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An Interpretive Study of Managing Emergent or Evolutionary Environmental and Energy Strategy

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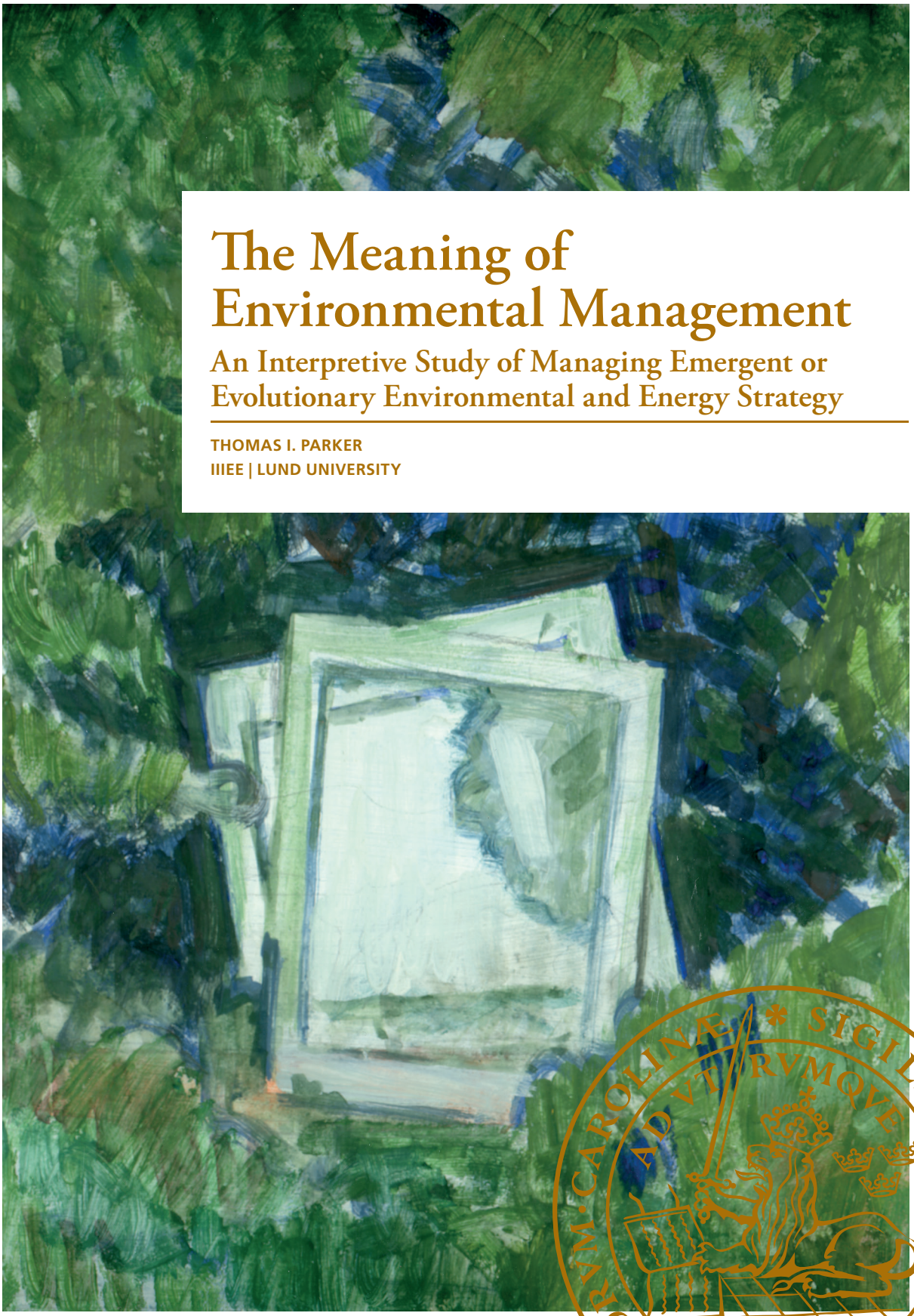

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THOMAS I. PARKER
IIIEE | LUND UNIVERSITY

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LUND
UNIVERSITY

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THE MEANING OF ENVIRONMENTAL MANAGEMENT

