projects and in project management be defined?

These questions were explored and some first conclusions were reached. It is, however, clear that still a lot of work has to be done on the implications of Sustainable Project Management and that there is a growing need of expertise, criteria and concepts to practically implement the concepts of sustainability in the management of projects. The consequences are not at all clear yet and may even be underestimated. However, it seems apparent that integrating the concepts of sustainability 'changes the game' of project management. Project management will need to develop from 'doing things right' to 'doing the right things right'. This implies taking responsibility for the results of the project, including the sustainability aspects of that result.

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Part III
Cases and Examples

The Potential of a Network-Centric Solution for Sustainability in Business Processes

Hans Thies, Ali Dada, and Katarina Stanoevska-Slabeva

Abstract Due to an increasing pressure from international regulation, customers and other stakeholders, companies are increasingly experiencing the need to incorporate sustainability considerations in their core business processes and daily operations. For this purpose they require software solutions that simplify the collection, analysis, and incorporation of sustainability indicators at the right processes across their operations. However, prevailing systems are enterprise-centric in the sense that they are owned and used by one focal company collecting the data from different sources and using it for its internal decision making. This paper will describe three example use cases in which sustainability plays a key role and will provide an overview of major problems with the current state of the art. In the second part of the paper, a new approach for sharing sustainability indicators is introduced that enables many providers and consumers of environmental data to connect to and leverage a common platform. Finally, the paper analyzes the potential risks and benefits of introducing such a network platform, using the three business use cases to illustrate the opportunities resulting from it.

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1 Introduction

Driven by governmental regulation, market demand and strategic considerations (Amacher, Koskela, & Ollikainen, 2004; Yalabik & Fairchild, 2011), companies are increasingly taking action to improve their sustainability records. For example, most large enterprises regularly assess their emission inventories, set reduction targets, and report on their improvements to various stakeholders (Seuring & Müller, 2008). Leading enterprises are even going beyond static sustainability reporting by incorporating environmental and social indicators into their core business operations, e.g. in product life-cycle management, material sourcing, and supplier management (Koplin, Seuring, & Mesterharm, 2007; Lobendahn Wood, Mathieux, Brissaud, & Evrard, 2010). Such companies have in particular understood the value of improving their processes to achieve environmental excellence; the same way they collaborate with others to improve their supply chains with respect to time, quality, and total cost (Handfield, Sroufe, & Walton, 2005; Sharfman, Shaft, & Anex, 2009).

Information systems are not "keeping up" with the above sustainability trends in business. First, most of the current IT solutions do not provide the needed sustainability indicators and related support in the daily business tasks; instead they mostly aim at supporting a separate environmental role in monitoring, improving, and reporting on sustainability targets (Matt, 2010). As discussed above, this is not enough because there is a high leverage in incorporating environmental indicators with the daily business operations and respective decisions. Second, most of the current solutions that provide support for inter-organizational data collection and considerations do that in a one-to-many, enterprise-centric approach that is difficult to scale. In this approach, each client independently requests data from many providers (e.g. its suppliers). Another client would do the same; therefore one supplier may need to respond to slightly different requests several times. This gives rise to, among others, cost and scalability problems (Linthicum, 2001).

This paper introduces a many-to-many, network-centric solution that companies can use, particularly in inter-organizational scenarios, to easily share and use environmental performance indicators (EPIs) in their business processes. The main idea of this new approach is that many data providers, for example suppliers in a supply chain, publish their requested EPIs on a common platform while many clients use this information in their business operations. Having a common platform for sharing the EPIs in a many-to-many approach eliminates the need for data providers to enter the data multiple times and saves the requesters the time and effort of collecting the EPIs.

The core contribution of the paper is to analyze the potential benefits and risks of providing such a solution. The next section summarizes the research methodology, followed by a literature research. The use cases are described in the fourth section, followed by a summary of the challenges of the status quo that were identified. Then the proposed network architecture is introduced and the benefits and risks are illustrated. The research concludes with a short summary and outlook.

2 Research Methodology

For collecting the requirements of a potential network-centric architecture and investigating potential benefits and risks of such a solution, the case study research approach as suggested by Yin (2003) and Eisenhardt (1989) was followed as illustrated by Fig. 1.

Based on an in-depth literature research, the requirement was deduced that a network-centric architecture for the inter-organizational exchange of environmental data will be beneficial for environmental management in terms of costs reduction and data quality improvement. Furthermore, an initial concept for such a platform was developed. Then an industry workshop involving environmental and technical employees of five European companies and three universities was conducted to select appropriate use cases. One conclusion of the workshop was that due to the large amount of data that is considered in sustainability supporting applications, the problems are particular eminent for large enterprises (LEs) and complex products. Furthermore, proposed use cases were ranked and the most prominent three of them were selected as being representative for current problems in inter-company cooperation related to sustainability matters. The data to be collected was identified as a combination of tacit expert knowledge and explicit knowledge contained in existing processes and software. Thus, expert interviews with environmental and technical staff were chosen as an appropriate data collection mechanism in conjunction with an examination of the software in use at the particular case companies. In each company, the status quo for the three use cases was identified and analyzed. Since the results proved extremely consistent despite the differences in industry and geographical region, no additional case studies were planned. Finally cross-case conclusions were drawn, the requirements for a

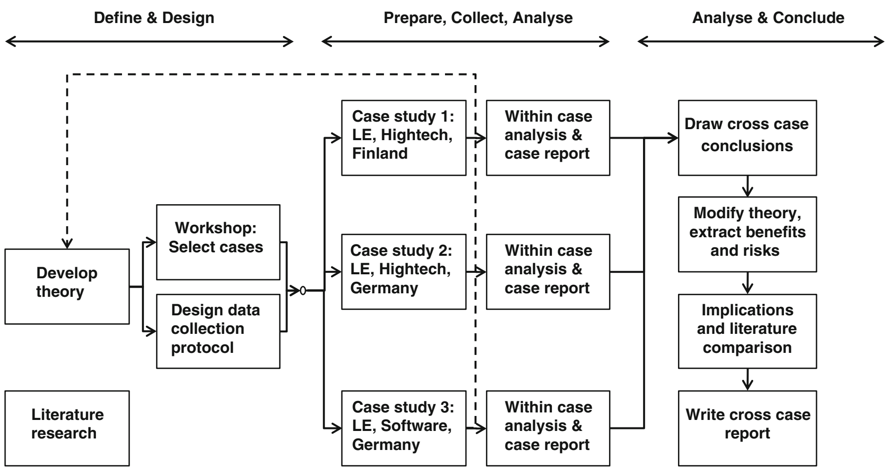

Fig. 1 Research methodology (Based on Yin 2003)

network-centric architecture were modified accordingly and implications were drawn. This was done together with the case companies leveraging two rounds of workshops. In a first round the proposed initial concept of the platform was refined. A second round served to identify potential benefits and risks related to a potential introduction of the platform. The results were furthermore compared with the body of knowledge from the literature review before the case report was written.

3 Related Work

In this section the body of knowledge related to this research in terms of processes (environmental supply chain management), supporting information systems (Green IS) and the underlying network-enabling systems and technologies will be presented. The literature was found using the academic databases Proquest (ABI/INFORM) and Elsevier (Science Direct) since they contain the journals and conference proceedings that were classified as most important for the research area. Complementary research in the university catalogue of the University of St. Gallen and Google Scholar completed the first body of knowledge, which was later enriched by forward and backward search. The literature presented is selective, thus only illustrates the most relevant research concisely.

3.1 Environmental Supply Chain Management

Environmental management (EM) comprises all efforts by a company to reduce the negative environmental impact of its products and operations across their life cycle (Klassen & McLaughlin, 1996). Papers already in the mid-1990s observed the need for a close interaction between environmental and operations management. For example, Gupta (1995) referred to prominent EM examples for including environmentally-friendly product design and waste minimization, e.g. source reduction and recycling. His thesis was that operations management must be directly involved in any of these, and in the setup of the overall environmental management system. The environment has also been suggested as an additional performance criterion for operations, in addition to traditional ones such as cost, quality, time and service (Burgos Jimenez & Cespedes Lorente, 2001). There are various environmental management topics, each with a vast body of research. Since the focus of the research presented in the paper at hand is on cross-organizational improvements, the most significant EM area to consider is the supply chain. Therefore, the rest of this subsection will address the topic of Environmental Supply Chain Management (ESCM).

Zsidisin and Siferd (2001) define ESCM for a firm as “the set of supply chain management policies held, actions taken, and relationships formed in response to concerns related to the natural environment with regard to the design, acquisition, production, distribution, use, reuse, and disposal of the firm's goods and services." Walker, Di Sisto and McBain (2008) provided a literature review of drivers and barriers for ESCM and grouped each by its category. For example, drivers can be internal (e.g. desire to reduce costs, quality improvement, pressure from investors) or external (e.g. regulations, customers, competition, society). Barriers can also be internal (e.g. costs, lack of training) or external (e.g. poor supplier commitment). Many studies took a case study approach to show how companies consider ESCM in practice (Bowen, Cousins, Lamming, & Faruk, 2006; Koplin et al., 2007; Lamming & Hampson, 1996; Lobendahn Wood et al., 2010). Prominent sustainability considerations included supplier management using indicators such as the implementation and certification of an environmental management system (Lamming & Hampson) and product stewardship such as procuring recycled materials (Bowen et al.). Also many authors relied on mathematical modeling techniques to derive formalized decision-making methods in ESCM. One of the main application areas is supplier selection (Handfield, Walton, Sroufe, & Melnyk, 2002; Humphreys, Wong, & Chan, 2003; Kuo, Wang, & Tien, 2010). For example, Handfield et al. constructed a decision-support model based on the Analytical Hierarchy Process to help companies evaluate the environmental performance of suppliers. They used a wide range of environmental indicators that included internal supplier programs, product-level considerations, and third party certification. Another application area of formal models in ESCM is in green product design (Dangelico & Pontrandolfo, 2010; Vinodh & Rathod, 2010). These papers aim to provide companies with formal methods to integrate environmental aspects in design issues, often taking a life cycle approach in the impact assessment.

As seen in this sub-section, there are many examples from research and industry on the importance and adoption of environmental indicators in various supply chain decision areas. This paper will provide more detailed examples of three prominent business scenarios, but first the state of the art information systems that address EM needs is investigated.

3.2 Green IS: Solutions for Environmental Sustainability

Companies generally follow one of four solution approaches to account for and manage their environmental performance indicators (EPIs) (Dada, Staake, & Fleisch, 2010):

- Spreadsheet-based home grown solutions are widely used, especially when companies are still in an early learning phase.
- Some companies are customizing traditional enterprise costing tools to fit the new need of environmental accounting.
- Specialized Life Cycle Assessment LCA tools are widely used for product-level impact analyses.
- Finally, special purpose EPI management tools are gaining in popularity.

- Fulfilling an environmental management task is the common end of all these approaches, however they generally do not allow traditional business solutions (e.g. for purchasing) to compare the environmental impact of alternative decisions. The following paragraph gives an overview of existing solutions pertaining to the last categories above, since they represent the state of the art in IT tools.

The relevance of carbon, energy, and waste management to businesses in the recent years led to a surge in business software designed to aid companies in this area. EPI management has become a common, voluntary practice for many companies, generating demand for dedicated, easy-to-use software. Traditional Environment, Health and Safety EH&S vendors in addition to niche market players are responding with extended or completely new functionalities to support this need (Jacobson, 2010). Some of the most prominent EPI management tools and their providers are (Dada, 2011):

- Enablon GHG-MS[1] (Enablon)
- GHG Management and Carbon Accounting[2] (Enviance)
- Hara Environmental and Energy Management[3] (Hara)
- IHS GHG and Energy Management Solution[4] (IHS)
- SAP Carbon Impact[5] (SAP)

The solutions offer a wide range of capabilities that support companies in their EPI management including data collection, EPI calculation, target management, what-if scenario modeling, emission reduction, and reporting. Most of them focus on the organizational level but some offer support over the product life cycle. However, these tools are meant to be used by environmental roles, instead of operational personnel that perform the business tasks of the firm. Also, the solutions are not designed as many-to-many network solutions that allow inter-organizational collection and leverage of EPIs.

As opposed to the significant body of EM research, there are only very few IS papers that aim to address the issue with concrete applications in this area. This is due to a bigger emphasis on Green IT (decreasing the environmental impact of IS) rather than Green IS (employing new IS applications to decrease environmental impact across industries) (Boudreau, Watson, & Chen, 2008). Only recently are authors investigating the latter, especially via papers that map out an IS research agenda to address the environmental sustainability challenges (Melville, 2010; Watson, Boudreau, & Chen, 2010). This paper takes account of this gap in Green

[1] http://enablon.com/products/carbon-management.aspx.

[2] http://www.enviance.com/solutions/greenhouse-gas-emissions.aspx.

[3] http://www.hara.com/solutions_overview.html.

[4] http://www.ihs.com/environmental-health-safety-sustainability/.

[5] http://sapcarbonimpact.com/.

IS research, specifically by proposing a network-solution to support scenarios requiring inter-organizational EPI sharing.

3.3 Network-Enabling Systems and Technologies

Authors have discussed various approaches and underlying technologies that enable better support for business networks than the traditional monolithic enterprise applications. Iyer, Freedman, Gaynor and Wyner (2003) argue that traditional information systems do not provide the required flexibility for implementing business network applications. This is due to the dynamic nature and rapid changes of business networks. The authors therefore propose using loosely-coupled web service infrastructure to address these needs. Camarinha-Matos and Afsarmanesh (2005) use the term "collaborative network" for a wider context that comprises various types of entities. Regarding the information system support, the authors refer to different contributing technologies including multi-agent technology, web services, pervasive computing, and location aware environments.

Several papers provided visions and concrete architectures based on web service infrastructures to enable network collaboration (Barros & Dumas, 2006; Boley & Chang, 2007; Heistracher et al., 2004). The vision introduced by Barros and Dumas is that of a marketplace of services offered by a plethora of providers to service consumers. Their high-level architecture for this "web service eco-system" includes various roles in addition to enabling technologies. The concept of cloud computing, delivering computing power, systems software and applications as services over the internet, has been identified as an enabling technologies for B2B networks as it provides the possibility for all partners to access the network using a third trusted entity as provider facilitating scalability and low costs at the same time (Armbrust et al., 2010). Boley and Chang stress the importance of semantic web ontologies and rules for the success of such network.

According to our knowledge, there is no literature that specifically discusses the concept of a business network for sustainability purposes. The next section provides example use cases where environmental considerations play a key role, before introducing a many-to-many network for sustainability.

4 As-is Analysis of Example Use Cases

This section describes three use cases with high sustainability and financial impact thereby illustrating why business processes and EPIs should be aligned more closely in order to improve in both areas. The use case approach was chosen to analyze the business-driven need for new network-centric solutions.

4.1 Sourcing and Procurement

The sourcing and procurement use case outlines the current environmental considerations pertaining to supplier management and operational purchasing. We also articulate the use case goals which follow from the high-level goal of enabling the purchasing organization in benchmarking different suppliers of the same material with regards to specific Environmental Performance Indicators (EPIs).

4.1.1 As-is Process Analysis

Supplier Management

Supplier management includes the evaluation of suppliers against several criteria such as quality, service, and financial aspects. Annual supplier evaluations typically follow an explicit program that includes setting performance categories and their weights, supplier scoring, and improvements. Environmental criteria are also part of this evaluation process, however they mostly comprise binary requirements that have to be fulfilled, e.g. existence of a certified environmental system, energy reduction programs, etc. However, because they are yes/no questions that all accepted suppliers have to meet, different suppliers of the same product are not differentiated in their environmental performance.

Material Compliance

The operational procurement function has the responsibility of carrying out the purchasing activities of a specific division, e.g. product line or business unit. Also, they should ensure that material-level environmental compliance requirements (e.g. WEEE and RoHS-compliance for electronics components) are included in the normal supplier contracts. Because of the compliance-driven nature, these requirements cannot be used to achieve environmental improvements: suppliers either comply or not, and there’s no basis for comparing compliant suppliers.

Environmental Assessments

The environmental management of a company performs two activities relevant for this use case. It is responsible for reporting on enterprise-level emissions; e.g. their greenhouse gas emissions. This sometimes includes emissions caused by suppliers and those due to supplied materials. It also conducts occasional product-based environmental assessments using the life-cycle assessment methodology. This requires data input from first tier suppliers and sometimes even beyond.

4.1.2 Use Case Goals

The high-level goal of this use case is to decrease the environmental impact across the product life cycle. This is achieved via including EPIs in the purchasing decisions, in particular for materials with high business and environmental leverage. Three success factors to measure the impact of any approach to include EPIs in the procurement process have been derived together with the industry experts:

- Usage of quantitative supplier-specific material-level EPIs
- Incorporation of EPIs in purchasing operations by the business users
- Percentage of suppliers that provide material EPI data without increase of cost

4.2 Design for Environment

Design for Environment (DfE) is a general concept that refers to a variety of design approaches that attempt to reduce the overall environmental impact of a product, process or service across its life cycle. Based on product and process data, the environmental impacts of different alternatives have to be calculated and compared. Design for environment deals with several topics like environmentally- conscious manufacturing, design for disposal, and packaging related topics. Besides the identification of weak points of a solution and the comparison of alternatives, the tradeoff between decisions in different life cycle phases has to be investigated. The goal is to identify the design alternatives within the product lifecycle that can enable environmental impact reduction at minimal additional costs.

4.2.1 As-is Process Analysis

Life Cycle Assessment (LCA) is conducted by environmental experts. The current process often is characterized by a time-consuming information retrieval from different databases, spreadsheets and other information sources even across organizational boarders. The main process steps applied to LCA are:

- Goal and Scope (Define system boundaries, data quality)
- Data inventory analysis (collecting data, calculation, allocation)
- Life cycle impact assessment
- Life cycle interpretation (weak point, what-if-scenario and sensitivity analysis)

Typical users involved are environmental experts (performing the LCA, setting environmental targets or thresholds), product management (providing input data, defining development directions), in addition to other departments (e.g. procurement, production) that might provide input data

4.2.2 Use Case Goals

The high-level goal of this use case is to decrease the environmental impact of products along their life cycle. This is achieved via *including EPIs in the comparison of design alternatives*. LCA is a part of the comparison and the following processes address two major process steps of LCA:

- Data inventory analysis (collecting data, calculation, allocation)
- What-if-scenarios as part of life cycle interpretation

In order to incorporate EPIs into early design decisions, the data should be presented in a way that non-experts in the environmental domain like product designers can understand it and make meaningful conclusions. On the other hand, the necessary detail level should be provided. For data that is not directly available, meaningful placeholders should be derived through assumptions, comparisons etc. Another use case goal is introducing bottom-up support (support of business users by a community through examples and best practices).

4.3 Preparation of an Environmental Performance Report

The communication of the organization's environmental performance is an integral part of any activity related to environmental sustainability. For efficient communication to a specific target group, different data in different granularity is needed. The goal is to enable an efficient, reliable, and transparent reporting.

4.3.1 As-is Process Analysis

Environmental communication can be divided into two types: Regular communication efforts and ad-hoc communication.

Regular Communication

Regular environmental communication efforts, such as quarterly or annual sustainability reports, have a given structure which only evolves occasionally. This means that the underlying data sources do not change significantly from report to report. Organizations often follow different standards that define the reporting, of which the Global Reporting Initiative (GRI) is the most widely acknowledged guideline for sustainability reporting (Nikolaeva & Bicho, 2010). The main work is related to the collection of the data, which still involves huge manual efforts. In order to retrieve the data, each involved facility or site has to be contacted and the data adapted for system usage. Often there are third parties involved that own the data and/or do the calculations and they too provide the data in formats that also have to be adapted. Environmental data is currently stored in multiple databases within the company, therefore for the creation of a report data has to be retrieved from different information sources.

Ad-hoc Communication

Ad-hoc communication efforts are triggered by a certain event, e.g. a customer request, a criticism to corporate behavior, etc. When an irregular report is created, in a first step the required data and system boundaries have to be determined. After this, the data has to be acquired. This involves accessing many data types in different locations and formats. Since not all data is available in digital format, it also involves finding people and manual work. In the next step, the data has to be transferred to an EPI calculation tool. If the data is incorrect or does not have the desired granularity, the data source and all manual processes have to be tested for correctness. Only then the EPIs for the report can be calculated.

4.3.2 Use Case Goals

The overall goal of environmental reporting is to provide environmental data to stakeholders within and beyond the organization in an easily digestible way. Until today, environmental reporting often is a one-off process that has no or only rarely connection to the daily business processes. This leads to a situation where environmental reporting is mainly seen as a cost driver and not as an enabler for a sustainable and innovative business. If the environmental reporting is used to make the supply chain more transparent, remove waste and risks and ensure compliance to environmental regulation, the opposite can be the case. Several cases have indeed shown that an increased transparency in environmental performance can also lead to an improved economic performance (Rao & Holt, 2005).

Organizations pursue different goals with environmental reporting. As summarized in the GRI Reporting Guidelines, the main ones are:

- Benchmarking and assessing sustainability performance with respect to laws, norms, codes, performance standards, and voluntary initiatives;
- Demonstrating how the organization influences and is influenced by expectations about sustainable development; and
- Comparing performance within an organization and between different organizations over time.

5 Challenges

This section will give an overview of the challenges identified in the three use cases.

Availability: The main problem in all use cases is the general availability of environmental data. Often, quantitative EPIs are not even in use, and only qualitative questionnaires are common for evaluating suppliers, for example.

Company-related environmental data is scattered within the organization, while product- or supply chain-related data is even scattered across organizational borders. As in the case of Sustainable Sourcing and Procurement, companies have to collect EPIs throughout the whole supply chain and establish connections to all their sub-suppliers for making product assessments. Since usually no direct business connections exist between those companies as well as no standardized processes, the data requests are difficult and response rates extremely low. In the case of design for environment, data from different sources has to be collected. Public databases are often imprecise or lack data for the exact required materials. Differing standards and collection methods complicate the process. This especially holds for data of new products where EPIs have not been calculated yet and the production process has not been established. As a consequence, the EPIs would have to be estimated. Suppliers may not be able or willing to provide EPIs in a very early stage of development. Additionally, some of the data may be confidential and therefore not be provided to other companies.