AN INTERPRETIVE STUDY OF MANAGING EMERGENT OR EVOLUTIONARY ENVIRONMENTAL AND ENERGY STRATEGY

Abstract

Because of the vital roles of industry in sustainable development, it is essential that environmental management is effective in preventing pollution. To this end, environmental management systems have been implemented to a growing extent in industry. Moreover, this Ph.D. research has demonstrated that environmental management efforts must be systematic to use environmental performance indicators effectively. However, the research has also revealed that environmental management systems did not necessarily improve environmental performance. In order to enable development of more effective environmental management, this Ph.D. research explored how environmental management efforts affected employees, whether effective environmental management might be contingent upon strategy contexts, and how environmental strategy was developed. In the context of emergent strategies, change, innovation and complexity, the research for this dissertation examined effective environmental management using interpretive methodology and case studies. Noting that strategy could be emergent, i.e. emanate from the organization rather than being imposed upon it, a goal of the research was to understand the practice of management without a predetermined strategy. The research findings demonstrated that management systems behaved differently depending on if the strategy context was deliberate, evolutionary or emergent. In deliberate strategy contexts, formal management systems may improve performance by reducing variability and risk. In evolutionary strategy contexts, formal management systems were employed in internal competition by champions. In the context of emergent strategies, formal management systems seemed to be irrelevant or even impediments to necessary change and innovation.

Key words: ENVIRONMENTAL MANAGEMENT SYSTEMS, CORPORATE STRATEGY, EMERGENT STRATEGY, INTERPRETIVE RESEARCH, PHENOMENOLOGY, CONTINGENCY THEORY, MANAGEMENT OF MEANING

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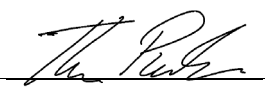
Signature  Date 2016-11-17

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Abstract

Because of the vital roles of industry in sustainable development, it is essential that environmental management is effective in preventing pollution. To this end, *environmental management systems* have been implemented to a growing extent in industry. Moreover, this Ph.D. research has demonstrated that environmental management efforts must be systematic to use *environmental performance indicators* effectively. However, the research has also revealed that environmental management systems did not necessarily improve environmental performance. In order to enable development of more effective environmental management, this Ph.D. research explored how environmental management efforts affected employees, whether effective environmental management might be contingent upon strategy contexts, and how environmental strategy was developed. In the context of emergent strategies, change, innovation and complexity, the research for this dissertation examined *effective* environmental management using interpretive methodology and case studies. Noting that strategy could be emergent, i.e. emanate from the organization rather than being imposed upon it, a goal of the research was to understand the practice of management without a predetermined strategy. The research findings demonstrated that management systems behaved differently depending on if the strategy context was *deliberate*, *evolutionary* or *emergent*. In *deliberate* strategy contexts, formal management systems may improve performance by reducing variability and risk. In *evolutionary* strategy contexts, formal management systems were employed in internal competition by champions. In the context of *emergent* strategies, formal management systems seemed to be irrelevant or even impediments to necessary change and innovation.

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Executive Summary

Over the past two decades, environmental management as an explicit function in industry has expanded considerably. In this expansion, environmental management systems (EMS) have played important roles, such as legitimizing environmental management and shaping a discourse around it, establishing and defining key concepts and approaches.

Improved environmental performance in industry is necessary for sustainable development. There is not a single, completely objective measure of environmental performance, but by independent assessments EMS do not consistently lead to improved environmental performance, even as this research has demonstrated that environmental management must be systematic to be effective. Therefore, a better understanding of how environmental management functions in practice was needed on which to base more effective management methods.

In this endeavor, to better understand the actual functionality of environmental management, a meaning-based view was adopted for this dissertation research. Such an *interpretive* methodology contrasts both with the *empirical-analytic* view and with the *critical-reflective*. The investigations were based on case studies which organizations were defined as systems of shared meaning and management as the creation and maintenance of such systems. Despite the interpretive methodology, the research had practical purposes: to apply the deepened understanding to improve environmental management.

Initial investigations demonstrated that the implementation of environmental management systems did not necessarily deliver improved performance, but the case evidence in the literature was mixed. The evidence did not demonstrate that environmental management systems were entirely without effect. These mixed results might indicate the effectiveness of EMS was contingent upon some condition.

In searching for a contingency factor that might explain the mixed results of implementing environmental management systems, studies of business strategy literature revealed that business strategies may be emergent, meaning that that they emerge as a pattern of action from the organization, rather than being centrally planned and then implemented. Emergent strategy format was shown to be

prevalent in business environments which are either too complex or too dynamic for effective planning. In a *strategy context* where strategy is emergent, then traditional definitions of management, where the role of management is defined as implementing a deliberate strategy, are not applicable. Noting that formal Environmental Management Systems do not necessarily deliver improved performance, and that traditional definitions of management are unusable for some strategy contexts, an objective of this dissertation is to contribute to understanding of how effective environmental management might function.