Lack of comparability: In all use cases, comparability is very limited due to different EPIs, baselines, and reporting standards. Not only is it impossible to compare the sustainability reports, suppliers and materials because of different reporting standards and different data included, but even comparing the EPI of an organization with e.g. the value of the preceding year is difficult. In order to gain a useful comparison, one would need to be sure that both companies use the same measurement methods and assumptions. Also, comparing suppliers from different geographical regions is almost impossible because of different regulations, energy mixes etc. Currently, data is often compared without making these considerations which then leads to less meaningful results. This is particularly eminent in the case of environmental reporting: Because no common standards and EPI implementation guidelines exist, the data of two companies are hardly comparable for the stakeholders. Additional reasons for this are the different organizational structures, product portfolios and geographical regions of operation. Even the reports of the same organization in two different periods may hardly be comparable because of mergers/acquisitions, changing regulation, and changing supplier base and economic growth. As a consequence, the reports are not interpretable by any user without a strong environmental reporting background.

Inflexibility: Due to complex processes and little automation, current approaches are very slow and inflexible. Definition and implementation of EPIs can take up to a year and more, accessing all data required and calculating EPIs up to 6 months. This makes it impossible to quickly react to socio-economic changes or specific crisis situations. If a new indicator that an organization would like to report on does not exist in the company yet, its ease of implementation depends on whether the necessary data has already been collected or measured somewhere.

Lack of process integration: This problem is particularly eminent in the case of sourcing and procurement. Environmental optimizations in purchasing will only take place when environmental indicators are incorporated into the processes, ideally in the procurement, design or reporting tools in use. Currently, the incorporation of material-level EPIs into the company processes and decisions is still not defined and without it, the indicators will not be applicable.

Costs: The current process is often characterized by time-consuming information retrieval from different databases, spreadsheets and other information sources even across organizational boarders. Since the data is scattered within the organization or even across its boarders, a huge number of employees has to be involved. Due to the lack of automation and incompatible formats and processes, the costs of bringing environmental data into the business processes are high. Especially the collection of all required data for environmental reporting is extremely time-consuming. This is not only an issue of data availability and process costs, but also of the critical reaction time to emerging events. In ad-hoc reporting, it is necessary to react to a certain situation and be able to support the argumentation with suitable data. A fast collection of data and computation of EPIs is therefore absolutely required in the context of ad-hoc environmental reporting.

6 Network-Centric EPI-Sharing System

Value creation that incorporates EPIs requires collaboration among different supply chain entities. This especially holds for product-level indicators, since the required resources are scattered along the whole supply chain. Collaboration in supply chains is not a new topic. However, the focus of most of these systems has been on logistics and procurement. The goal of keeping procurement costs and inventories low while keeping cycle times short has motivated partners to work together and reveal data. This has lead to a number of different approaches which support collaboration through the mechanisms of information integration, process and resource coordination and reporting of performance measures (Lee, Kim, Noh, & Lee, 2010). The types of collaboration systems fall into three major categories (McLaren, Head, & Yuan, 2002):

- Message-based systems which enable one-to-one communication between the supply chain partners, using standards such as EDI or XML-based messages,
- Electronic portals or marketplaces which mainly serve for offering and purchasing of products. They are either based on one-to-many or many-to-many communication, depending on the exact specification,
- Shared collaborative SCM systems, such as systems for collaborative planning, forecasting and replenishment (CPFR). Many of these systems are ERP-based. This leads to the fact that in most cases although the principle follows a network-based approach, messages are exchanged one-to-one.

These systems differ in their total costs of operation and their opportunity costs through inflexibility and lock-in as well as in their capabilities for enabling the integration of information and processes.

Although they promise many benefits, the adoption of systems of all three types has fallen short of all expectations. The reasons for this have been discussed controversially. The most mentioned arguments have been the lacking trust of partners to reveal data within the supply chain, supplier resistance, and high costs of implementing the system combined with long periods of amortization. The argument of trust is supported by the fact that during the last years, small private networks in industries with static vendor relationships have been more successful. In contrast to that, open network-based approaches in dynamic industries reveal their true benefits with an increasing number of participants. This leads to a first-mover problem, where nobody wants to take the first step in fear the network may never reach a critical mass to justify investments (McLaren et al., 2002).

Since traditional mechanism are costly and fail to collect all required data with sufficient quality, we propose the concept of a network-centric information system for B2B EPI exchange. This idea is similar to that of Supply Chain Collaboration Information Systems: Through connecting all partners in the supply chain via a central data repository, the ease of sharing and accessing high quality data is improved, and the low response rates of classical one-to-one communication can be avoided.

It is almost impossible to establish business relationships with all necessary organizations by classical means. According to the interviews with industry partners, experience has shown that response rates are in general as low as 5–10%. All other data has to be collected manually, e.g. by material experts and consultants, with the corresponding high costs. One important reason for this is the high costs of implementing one-to-one communication channels with a high number of partner organizations. Electronic Data Interchange (EDI) as the dominant one-to-one communication technology has never accomplished its expectations because the entry costs for small and medium-sized companies without strong IT-department have been too high (Iacovou, Benbasat, & Dexter, 1995). As shown in the use case descriptions, not even commonly accepted standards exist, which means that the companies have to communicate their data using not only one, but many different standards and formats. The network-centric IS approach solves this problem by a number of different means:

- Single source for accessing and sharing EPIs
- An EPI description language for describing EPIs and related data
- Common environmental reports, supplier EPIs etc. provided by the community
- Interface to use case specific backend systems
- Content such as reporting standards, important regulations, etc.
- An EPI community

Organizations only have to join the network once. Since the platform works based on the cloud paradigm on demand, no installation is necessary and implementation costs are kept low. After their identity has been approved by the provider, they can load their EPIs on the platform, share it with stakeholders and request access to other companies' data.

The System supports functionality in three main areas (see Fig. 2): Transaction, analytics and collaboration. Besides the transactional use case support which is ensured through lightweight gadgets and applications on top of the platform as well as an interface for backend integration, analytical functionality can provide

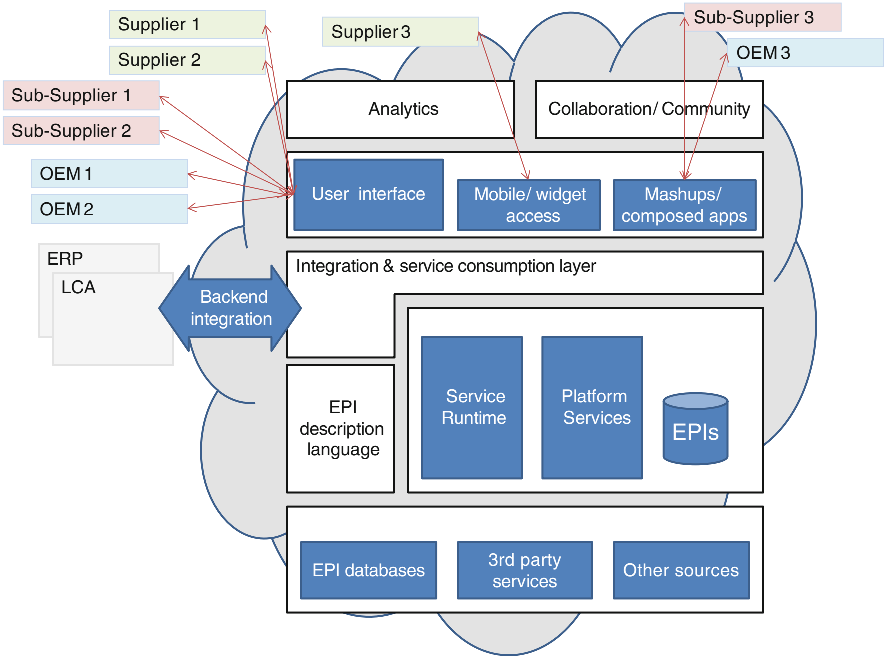

Fig. 2 Network-centric EPI-sharing system

information about the status of the supply chain, industry averages, industry benchmarks, typical problems and solutions, extended search functionality etc. Collaboration functionality enables easy connections to partners, fast communication and problem-solving tools.

7 First Assessment of the Network-Centric Solution

7.1 Expected Benefits

During the second industry workshop with the three partners involved in the use cases, potential benefits of the proposed system were identified. Interestingly, the potential benefits of the system that have been identified by experts relate to the problems of the status quo. It cannot be presumed that all benefits can be achieved to the same degree.

7.1.1 EPI Availability

The system is planned as a common source for EPI data within a supply chain, or even within an industry. Thereby, it will be able to make EPIs available across organizations. By dramatically decreasing the amount of connections and data sources needed while increasing availability of support and best practices through the community, providing EPIs will become easier and less expensive. Also, increased transparency in EPI calculation may lead to higher demand for environmental reporting by the stakeholders. In the case of Sustainable Sourcing and Procurement, the whole supply chain including small and medium enterprises can be enabled to take part in the process of providing data for e.g. product assessments through reducing the effort for publishing by providing a single platform offering simple web access and community support as well as example implementations and best practices. Similar results are expected in the case of Design for Environment.

7.1.2 Transparency and Comparability of EPIs

With a network-centric solution, it will be easier to implement and converge towards common baselines, system boundaries and methodologies. Furthermore standardization will be encouraged by providing best practices. In the case of Design for Environment, the community can help to provide more standardized EPIs. Furthermore, a common EPI "language" leads to a clear understanding to what is included in the indicators and thus the reports. The idea is not to provide the standards top-down but to encourage the community to reach de-facto standards by reuse of the most commonly used practices in EPI calculation and sharing so that system boundaries and EPI calculation methodologies will converge within an industry. The reason why this is presumed to happen is that cost pressure will not allow for several reporting standards to exist at the same time because the additional effort exceeds the benefits. Although the workshop indicated the possibility of this development, this hypothesis remains to be tested.

7.1.3 Flexible Calculation of EPIs

The long periods of time that are required for the implementation of completely new EPIs can only be solved if environmental reporting becomes as much of a standard as financial reporting is today. Establishing a network-centric solution as a primary source for providing and consuming EPIs would support this process and speed up data acquisition. However, as one expert stated, the implementation of new EPIs can only work if it goes hand in hand with a change in processes and corporate culture, including executive support.

7.1.4 Process Integration

The increased environmental transparency achieved at reasonable costs enabled new business benefits that can help anchoring the awareness of integrating EPIs with processes. This is supported by a standardized interface for backend integration. The interface can facilitate integration with Product Lifecycle Management (PLM) tools in the case of Design for Environment or to SRM/procurement tools in the case of Sustainable Sourcing and Procurement.