Studies of the theory of *emergent*, *planned* and *evolutionary* strategy and their respective contexts revealed that formal management systems functioned as negative feedback loops, their corrective functions strengthening stability and conformance to planned strategy, whereas informal management systems exhibited positive feedback loops leading to instability, innovation and change. Theoretical studies on management and organization supplied models or "metaphors" appropriate for different strategy contexts and corresponding to various methods of study.

An interpretive analysis of a particular organization case study revealed that formal management system initiatives at that organization had no demonstrable effect on behavior, whereas informal management practices did. Particularly, personal interaction within the organization hierarchy was demonstrated to be an effective management instrument. Also, meaning-creation by an act of measurement was demonstrated. These results, although not generalizable in themselves, elucidate the difference between formal and informal management and demonstrate the effectiveness of interpretive methodology in management studies, paving the way for further similar research.

The analyses in this dissertation research demonstrate that environmental management effectiveness is contingent upon strategy context. For operations that are stable and straightforward, management for conformity, typical of formal management systems such as EMS, may be appropriate. Conformance management may not lead to significant gains in improvement, but should reduce non-conformance and risk.

In an evolutionary strategy environment, where competing strategy concepts co-exist in an organization, the agents employed to implement strategy can affect the content of strategy. A champion for a strategic cause, equipped with appropriate powers of authority, can affect strategy, even if the stakeholders are indifferent. The choice of representative and delegation of authority therefore, have strategic implications.

In an emergent strategy setting, the role of management can be usefully envisaged, as in interpretive social science, as organization-making. In this view, management

creates the mechanisms for shared meaning in the organization. Such mechanisms can include training, meetings, data collection and awards. In social science, these would be viewed as cultural rituals. The shared meaning so created prepares the organization for coherent responses to its environment.

A case study demonstrated the simultaneous existence of deliberate, evolutionary and emergent strategy contexts in the same organization. The possibility of different functions existing in different strategy contexts has the consequence that the appropriateness and functionality of an EMS may be dependent on the environmental strategy context, which may differ from the general strategy context.

The results of the research also have implications for the use of planning in management. The research demonstrates that even if complexity and change can make strategic plans meaningless, that does not make the planning process meaningless. On the contrary, planning processes are useful to help an organization to develop a 'system of shared meaning'. Such processes are organization-creating and prepare the organization to respond coherently to their dynamic environment.

Environmental management does seem to be contingent upon the strategic context in which the management operates, with the vital new qualifier that the environmental strategy context may differ from general strategy context. Depending on the strategy context, the role of the environmental manager and contents of effective environmental management vary considerably.

Meningen med miljöledning
(Popular science summary in Swedish)

Miljöledning, inklusive rollen som miljöchef verkar vara beroende av organisationens strategiska omgivning.

Förbättrad miljöprestanda inom industrin är nödvändig för en hållbar utveckling. Under de senaste två decennierna har miljöledning blivit allt vanligare som en klart uttalad funktion inom industrin. I denna spridning har miljöledningssystem (MLS) spelat en viktig roll, genom att göra miljöarbetet brett accepterat och genom att forma ett språkbruk kring det, med hjälp av klart definierade nyckelbegrepp.

Det finns inget helt objektivt mått på miljöprestationer, men oberoende bedömningar visar att införande av MLS i en verksamhet inte nödvändigtvis leder till förbättrad miljöprestanda, trots att forskning har visat att miljöledningssystemen måste vara systematiska för att vara effektiva. Därför behövdes bättre kunskap om hur miljöledning fungerar i praktiken som underlag för att utveckla effektivare interna styrmedel för företagen.

För att bidra till kunskap om hur miljöledning verkar i organisationer, har denna avhandling baserats på fallstudier gjorda med ett tolkande förhållningssätt. Forskning i miljöledning och organisationsforskning generellt är social vetenskap. Vetenskapsfilosofer skiljer på tre typer av social forskning:

- *Analyserande*, som söker objektivt mäta, förklara, bygga modeller och förutspå reaktioner på förändring;
- *Tolkande*, som söker förstå genom detaljrika beskrivningar så att en social verklighet kan förstås av någon som tillhör en annan;
- *Kritisk* – försöker befria människor från sociala bojor.