7.1.5 Performance and Costs of EPI Calculation

For many experts, costs were only a secondary problem, since the availability and quality of EPIs has not reached a satisfactory point. Nevertheless, if environmental reporting and business considerations become more of a standard, costs will ultimately become an important factor. With a single network, transactional costs to provide the data (once instead of per-request) will decrease. In the case of Design for Environment, the EPI language can foster streamlined system boundary setting, methodologies and data source discovery, and a message system can send notifications to required contributors. At the same time, the support of the community can help to learn best practices and enhance the speed and quality of reporting, while reducing costs.

7.2 Risks Associated with the Introduction of the System

We describe in this section a list of potential risks that may hinder the adoption or the applicability of the system, which were identified through industry interviews.

7.2.1 System and Technology Risks

Critical requirements are not met: A system that doesn't adequately satisfy (at least the high-priority) users' functional and non-functional requirements would not meet its business purpose and runs into a high adoption risk.

Technology does not scale: The underlying goal of the platform is to connect many companies and huge amounts of their environmental data to use across multiple processes. This poses a technology scalability requirement that should be met to realize the full potential of the system.

Ease of use: The value and adoption of an information system is closely linked with its ease-of-use, especially for non-IT experts, e.g. business users and environmental experts. The severity of this risk can only be assessed based on the first results of the development effort.

Cloud computing acceptance: There are still a few insecurities concerning the use of cloud computing for business critical applications: These relate to data security, legal terms and a general insecurity about the risks and future of cloud computing.

7.2.2 Market Adoption Risks

No critical mass: The platform only has value through high availability of user-provided content. With only a few participants, the proposed use cases, most of which are in inter-organizational scenarios, will not add value compared to the status quo solutions. After a certain critical mass of adopters, it will become easier to gain even more users because of network effects.

Perception of environmental issues: Different companies, industries, and countries have a very different perception of the importance of environmental issues. If they are not seen as highly significant for businesses and not backed by top management, there is a high risk of market acceptance.

Lack of community commitment: A lack of community commitment will directly affect the standardization potential and content which is intended to be provided by the community.

Quicker solution on the market: There are also issues related to the competitive landscape, e.g. if a solution that addresses the same domain with similar technology gets quicker on the market. Once such a competitor wins many customers, it would become difficult to gain much market share by another solution.

7.2.3 Platform Data Risks

Data confidentiality: A network-centric EPI sharing system requires partners to provide their EPIs to a wider community of companies that may include competitors. This may give rise to confidentiality concerns among companies that need to be addressed with suitable mechanisms.

Data availability: Another data dimension is its availability: the network-centric EPI sharing platform would not be used if it lacked valuable information. This situation can be due to many of the risks above which results in lack of users and wide adoption, directly affecting the availability of data.

Data accuracy: The value of a network-centric platform lies in the data it has. EPI providers may enter data that shows a better performance than is actually the case. There are several similar situations where, without a data assurance mechanism, the platform EPIs would not be usable. A very important aspect of data quality is related to the reliability and accuracy of data, which are recurring themes in environmental studies and information sources. Low data reliability, e.g. because certain companies do not have the capability or integrity to provide data with sufficient accuracy, would directly affect the leverage and value of the platform.

Data actuality: The applicability of the data provided on the platform is closely related to its actuality. Only current data enables functions such as a comparison of different materials by different suppliers in the "Design for Environment" use case, or ad-hoc reporting in the environmental reporting use case.

8 Conclusion

This paper is motivated by the importance of incorporating environmental indicators in core business processes, in particular in those with a high need for inter-organizational data. The availability of such indicators enables making the right decisions; however current systems still rely on one-to-many solutions to collect the data. Since these do not scale for the industry needs, this paper introduces a many-to-many network-centric solution to solve this problem. To make the current shortcomings and solution more concrete, we presented three use cases where sustainability has a prominent role to play. These were analyzed by experts with respect to their status-quo, current problems and desired goals, in addition to the impact of introducing the network-centric system for collecting and managing inter-organizational EPIs. The paper provides an assessment of the potential impact of such a system. As future research, a prototypical solution will be implemented which enable a more detailed assessment of the system, thereby better analyzing its actual impact.

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Understanding the Maturity of Sustainable ICT

Edward Curry and Brian Donnellan

Abstract Sustainable ICT (SICT) can develop solutions that offer benefits both internally in IT and across the extended enterprise. However, because the field is new and evolving, few guidelines and best practices are available. There is a need to improve the SICT behaviours, practices and processes within organizations to deliver greater value from SICT. To address the issue, a consortium of leading organizations from industry, the nonprofits sector, and academia decided to develop a framework for systematically assessing and improving SICT capabilities.

The SICT Capability Maturity Framework (SICT-CMF) gives organizations a vital tool to manage their sustainability capability. The framework provides a comprehensive value-based model for organizing, evaluating, planning, and managing SICT capabilities. Using the framework, organizations can assess the maturity of their SICT capability and systematically improve capabilities in a measurable way to meet the sustainability objectives including reducing environmental impacts and increasing profitability. The core of SICT-CMF is a maturity model for SICT which provides a management system with associated improvement roadmaps that guide senior IT and business management in selecting strategies to continuously improve, develop, and manage the sustainable IT capability.

This chapter describes the SICT-CMF and the use of it to determine the maturity of sustainable IT capability within a number of leading organisations. The chapter highlights the challenges in managing SICT and motivates the benefit of maturity models. The development process for the SICT-CMF is discussed and the role of Design Science in the development cycle is explored. The application of the

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resulting model and its use to measure SICT maturity is discussed together with an analysis of the average results for organisations using the model. The chapter concludes with practical insights gained from the assessments.

1 Introduction

Addressing environmental concerns with sustainable solutions plays an ever-increasing role in remaining competitive in today's market place. Researchers estimate that information and communication technology (ICT) is responsible for at least 2% of global greenhouse gas (GHG) emissions (Webb, 2008). Furthermore, in any individual business, ICT is responsible for a much higher percentage of that business's GHG footprint. Yet researchers also estimate that ICT can provide business solutions to reduce its GHG footprint fivefold (Enkvist, Naucler, & Rosander, 2007).

As organizations embrace sustainability agendas they will need to develop relevant capabilities to deliver on the promise. IT departments that want to be key players within their organization's sustainability strategy will need to develop significant Sustainable ICT (SICT) capability. Green IT (Murugesan, 2008) and Green IS (Boudreau, Chen, & Huber, 2008) are the primary tools that are used within an SICT capability to enable sustainability business practices. However, a SICT capability goes beyond technology to encompassing other factors such as alignment with corporate sustainability strategy, project planning, developing expertise, culture, and governance. Using Green IT and Green IS SICT can develop solutions that offer benefits both internally and across the enterprise by:

- Aligning all ICT processes and practices with the core principles of sustainability, which are to reduce, reuse, and recycle; and
- Finding innovative ways to use ICT in business processes to deliver sustainability benefits across the enterprise and beyond.

However, because the field is new and evolving, few guidelines and best practices are available.

To address this issue, a consortium of leading organizations from industry, the non-profit sector, and academia has developed and tested a framework for systematically assessing and improving SICT capabilities. The Innovation Value Institute (IVI; http://ivi.nuim.ie) consortium used an open-innovation model of collaboration, engaging academia and industry in scholarly work to create the SICT-Capability Maturity Framework (SICT-CMF).

Over the past 2 years member organisations of the IVI have applied the maturity framework to better understanding of their sustainable IT maturity. The assessment providing them with insights into what they are doing well and where they needed to improve.

This chapter describes the SICT-CMF and the use of it to determine the maturity of sustainable IT capability within a number of leading organisations within the last 2 years. The chapter starts by highlighting the challenges in managing Sustainable ICT and motivates the benefit of maturity models. The development process for the SICT_CMF is then discussed in Sect. 3, detailing the role of design science in the definition. Section 4 describes the resulting model and how it should be used to measure SICT maturity. The application of the model is the focus of Sect. 5 along with an analysis of the average results for organisations using the model. Section 6 provides an overview of the practical insights gained from the assessments.

2 Challenges for SICT Management

Sustainability is an important business issue, affecting new products and services, compliance, cost reduction opportunities, the organization's reputation, and revenue generation. Many organizations think it requires a significant transformational change program, yet the ultimate goal is to embed sustainability into business-as-usual activities.

Organizations face many challenges in developing and driving their overall sustainability strategies and programs:

- The complexity of the subject and its rapid evolution,
- The lack of agreed-upon and consistent standards,
- Changing stakeholder expectations,
- The lack of subject-matter expertise,
- The need for new metrics and measures, and
- Evolving and increasing regulations and legislation around the world.

Unfortunately, organizations often don't exploit ICT's full potential in their efforts to achieve sustainability. Business and IT leaders frequently can't find satisfactory answers to questions such as

- Does the organization recognize ICT as a significant contributor to its overall sustainability strategy?
- How is ICT contributing to the organization's sustainability goals?
- What more could ICT do to contribute to those goals?
- Are there clear measurable goals and objectives for SICT?

IT departments face additional challenges specific to new ICT methods and tools, industry metrics, and standards bodies as well as a general lack of relevant information such as power consumption quantifications.

The challenge for IT departments is further complicated by the fact that sustainability is an enterprise-wide issue that spans the full value chain. The business is facing its own challenges in developing clear strategies and priorities to address a burning problem in such a dynamic and uncertain environment and might lack the maturity to fully include SICT in its efforts. This puts the onus on the ICT organization to deliver SICT benefits across the organization.

2.1 The Need for a Sustainable ICT Maturity Model

There is a need to improve the sustainable IT behaviours, practices and processes within organizations to deliver greater value from Sustainable IT. To address the issue, a consortium of leading organizations from industry, the nonprofits sector, and academia decided to develop a framework for systematically assessing and improving SICT capabilities. The core of this framework is a maturity model for Sustainable ICT which provides a management system with associated improvement roadmaps that guide senior IT and business management in selecting strategies to continuously improve, develop, and manage the sustainable IT capability.

Maturity models are tools that have been used to improve many capabilities within organizations, from Business Process Management (BPM) (Rosemann & de Bruin, 2005) to Software Engineering (Paulk, Weber, Curtis, & Chrissis, 1993). Typically, these models consist of a set of levels that describe how well the behaviours, practices, and processes of an organization can reliably produce required outcomes. They can have multiple uses within an organization, from helping them find a place to start, providing a foundation to build a common language and shared vision, to helping organization priorities actions and define roadmaps. If a community of organizations defines the model it can capture the collective knowledge of the community's prior experiences. A maturity model could also be used as an assessment tool and benchmark for comparison assessments of the capabilities of different organizations.

3 Developing a SICT Maturity Model: A Design Science Approach

The Innovation Value Institute (IVI; http://ivi.nuim.ie) consortium used an open-innovation model of collaboration, engaging academia and industry in scholarly work to create the SICT-Capability Maturity Framework (SICT-CMF). The development of the SICT-CMF was undertaken using a design process with defined review stages and development activities based on the Design Science Research (DSR) guidelines advocated by Hevner, March, Park and Ram (2004). During the design process, researchers participate together with practitioners within research teams to capture the views of key domain experts.

The process of designing, constructing and adapting generic artefacts method engineering has been recognized within Design Science. The focus of method engineering are models, methods, techniques and tools Brinkkemper (1996), March and Smith (1995) and Punter and Lemmen (1996) describe the discipline from a process perspective where methods are comprised of phases; phases are comprised of design steps; and design steps are comprised of design sub-steps.

As Mettler and Rohner (2009) summarize, methods are systematic, goal-oriented and repeatable. In order to ensure consistency between results and the design process meta-models and a coherent design process are essential. In this regard, Gutzwiller (1994) proposes a meta-model for methods that includes activities, roles, specifications, documents and techniques. The meta-model facilitates a consistent and concise method, which in turn allows for their application in a goal oriented, systematic and repeatable fashion. According to Gutzwiller activities are the construction of tasks that create certain results. These activities are assigned to roles and the results are recorded in previously defined and structured specification documents. The techniques comprise of the detailed instructions for the production of the specification documents. Tools can be associated with this process. The result meta-model describes the information model of the results. Results are then applied to organizational contexts by adapting the result documents. The approach forms three elements: Design process, result documents and the adaption/application to organizational contexts.

The design activity can thus be seen as a discipline aimed at developing knowledge about the processes of giving form, about the processes of creating ideas, and about the design process as it proceeds from idea to design result Bratteteig (2007). Carlsson also stresses the broader context of design and use as important for both the design ideas and the material-discursive practices developed during design. Carlsson (2010) states that the aim of IS Design Science research is to develop practical knowledge for the design and realization of ‘IS initiatives’ or to be used in the improvement of the performance of existing IS—something that the author claims had been excluded by Hevner et al. (2004). By an IS initiative Carlsson means the design and implementation of an intervention in a socio-technical system where IS (including IS artefacts) are critical means for achieving the desired outcomes of the intervention.

4 A Capability Maturity Framework for SICT

The IVI has developed a capability maturity framework for managing SICT. The SICT-CMF (Donnellan, Sheridan, & Curry, 2011) complements existing approaches for measuring SICT maturity, such as the G-readiness framework (which provides a benchmark score against SICT best practices) (Molla et al., 2008; O’Flynn, 2010) or the Gartner Green IT Score Card (which measures corporate social responsibility compliance). It offers a comprehensive value-based model for organizing, evaluating, planning, and managing SICT capabilities, and it fits within the IVI’s IT-Capability Maturity Framework (IT-CMF) (Curley, 2004; Hevner et al., 2004). The IT-CMF identifies 32 critical IT processes and describes an approach to designing maturity frameworks for each process.

The SICT-CMF assessment methodology determines how SICT capabilities are contributing to the business organization’s overall sustainability goals and objectives. This gap analysis between what the business wants and what SICT is actually achieving positions the SICT-CMF as a management tool for aligning SICT capabilities with business sustainability objectives.

The framework focuses on the execution of four key actions for increasing SICT's business value:

- Define the scope and goal of SICT,
- Understand the current SICT capability maturity level,
- Systematically develop and manage the SICT capability building blocks, and
- Assess and manage SICT progress over time.

Here we outline these actions in more detail and discuss their implementation.

4.1 Defining the Scope and Goal

First, the organization must define the scope of its SICT effort. As a prerequisite, the organization should identify how it views sustainability and its own aspirations. Typically, organizational goals involve one or more of the following:

- Develop significant capabilities and a reputation for environmental leadership,
- Keep pace with industry or stakeholder expectations, or
- Meet minimum compliance requirements and reap readily available benefits.

Agreeing on the desired business posture on sustainability will have a significant impact on business and thus on SICT goals and priorities. After deciding to improve SICT, organizations are often keen to aim for a consistent and widespread approach across the organization. However, getting it right is an iterative process and requires investment from both business and IT to learn from the implementation and gain longer-term benefits.

4.2 Understanding the Capability Maturity Level

Once the scope and goals of SICT are clear, the organization must identify its current capability maturity level by examining, across business functions, its broader attitude toward SICT and its view of SICT's contribution to sustainability.

Second, the organization must define the goals of its SICT effort. It's important to be clear on the organization's business objectives and the role of SICT in enabling those objectives. Having a transparent agreement between business and IT stakeholders can tangibly help achieve those objectives. Significant benefits can be gained even by simply understanding the relationship between business and SICT goals.

The framework defines a five-level maturity curve for identifying and developing SICT capabilities:

- Initial: SICT is ad hoc; there's little understanding of the subject and few or no related policies. Accountabilities for SICT aren't defined, and SICT isn't considered in the systems life cycle.
- Basic: There's a limited SICT strategy with associated execution plans. It's largely reactive and lacks consistency. There's an increasing awareness of the subject, but accountability isn't clearly established. Some policies might exist but are adopted inconsistently.
- Intermediate: A SICT strategy exists with associated plans and priorities. The organization has developed capabilities and skills and encourages individuals to contribute to sustainability programs. The organization includes SICT across the full systems life cycle, and it tracks targets and metrics on an individual project basis.
- Advanced: Sustainability is a core component of the IT and business planning life cycles. IT and business jointly drive programs and progress. The organization recognizes SICT as a significant contributor to its sustainability strategy. It aligns business and SICT metrics to achieve success across the enterprise. It also designs policies to enable the achievement of best practices.
- Optimizing: The organization employs SICT practices across the extended enterprise to include customers, suppliers, and partners. The industry recognizes the organization as a sustainability leader and uses its SICT practices to drive industry standards. The organization recognizes SICT as a key factor in driving sustainability as a competitive differentiator.

This maturity curve serves two important purposes. First, it's the basis of an assessment process that helps to determine the current maturity level. Second, it provides a view of the growth path by identifying the next set of capabilities an organization should develop to drive greater business value from SICT. A contrast of low- and high-levels of Sustainable ICT are offered in Fig. 1.

Based on SICT-CMF experiences to date, the typical timeline for a maturity assessment is 4 weeks. However, its main component is a survey that takes no more than 30 min to complete, and it can remain open for as long as the participating

Low Maturity	Maturity Levels	High Maturity
Un- coordinated, isolated projects		Coordinated SICT Activities
Low SICT Skills		High SICT Expertise
Key Personnel		Organisational Wide Coverage
Reactive		Proactive
Vague Metrics		Meaningful Metrics
Internally Focused		Extended Organisation
Low Resourcing		Efficient Resourcing
Naïve		Comprehensive Understanding
Static		Innovative

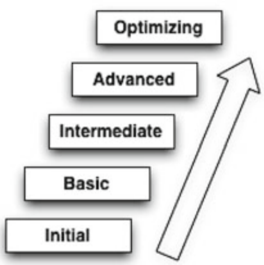

Fig. 1 Comparison of low and high maturity of SICT

organizations chooses. Typically, a range of business and IT individuals who are involved in or accountable for SICT complete the survey. Targeted interviews that last between 30 and 90 min can support the survey data, and metrics can validate and augment the results.

4.3 Developing SICT Capability Building Blocks

Although it's useful to understand the broad path to increasing maturity, it's more important to assess an organization's specific capabilities related to SICT. The SICT framework consists of nine capability building blocks (see Table 1) across the following four categories:

Table 1 Capability building blocks of sustainable information and communication technology (SICT)

Category	Capability building block	Description
Strategy and planning	Alignment	Define and execute the ICT sustainability strategy to influence and align to business sustainability objectives
	Objectives	Define and agree on sustainability objectives for ICT
Process management	Operations and life cycle	Source (purchase), operate, and dispose of ICT systems to deliver sustainability objectives
	ICT-enabled business processes	Create provisions for ICT systems that enable improved sustainability outcomes across the extended enterprise
	Performance and reporting	Report and demonstrate progress against ICT-specific and ICT-enabled sustainability objectives, within the ICT business and across the extended enterprise
People and culture	Adoption	Embed sustainability principles across ICT and the extended enterprise
	Language	Define, communicate, and use common sustainability language and vocabulary across ICT and other business units, including the extended enterprise, to leverage a common understanding
Governance	External compliance	Evangelize sustainability successes and contribute to industry best practices
	Corporate policies	Enable and demonstrate compliance with ICT and business sustainability legislation and regulation. Require accountability for sustainability roles and decision making across ICT and the enterprise

Strategy and planning, which includes the specific objectives of SICT and its alignment with the organization's overall sustainability strategy, objectives, and goals;

- Process management, which includes the sourcing, operation and disposal of ICT systems, as well as the provision of systems based on sustainability objectives and the reporting of performance;
- People and culture, which defines a common language to improve communication throughout the enterprise and establishes activities to help embed sustainability principles across IT and the wider enterprise; and
- Governance, which develops common and consistent policies and requires accountability and compliance with relevant regulation and legislation.

The first step to systematically develop and manage the nine capabilities within this framework is to assess the organizations status in relation to each one.

The assessment begins with the survey of IT and business leaders to understand their individual assessments of the maturity and importance of these capabilities. A series of interviews with key stakeholders augments the survey to understand key business priorities and SICT drivers, successes achieved, and initiatives taken or planned. In addition to helping organizations understand their current maturity level, the initial assessment provides insight into the value placed on each capability, which will undoubtedly vary according to each organization's strategy and objectives. The assessment also provides valuable insight into the similarities and differences in how key stakeholders view both the importance and maturity of individual capabilities, as well as the overall vision for success. Understanding the current levels of maturity and strategic importance lets an organization quickly identify gaps in capabilities. This is the foundation for developing a meaningful action plan.

4.4 Assessing and Managing SICT Progress

With the initial assessment complete, organizations will have a clear view of current capability and key areas for action and improvement. However, to further develop SICT capability, the organization should assess and manage SICT progress over time by using the assessment results to

- Develop a roadmap and action plan, and
- Add a yearly follow-up assessment to the overall IT management process to measure over time both progress and the value delivered from adopting SICT.

Agreeing on stakeholder ownership for each priority area is critical to developing both short-term and long-term action plans for improvement. The assessment results can be used to prioritize the opportunities for quick wins—that is, those capabilities that have smaller gaps between current and desired maturity and those that are recognized as more important but might have a bigger gap to bridge.

Table 2 Average SICT maturity

Category	Capability	AVR CBB	Low	High	Diff	AVR Cat
Strategy and planning	Alignment	2.61	2.38	3.2	0.82	2.51
	Objectives	2.41	2.08	2.8	0.72	
Process management	Operations and life cycle	2.46	2.32	2.8	0.48	2.52
	ICT-enabled business processes	2.70	2.5	3	0.5	
	Performance and reporting	2.40	1.2	3	1.8	
People and culture	Adoption	2.03	1.89	2.3	0.41	2.18
	Language	2.33	2	2.9	0.9	
Governance	External compliance	2.19	1.8	2.9	1.1	2.24
	Corporate policies	2.28	1.4	2.9	1.5	

5 An Overview Sustainable ICT Maturity: The IVI Experience

The assessment of sustainable IT was carried out in a number of global firms over the last 2 years. The assessment methodology included interview stakeholder from both the IT organizations and the business and including individuals involved with IT and corporate sustainability programs. The average results for the SICT maturity of the examined organisations is presented in Table 2.