Tidigare tolkande forskning av organisationer har fokuserat på hur mening skapas, alltså hur människor i en organisation tillsammans ger en för organisationen särskiljande mening åt en händelse. Titeln för arbetet, ”Meningen med miljöledning”, syftar på detta och är lite av en ordlek. Avhandlingen behandlar meningen med miljöledning i två betydelser, dels hur miljöledning skapar gemensam mening i en organisation och dels hur miljöledning kan bli mer

meningsfull i betydelse att den ger bättre resultat för naturmiljön. Den senare betydelsen av ”meningen med miljöledning” är alltså ett exempel på den första kategorin av social forskning, den analyserande. Den sammanfattande studien i den här avhandlingen har det förhållningssättet.

Inledande undersökningar visade alltså att införandet av miljöledningssystem i företag inte nödvändigtvis gav bättre prestationer, men resultaten var blandade. Tidigare forskning hade inte visat att miljöledningssystem var helt utan effekt. Dessa blandade resultat skulle kunna tyda på effektiviteten av MLS var beroende av någon faktor som inte tidigare identifierats.

I sökandet efter en faktor som skulle kunna förklara de blandade resultaten av införandet av miljöledningssystem, påträffade jag forskning om affärsstrategi som beskrev att strategier kan vara *framväxande*, snarare än *avsiktliga*. En framväxande strategi innebär att strategin växer fram som ett handlingsmönster från organisationen, i jämförelse med en avsiktlig strategi som bestäms först och sedan genomförs. Framväxande strategier visade sig vara vanligare i affärsmiljöer som antingen var för komplicerade eller för föränderliga för effektiv planering. Hur strategi bildas skulle kunna ha betydelse för hur företag styrs, eftersom mycket etablerad kunskap om hur företag styrs baseras på tanken att de styrs i enlighet med redan beslutade strategier. Därför skulle formen för strategibildning kunna vara en faktor som påverkade effektiviteten i miljöledningsarbetet.

Förutom avsiktlig och framväxande strategi, identifierade jag ytterligare en form av strategibildningen, den *evolutionära*. Evolutionär strategibildning kännetecknas av att olika strategiinriktningar samexisterar i en organisation och tävlar internt om efterföljare. Evolutionär strategibildning är ett mellanting mellan planerad och framväxande. I en evolutionär strategibildning kan de enskilda, sinsemellan tävlande strategierna vara planerade, men resultatet är framväxande.

Strategiforskning har använt modeller lånade från reglerteori för att visa att formella ledningssystem fungerade som negativa återkopplingar; deras korrigerande funktioner stärkte stabiliteten och överensstämmelsen med planerad strategi. Informella ledningssystem uppvisade tvärtom positiva återkopplingar, sådana som leder till instabilitet, innovation och förändring.

En av fallstudierna som underbygger denna avhandling visade att det formella miljöledningssystemet inte hade någon påvisbar effekt på beteendet hos medarbetarna i organisationen, medan informellt ledarskap hade effekt. Speciellt var personlig interaktion inom organisationshierarkin ett effektivt styrinstrument. Det chefen sa tillmättes alltså betydelse, men inte det som stod i en policy. Det resultatet gäller för just den organisationen, och behöver inte vara allmänt sant, men det visar skillnaden mellan formell och informell styrning och demonstrerar

effektiviteten av tolkande metod i ledningsstudier, vilket banar väg för mer liknande forskning.

Analyserna i den sammanfattande delen av denna avhandling visar att effektivitet hos miljöledningssystem är knuten till organisationens strategiska miljö. För verksamheter som är jämförelsevis stabila och enkla, där meningsfull planering kan göras i förväg, kan styrningsmetoder som bygger på överensstämmelse med plan, typiska för formella ledningssystem såsom EMS, vara lämpliga. Denna typ av ledning minskar avvikelser och risker.

I en evolutionär strategimiljö, där konkurrerande strategikoncept samexisterar i en organisation, visar avhandlingen att enskilda anställda kan påverka innehållet i strategin, oavsett omgivningen. En förespråkare för en viss strategisk inriktning, utrustade med lämpliga befogenheter, kan påverka strategi, även om företagets intressenter är likgiltiga. Valet av nyckelmedarbetare och delegation av befogenheter kan därför ha strategiska konsekvenser.