5.1 Commentary on Assessment Results

The assessment revealed the maturity of sustainable IT capabilities across the following four categories:

5.1.1 Strategy and Planning (2.51)

In general the Organisations had specific SICT objectives of that are aligned with the organization's overall sustainability strategy, objectives, and goals. Sustainable programs have executive sponsorship and many organisations have established a program to coordinate sustainable initiatives. There is a clear focus on key measurable IT projects along with policy and compliance, especially where relevant legislation is in place (i.e. environmental). Some business metrics are defined and used where local opportunities arise, however the maturity of organisation-wide sustainable metrics is low.

5.1.2 Process Management (2.52)

Operations and life-cycle management scored as the highest average capability. Most organisations have ICT policies adopted to source and dispose of ICT assets against defined environmental metrics. Design of ICT systems prioritizes sustainability targets and they are tracked on a project-by-project basis with sustainable IT metrics, alignment, objectives, and rewards mechanisms all in place. However, IT could contribute more to the overall organisation's carbon footprint; they need to do both Green IT and IT for Green.

5.1.3 People and Culture (2.18)

Adoption was scored as the lowest capability assessed. There is scope for improvement in the driving adoption of sustainability, as well as creating awareness and increasing practical relevance for all employees, not just sustainability specialists in specific projects. There is further opportunity to establish activities to help embed sustainability principles across IT and the wider enterprise. Initiatives such as tying staff compensation to sustainability goals are positive steps in this direction. While some organisations have a common language defined, this is often limited to use within IT. There is a need to increase awareness of sustainability issues.

5.1.4 Governance (2.24)

Most organisations score well in relation to having suitable sustainable regulatory compliance and corporate policies in place. They recognize the importance of regulatory compliance and align with relevant regulation and legislation. Common SICT policies may exist, however there is limited documentation and inconsistent adoption within IT.

5.2 Summary of Key Practices

While no organisation was found to have SICT capabilities at the Advanced or Optimising maturity levels, they are incorporating SICT within their strategy and planning. The key practices relating to SICT found in most organizations include:

- SICT strategy developed and aligned to business programmes with appropriate roadmap, resourcing and skills in place.
- SICT policies across lifecycle, operations and some business process.
- Consistent measures and benchmarking for sustainability success and objectives within IT
- IT reviews relevant SICT policies and compliance with business units and tracks performance
- Defined roles and structure for IT accountability for SICT, in particular environmental compliance.

The SICT-CMF assessments gave organisations a better understanding of their SICT maturity, and allowed them to create a suitable action plan. The main challenges exist in the area of awareness and communication of SICT. Key practices that are needed to improve the maturity of SICT capabilities include:

- Formalise and enhance SICT audits, benchmarks, metrics and scorecards
- Expand and leverage SICT expertise across the organization
- Standardise SICT principles across lifecycle both internal and external to IT
- Engage systematically with business leaders on SICT-enabled business processes and a long-term strategy for sustainable SICT
- Language for common understanding is important. Formalize and enhance communications on SICT concerns and celebrate success.

6 Insights from Assessments

As a relatively new and rapidly evolving field, businesses face many challenges in achieving their sustainability objectives. Initial application of the framework has revealed some common requirements.

6.1 Obtain Senior Management's Vision

The pilot assessments confirmed that a key requirement is a clearly articulated business vision for sustainability with associated goals and milestones. Senior-level drive, visibility, and communication regarding sustainability are critical for successfully developing SICT, as is accountability. Otherwise, successes remain isolated, and the organization doesn't leverage the full benefits.

6.2 Engage IT and Business Organizations

Performing an assessment provides both the IT department and business organizations with a new view of the true nature of their SICT efforts. In many cases, it's a wake-up call for both parties.

Although some organizations recognize technology's increasingly valuable role in achieving sustainability objectives, other business executives see SICT's contribution as limited to data-centre and power-saving activities. Other CIOs are tempted to move forward on their own while the organization is still working on its overall sustainability strategy and objectives. However, broad actions are needed across both IT and the business—not just in IT.

6.3 Accept Cultural Change

Driving SICT adoption within the wider organization is a significant challenge. Engaging the general workforce requires a shift in culture that embeds SICT into the everyday work routine.

Developing and agreeing on the right metrics remains a common challenge, as does recognizing the need for new approaches to assess the return on investment. Although SICT incorporates all the activities associated with a major change program, success requires the organization to view SICT as "business as usual."

Incentives are another area that requires specific consideration for cultural changes. Incentives will vary across the various organizational layers, ranging from awards and recognition for new ideas and innovation, to a direct relationship between sustainable performance and rewards for senior executives.

6.4 Understand the Potential and Expand Expertise

Executives at senior levels in organizations have a good understanding of SICT issues and recognize there's much more to learn and do. However, the misconception remains that sustainability typically represents a cost to the organization. Executives don't always realize the potential benefits, including cost savings and revenue generation based on new business opportunities. Undoubtedly, investments are needed, but they deliver benefits in both the short and long term. Specific benefits will vary according to business maturity, industry sector, and desired sustainability posture but typically include reduced energy, carbon footprint, environmental impact, and travel costs.

As a relatively new and rapidly evolving field, SICT skills and experience are still in short supply. While pockets of expertise exist, with strong individual technical experts, SICT across the wider organization is limited. Education will be critical to changing this skills shortage. It's also the key to changing the culture and embedding SICT into the organization's core values.

7 Conclusion

The SICT Capability Maturity Framework gives organizations a vital tool to manage their sustainability capability. The framework provides a comprehensive value-based model for organizing, evaluating, planning, and managing SICT capabilities. Using the framework, organizations can assess the maturity of their SICT capability and systematically improve capabilities in a measurable way to meet the sustainability objectives including reducing environmental impacts and increasing profitability. The framework was developed using an open-innovation model of collaboration, engaging academia and industry in scholarly work following a design science research approach.

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Ecosia.org: The Business Case of a Green Search Engine

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Abstract The environmental impact of search engines is facing increasing public attention within the discussion about Green IS and Green IT. The search engine Ecosia.org takes advantage of this situation by pursuing an IT-enabled green business model. Enterprises following this concept have the objective to make a positive environmental contribution. Ecosia contributes to the environment by donating most of its revenues to the World Wildlife Fund (WWF). Regarding this, the question arises if green business models possess a potential for success in the search engine market. To describe the business case of Ecosia we apply case study research and survey search engine users. The findings provide implications on the relevance and impact of IT-enabled green business models in the scope of information systems (IS) research. This paper is an initial starting point for further research on IT-enabled green business models in IS.

1 Introduction

The increasing dissemination and utilization of information technology (IT) into all areas of life leads to rising energy consumption and growing environmental problems. IT accounts for 2% of the 41 billion tons of global CO_2 emissions each year (Buhl & Jetter, 2009).

In information systems (IS), the environmental impact of IT and related measures for its reduction and management are being discussed under the headings of “Green IS” and “Green IT” (Kuo & Dick, 2010; Schmidt, Erek, Kolbe, & Zarnekow, 2009; Watson, Boudreau, & Chen, 2010; Yi & Thomas, 2007).

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Within the scope of this discussion the environmental impact of search engines and their enormous data centers face increasing public attention. The market leader Google for example operates approximately 450,000 servers, consuming about 800 Giga Watt hours (GWh) of electricity per year (Chou, 2008). Thereby, Google is indirectly responsible for enormous amounts of CO_2 emissions, because electricity is often generated by coal or gas combustion, which creates CO_2 emissions.

Estimations of the level of CO_2 emissions caused by a Google search request vary between 1 and 10 g and are discussed controversially (Glass, 2009; Leake & Woods, 2009). Thus, regardless of the financial success, Google has come under environmental criticism.

The search engine Ecosia takes advantage of this situation by pursuing an IT-enabled green business model that distinguishes itself from the main search engines in the market. Ecosia does not aim to maximize monetary profit. Instead, it tries to make a positive environmental contribution.

To achieve its objectives, Ecosia cooperates with nonprofit organizations and the established search engine providers Bing and Yahoo.

Research in other domains illustrates that sustainable products and services can positively influence consumers' behavior (Du, Bhattacharya, & Sen, 2007; Lichtenstein, Drumwright, & Braig, 2004; Luo & Bhattacharya, 2006). This can be observed especially in the food industry with the increasing prominence of organic food. This trend is likely to disseminate into other industries (Ray & Anderson, 2001).

Regarding the IT-enabled green business model of Ecosia, the following research question arises:

What is the business case of Ecosia?

This question is answered by a thorough analysis of the search engine Ecosia and its environment. The aim of this paper is to provide professionals, researchers, and lecturers with an understanding of IT-enabled green business models. In Green IS research the topic of IT-enabled green business is still lacking theoretical foundation and demands further scientific investigation.

This paper contributes to the research branch of Green IS which investigates environmental questions and aspects in the scope of IS (Schmidt, Schmidtchen, Erek, Kolbe, & Zarnekow, 2010; Watson et al., 2010).

2 Related Research

2.1 Traditional Business Models

A good business model is essential to every successful enterprise or organization (Magretta, 2002). It should describe a path from basic human needs to continuous financial success (Magretta). For this the business model substantiates all essential elements. According to Teece (2010) the essence of a business model is "…defining the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit. It thus reflects management's hypothesis about what customers want, how they want it, and how the enterprise can organize to best meet those needs, get paid for doing so, and make a profit."

This customer and profit focused definition neglects the fact, that other business actors and organizations can also play an important role in a business model. Furthermore, the objectives of these actors can be monetary or nonmonetary type. Especially companies that do follow the concept of IT-enabled green business pursue nonmonetary objectives.

Timmers (1998) offers a broader definition that also mentions other business actors and general benefits. From his point of view, a business model is defined as "[…] an architecture for the products, services and information flows, including a description of various business actors and their roles, a description of the potential benefits for the various business actors, and a description of the sources of revenues."

In a business model, involved parties are not necessarily business actors. Governmental and nongovernmental organizations (NGOs) can also play a substantial role. They are generally referred to as "stakeholders" (Freeman, 1984). Therefore, Timmer's (1998) definition has to be expanded to include IT-enabled green business models.

Hence, a business model describes the architecture of the products, services and information flows, including a description of relevant economic and noneconomic stakeholders and their roles, a description of the potential economic, social, and environmental benefits for the various business stakeholders and a description of the sources of revenues.

2.2 IT-Enabled Green Business Models

Green business has grown into an important management concept (Starik & Rands, 1995). Although its economic dimension is often highlighted, green business is based on ethical considerations (Schendler, 2002). A business model can be interpreted as green if it primarily pursues environmental objectives under the minimum constraint of cost-coverage. An IT-enabled green business model distinguishes itself from traditional business models by the vital role of IT. An initial comparison between the two types is outlined in Table 1.

The condition that must be in place for an IT-enabled green business model to succeed is that the firm must operate at or beyond the cost recovery point. Therefore, donations or grants can play a significant role as a source of revenue (Emerson, 2003).

In practice, there are examples of IT-enabled green business models in various industries (Table 2). They are all enabled by IT and use resources efficiently, avoid harmful waste, create transparency and/or invest their revenues to support environmental initiatives.

Table 1 Comparison of a traditional business model and an IT-enabled green business model

Attribute	Traditional business model	IT-enabled green business model
Objective	Profit maximization	Maximization of environmental benefits at full cost recovery
Role of IT/IS	Green IT aligns to the business model	Green IS enables the business model
Main stakeholders	Investors, shareholders	Society, legislation, investors, shareholders
Appropriation of profits	Dividends to investors and shareholders, reinvestment	Reinvestment, extension of activities, payback of investors
Objectives of investors	Added financial value (one-dimensional)	Contribution to the environment, conservation of value (multi-dimensional)
Potential customers	Price/performance oriented	Quality/environment oriented

Table 2 Examples of IT-enabled green business models from various industries

Name	Homepage	Type of service	Customers	Environmental benefits
(car2go, 2011)	car2go.com	Transportation	City residents	IT-enabled car sharing concept, using online maps. Reduces traffic jams, emissions, stress and noise
(Cyber Rain Inc., 2011)	cyber-rain.com	Software	Garden owners	Cyber Rain uses wireless technology to check the local weather forecast and to adjust sprinkler watering schedules to match daily conditions, which saves up to 40% of water
(Ecosia, 2010a)	ecosia.org	Internet search engine	Internet users	Ecosia is a green search engine that donates at least 80% of its advertising revenue to a rainforest protection program run by the WWF
(GreenQloud, 2011)	greenqloud.com	IT services	IT departments	GreenQloud operates data centers that are 100% powered by renewable geothermal and hydropower energy
(ifu Hamburg GmbH, 2011)	umberto.de	Software	Manufacturers	Umberto is the software tool for material and energy flow analysis and life cycle assessment
(Metrolight Ltd., 2011)	metrolight.com	Electronic ballasts/ software	Organizations with major lighting	Metrolight manufactures electronic ballasts that power energy efficient lighting systems, saving up to 65% of lighting costs
(Verdiem, 2011)	verdiem.com	Software	IT departments	Verdiem provides enterprise software solutions to reduce energy consumption of PC networks
(Zonzoo, 2011)	zonzoo.co.uk	Service	Mobile phone users	Zonzoo buys old mobile phones and recycles them, and plants a tree for every old phone

3 Methodology

To describe the business case of Ecosia, we follow a case study research design. Case study research is suitable for exploration of new topic areas which lack empirical validation (Crane, 1999; Eisenhardt, 1989; Robertson, 1993). This applies to the given situation of IT-enabled green business models in the search engine market.

Case study research employs various data collection methods, such as document and literature analysis, interviews, observations or questionnaires (Eisenhardt, 1989). Our investigation is based on:

Multiple interviews with the founder and CEO of Ecosia Christian Kroll from October to December 2010;
An in-depth analysis of all information provided by Ecosia;
A comprehensive market and media research;
And a questionnaire with 205 search engine users.

With this information the research question is answered. All interviews were documented and transcribed. The online survey was developed and tested with search engine users.

The questionnaire was completed by 220 persons in a time frame from November 2010 until January 2011. Fifteen data sets were discarded since they were not completed sufficiently. The survey was presented online and its link published on the university's website and spread to personal contacts.

The data sample shows the following characteristics: The gender is almost equally distributed, with 48% women and 52% men. Forty-eight percent of the sample receives a monthly income below EUR 1,000. The sample population is mainly young: 64% of the survey participants are between 18 and 30 years old.

On an educational level, 79% have either a higher education entrance qualification or even an academic degree. Concerning the self-perception of the value-structure, the participants consider themselves as social (41%), ecological (27%), and economic (30%) oriented (2% missing values).

The resulting dataset is used to analyze the importance of certain search engine properties. Pearson's chi-square test is run to determine which socio-demographic user group has a stronger interest in a green search engine like Ecosia. Based on these findings the business case of Ecosia is illustrated.

4 The Business Case of Ecosia

4.1 Company Overview

Ecosia is an independent, non-profit internet search engine, which defines itself as a social business enterprise (Yunus, 2008). Ecosia spends at least 80% of its revenues

Table 3 Overview of Ecosia

Foundation	2009
Headquarters	Wittenberg/Germany
Industry	Internet, social business
Products and services	Internet search services
Short description	Independent non-profit website
Partners	Yahoo, Bing, WWF
URL	http://www.ecosia.org
Revenue (estimated 2010)	approx. EUR140,000
Donations to WWF (estimated 2010)	approx. EUR 112,000
Employees	3 core employees, 10–15 volunteers
IT infrastructure	1 server, use of the external infrastructure from Yahoo and Bing

to a rainforest protection program run by the WWF. The project uses the money for the sustainable protection of rainforests in the Brazilian Tumucumaque-Park (Ecosia, 2010b; WWF, 2009). The average revenues of each web search equal 0.13 Euro Cent which represents the cost for saving up to 2 m^2 of rain forest. By this more than 202 million m^2 of rain forest have been protected.

This behavior distinguishes the search engine from other major ones in the market. Ecosia is an example of an IT-enabled green business model in the search engine market (see Table 3).

4.2 Ecosia's Business Model

Bing provides Ecosia with search results, Yahoo with sponsored links (Fig. 1). Ecosia does not run an own search index because of financial limitations and technological complexity. Its revenues are generated by user clicks on sponsored links. A minor portion of these revenues is paid to the technology partners. Ecosia receives payments for every click on a sponsored link. Since at least 80% of this amount is donated to WWF, only the remaining sum of up to 20% can be used for salaries, servers, domains, marketing and corporations with other enterprises. In doing so the CEO pays himself a salary below EUR 1,000 per month (Vensky, 2010).

Ecosia operates at the level of full cost recovery. Since the foundation of Ecosia in 2009 the number of search requests has steadily increased. In April 2010 Ecosia generated over EUR 11,000 of revenues with around nine million search requests summing up to a market share of approximately 0.2% of the German search engines (comScore, 2010; Ecosia, 2010a). The majority of Ecosia's search requests originated from Germany (55%), Switzerland (13%) and France (10%) (Ecosia, 2010c).

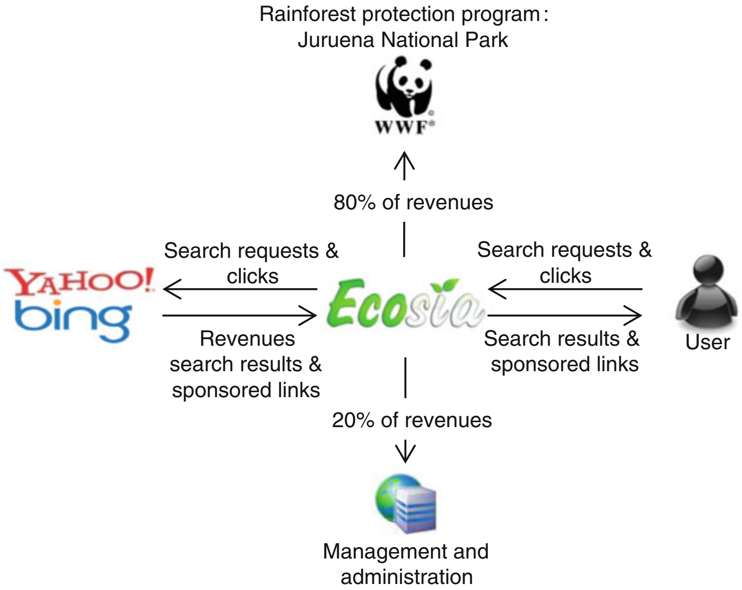

Fig. 1 IT-enabled green business model of Ecosia

The business model imposes a narrow financial scope for Ecosia. It depends on low cost marketing tools such as word-of-mouth advertising, press releases and media interviews. This marketing strategy has been successful in Germany and is confirmed by media publications (Otten, 2010; Vensky, 2010).

In the long run, Ecosia aims to gain a global market share of 1%. According to its own account, the company is confronted with the following strategic challenges to achieve this goal (Kroll, 2010):

- Self-financing by increased revenues;
- Relationship management of existing partnerships;
- Obtaining Google as an additional partner;
- Internationalization of user groups, (especially USA);
- Development of university and school partnerships.

To reach a global share of 1% in the search engine market Ecosia needs to internationalize its user groups and grow beyond the German and European market.

4.3 Supplier Relationships

Managing the existing relationships is of vital importance to Ecosia, because the company is not operating an own search index and is therefore dependent on the search technology of Bing and Yahoo to provide a competitive search service, whereby Bing delivers the search results and Yahoo matching advertisement links.

A partnership with Google is aspired although the internet giant hesitates. Obtaining the market leader Google as an additional partner would enhance Ecosia's search services significantly. Users would then be able to select one of the three search engines. This could potentially lead to more users and higher revenues, which enables Ecosia to donate more money for rainforest protection.

The motivation of Bing and Yahoo to cooperate with Ecosia derives from the assumption that every new Ecosia user very likely used Google before (Kroll, 2010). Therefore, Bing and Yahoo view Ecosia as a strategic instrument to take market share away from Google and to exert pressure on Google in the scope of environmental issues.

As a profit maximizing company it does not seem reasonable for Google to cooperate with Ecosia, because a growing user number of Ecosia would mean decreasing profits for Google. Nevertheless, switching costs for search engine users are very low. Therefore, this development exerts pressure on the market leader Google demanding a reaction, especially if the user numbers of Ecosia keep growing. This could finally lead Google to also cooperate with Ecosia or to initiate own projects in this topic area, leading to a race to the top (Hahn, 2009).

In a race to the top situation, the three major search engines would start to compete over their environmental contribution to serve the people and the planet better (Yunus, 2006). The entire environmental contribution of the search engine market would finally increase.

4.4 Competition in the Search Engine Market

With a market share of 89.6% Google is dominating the German search engine market (WebHits, 2010). Yahoo and Bing merely possess a market share of 2.6% and 2.2%, respectively (WebHits). The German search engine market (4%) is much smaller than the US market (17%) of all global search requests (comScore, 2010). On the international level, too, the market lead of Google is unchallenged, although it is not as explicit as in Germany. In the US the three major search engines Google (65.1%), Yahoo (13.8%) and Bing (13.0%) share about 92% of the market amongst themselves (Wire, 2010) (Table 4).

Besides Ecosia there are other providers in the search engine market which claim to follow a similar concept (Table 2).

Except from GoodSearch all companies were founded in the past 2 years. This illustrates a growing importance of socially and environmentally oriented business models for web services. The overview shows that Google, Yahoo and Bing cooperate in some form with these businesses.

Table 4 Selection of socially and environmentally oriented web search providers

Name	URL	Since	Partners	Commitment
(Benefind, 2010)	benefind.de	2009	Yahoo, Bing	Donation of 0.5 Euro Cent per search query to charitable purposes
(Blackle – Heap Media, 2010)	blackle.com	2010	Google	Energy saving internet search by black background
(Ecocho, 2010)	ecocho.eu	2008	Yahoo	Purchase of CO_2 certificates
(Ecosia, 2010a)	ecosia.org	2009	Yahoo, Bing, WWF	Donation of 80% of all revenues to the WWF
(Forestle, 2010)	forestle.de	2008	Yahoo, The Nature Conservancy	Donation of 90% of all revenues to the group The Nature Conservancy
(GoodSearch, 2010)	goodsearch.com	2005	Yahoo	Donation of 50% of the profit for charitable purposes
(Treehoo, 2010)	treehoo.com	2008	Yahoo, Trees for the Future	Donation of 50% of the profit to the group “Trees for the Future” to plant trees
(Znout, 2010)	znout.org	2008	Google	Purchase of CO_2 certificates

4.5 Market Potential

According to Facebook.com Ecosia’s growing popularity is illustrated by over 150,000 people who “like” the search engine (Facebook – Ecosia, 2010).

In the case of Ecosia the user acquisition is not done by a typical product or service differentiation. Instead the environmental focus of the business model is being advertised and communicated towards the users. Therefore, users who are receptive for environmental topics belong to the target group of Ecosia.

Hints concerning the market potential are provided from the consumer group called LOHAS. LOHAS stands for “Lifestyle of Health and Sustainability” and describes a “movement with strong influence on consumption and values” within the society (Ray & Anderson, 2001; Wenzel, Kirig, & Rauch, 2007). This lifestyle does not portray an exclusive target group but a “new social majority” (Wenzel et al.). This trend can be observed in the food industry with the increasing prominence of organic food. It is likely to disseminate into other types of industries (Ray & Anderson).

The expanding share of the LOHAS on the German market is estimated to be one-third (Wenzel et al., 2007). If these findings are transferred to search engine users, it can be assumed that one-third of all users would rather prefer a search engine with a green business model than a traditional search engine.

Research on the marketing of Green IT PCs shows similar findings. Results from a conjoint-analysis of 500 internet users estimate a potential market share for PCs with environmental friendly product attributes of up to 26.6% (Schmidt et al., 2010). For this target group environmental attributes are relatively more important than price and performance. The members of this target group are significantly older, better educated and have an above average probability to be female (Schmidt et al.). Other research confirms the finding that women value environmentally friendly products and services higher than men (Lee, 2009).

The above findings lead to the hypothesis that at least one quarter of all users could be enticed to use a green search engine, such as Ecosia. It can be assumed that the relevant target group for Ecosia is likely to be older, better educated and female.

4.6 Target Users

Out of the survey sample, 46.5% stated that Ecosia could present an alternative to their currently preferred search engine. This group can be described by the following characteristics.

- Regarding the gender, 59.1% are female. This confirms other findings that women prefer environmental products and services more than men (e.g. Schmidt et al., 2010).
- The age also plays an important role for being willing to use a "green" search engine. Only 41.7% of the people younger than 30 years are willing to use Ecosia whereas in the older segment this quota is at 55.7%.
- The self-perception also has an effect. 61.7% of the environmentally oriented, 49.3% of the socially oriented and only 29.8% of the economically oriented participants consider Ecosia as an alternative.
- The fact of having children is another significant difference. People raising kids are more likely to use Ecosia (67.4%) than people not having any children (40.8%).

All these distinguishing features have been tested on their significance using the χ^2-Test. The results are illustrated in Table 5.

4.7 Summary

The business case of Ecosia depends on two basic assumptions: internet users have a need for a powerful search engine and are willing to choose a provider that generates an ecological and thus societal surplus.

Table 5 Significance levels for considering Ecosia as an alternative

	χ^2-value	Degrees of freedom	Significance level (2-sided)
Female/male	8.175	1	<0.01***
Younger/older	3.251	1	<0.10*
Self-perception	11.008	2	<0.01***
Having children	9.372	1	<0.01***

To communicate this surplus, Ecosia's website is kept simple and transparent. User's looking for evidence that their application of Ecosia is really making a difference can easily find documents like statements about Ecosia's revenue and the receipts for the payments made to the WWF.

A higher amount of search requests leads to an increased number of matching advertisements. Every successful advertisement delivers revenues. The majority of these revenues is donated. This is possible because Ecosia keeps its cost structure very simple:

- Ecosia does not provide an own search engine, so that hardware and maintenance cost can be minimized.
- Ecosia does not aim to pursue shareholder's monetary interest, so that all surpluses can be donated for the good cause.
- The owner of Ecosia considers this website as a personal contribution to the environment and society rather than an investment object, so that his personal withdrawals are part of the administrative cost and reduced to a minimum.
- The technology providers consider Ecosia as a strategic instrument to tackle Google and therefore accept relatively low payments for their services.
- Marketing is done by cost neutral with viral and social marketing campaigns.

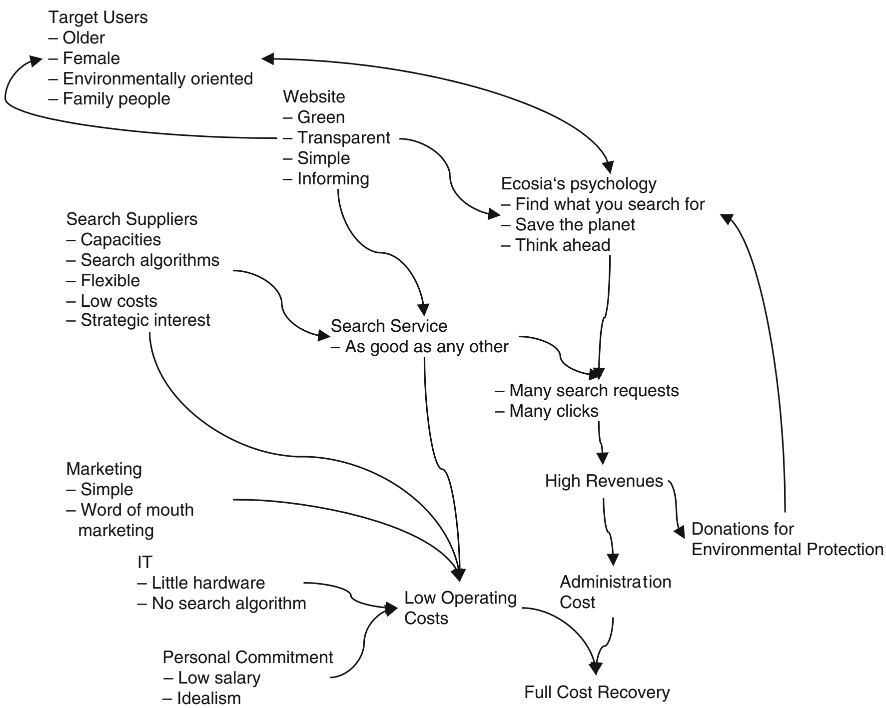

Fig. 2 The business case of Ecosia

These findings are consolidated in Fig. 2. It illustrates how Ecosia successfully operates in the search engine market and contributes to the environment.

5 Business and Research Implications

Finally, we have to discuss the implications for business and research derived from our findings.

First, there are clear implications for Ecosia. The analysis of the market potential backs Ecosia's business model. Ecosia should direct its communication towards older, female, and family oriented users. This also needs to be considered when selecting appropriate marketing tools and channels.

Ecosia also has to develop the overall sustainability of its IT-enabled green business model. The vital dependence on the strong personal commitment of the founder imposes a great risk. Therefore, the whole concept of Ecosia should be supported by multiple actors. This would allow a continuous transformation process without putting the search engine at stake.

The survey findings indicate that especially socially and environmentally oriented persons tend to be interested in Ecosia's concept. To assist stronger growth, Ecosia should possibly use public relations actions in target group oriented media and events like social or environmental NGO magazines or gatherings. Bringing people to use Ecosia should be considered as a win-win-situation within these groups and should hence be free of financial cost. The findings about education, age group and gender can help to develop a successful campaign.

Second, there are implications for business. The case of Ecosia illustrates, that an internet based IT-enabled green business model in connection with strong personal commitment can be successful and creates positive benefits for the society. The potential market share of an IT-enabled green search engine should be somewhere around one quarter to one third. Furthermore, this case illustrates that Ecosia's business model offers the possibility to conquer a market niche even in a quasi monopolistic market such as the global search engine market. The commitment of one company can move other companies to follow – leading to a competition over social and environmental contributions, a so called race to the top. By this effect the objectives of a green business model can be achieved indirectly.

Furthermore, it can be stated that the value of a service is not only determined by its performance, quality or price, also the business model influences the users' perception. Therefore, including social and environmental aspects into traditional business model leads to an emergence of new business models. This leads to a multiplicity of opportunities beyond the search engine market. Especially markets in which social and environmental issues have been neglected and the target group of environmentally oriented consumers has not been addressed seem to be suitable. A possible example of this would be the idea of an eco-Ebay.com or a socially oriented Amazon.com, which would donate a certain percentage of their revenues.

By doing so, it should be possible to obtain quickly a significant number of customers or users.

Third, there are implications for research. This paper is an initial approach to grasp the relevance of IT-enabled green business models in IS research. The dynamic of the IS field makes it highly relevant for this concept. Still, the topic is lacking theoretical foundation and demands further scientific investigation. Applicable theories and concepts are needed to further elaborate this idea. Investigating the race to the top effect in IS or estimating the relevance of environmental protection in IS services should be the next steps of research.

The initial survey presented above shows first hints of the potential structure of the target group for green business. Self-perception concerning values, as well as age and knowledge play an important role towards the interest for these business models. Further research needs to validate these findings and try to find out about the motivation of the different groups for using such services in order to either adapt the business models, the advertisement or both.

Further research need to focus on the idea of IT-enabled green business models, for which Ecosia is an example. An analysis of present examples and the development of new IT-enabled green contribute to the research on Green IS.

6 Conclusion and Discussion

The case study illustrates how a market niche in a quasi monopolistic market, such as the search engine market can be conquered by a green business model. In this situation the support by other market actors seems likely. For them it is a strategic instrument to tackle the market leader.

The development can finally lead companies to a competition over social and environmental contributions, called "race to the top".

The survey shows that the user group taking such an IT-enabled green business model into account is not homogeneous: certain groups seem to have a stronger affinity towards these services and products than others.

Concerning the research question, the following conclusions can be made:

- IT-enabled green business models do have a potential for success in the search engine market. Ecosia for example has a growing user base.
- Ecosia's model influences the market: major players like Yahoo and Bing agreed to strategic alliances with Ecosia to strengthen their position against Google.
- The user group of Ecosia is not homogenous. Especially elderly, female, and environmentally oriented people consider Ecosia as an alternative to their current search engine.

Nevertheless, the results derived from the survey data have to be considered regarding some limitations. The survey was mainly promoted in an academic context. This might have an impact on the income and knowledge structure. Also, the survey does not cover why or not persons consider Ecosia as an alternative to their current search engine. These findings demand further validation. There are some suggestions for future research:

Multiple case studies with other IT-enabled green business enterprises are recommended. This should provide findings on the market relevance and future significance of these types of business models.

Additionally, the implementation of an experimental, student-run IT-enabled green business model could be a way of gaining more insights about the motivation and interests of the developer and customer group of green businesses.

Giving the growing dissemination and application of IT and the societal shift the relevance of social and environmental topics is destined to gain even more importance in the future. In this context green enterprises in the scope of IS are a new development, which demands further investigation.

This paper contributes a first concept and initial hypotheses for the topic of IT-enabled green business models by analyzing the business case of the green search engine Ecosia.

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