I dynamiska och komplexa strategimiljöer, där en framväxande strategibildning kan förväntas, kan ledningens roll med fördel betraktas på samma sätt som i tolkande samhällsvetenskap, som organisationskapande. I en sådan syn skapar organisationsledningen mekanismerna för att det ska bildas gemensam mening i organisationen. Sådana mekanismer kan omfatta utbildning, möten, datainsamling och utmärkelser. I samhällsvetenskap, skulle dessa ses som kulturella ritualer. Den gemensamma mening som ritualerna skapar förbereder organisationen för sammanhängande svar på sin omgivning.

En av studierna som underbygger avhandlingen visade samtidig existens av avsiktlig, evolutionär och framväxande strategi i samma organisation. Att olika strategimiljöer kunde samexistera hade inte förutspåtts av strategilitteraturen. Möjligheten att olika funktioner i en organisation existerar i olika strategisammanhang har till följd att lämpligheten och funktionaliteten hos ett MLS kan vara beroende av det miljöstrategiska sammanhanget, som kan skilja sig från det allmänna strategisammanhanget.

Resultaten av forskningen har också konsekvenser för användningen av planering i organisationsledning. Avhandlingen visar att även om komplexitet och förändring kan göra strategiska planer meningslösa, betyder det inte att planeringsprocessen är meningslös. Tvärtom, planeringsprocesser är användbara för att hjälpa en organisation för att utveckla en gemensam tolkning av omvärlden. Sådana processer är organisationsskapande och förbereder organisationen på att svara på ett enhetligt sätt på sin dynamiska miljö, utan att svaret har samordnats.

1. Introduction

Growth, in the human population and wealth, leads to increased demands of goods and services that inevitably cost energy and raw materials to provide, impacting the natural environment (e.g. IPCC 2014; Chu and Majumdar 2012; Gerland et al. 2014). Industry seeks to produce goods and services to satisfy human needs. In that capacity, industry both contributes immensely to human welfare, and substantially negatively affects the natural environment. The holistic and integrative approaches of cleaner production were designed to help industry be more efficient and to reduce toxic risks via preventing the generation of pollutants at their sources.

The overall goal of my[1] research journey was to contribute to improvement of environmental performance in a cleaner production perspective. The focus of the research was on the role of management, in the hope that a contribution to knowledge of management of cleaner production would lead to an improvement in environmental performance. During the (protracted) course of this research, the term cleaner production has had varied usage. In this dissertation, it is used mainly to specifically designate efforts to prevent pollution, whereas environmental management and energy management might include other issues, such as permissibility, communications and (in the case of energy) price and supply. However, management for cleaner production constitutes a substantially smaller body of knowledge than the broader concept of environmental management, and indeed sustainability management. The research is therefore grounded in the literature of environmental management.

[1] The articles in this dissertation all avoid the first person singular, as this was a demand to get published. The avoidance of the first person is a reflection of the prevalence of a rationalistic research tradition. ”In a general sense, the rationalistic research tradition within social science is based on a dualistic ontology and objectivistic epistemology” (Sandberg 1994, 16). The dualism is that the researcher and the object of research are separate existences. Objectivistic means that there are observable facts and objects, meaning that a correct scientific observation would be the same, independent of the researcher. Phenomenological research, on the contrary, is philosophically based on ontology of individual, constructed “life-worlds” and interpretive epistemology. In such research, it is actually not appropriate to make a pretext of separation between the object and subject of research by such grammatical feints as using the third person or passive voice instead of first person. Instead, it would be preferable to present the researcher as a part of the research. I have therefore, appended a brief presentation of myself, my experiences and my beliefs.

Moreover, the endeavor to improve environmental management has amalgamated with that of environmental management systems (EMS), which are increasingly used in business (Feng, Zhao, and Su 2014). Therefore, to best fulfil the goal of improving management for cleaner production, it is expedient to study and discuss EMS. Whether implementation of an EMS as a whole actually leads to improved environmental performance is questioned in the literature. For example, according to Könnölä and Unruh (2007) "EMS can contribute to inertia". The connection between EMS and environmental performance is explored further in this research.

Concomitantly to the development of Environmental Management, starting in 1985 (Mintzberg and Waters 1985), strategy research demonstrated that strategies could be emergent rather than deliberate, meaning that they could develop from within the organization as a coherent pattern of responses, rather than being planned in advance and then implemented. These researchers connected emergent strategy, and the failure of deliberate, or planned strategy with change and complexity. Change or complexity could cause conditions that make it impossible to develop an appropriate strategic plan (Mintzberg 2000). The differing characteristics of the business environment that effect how strategy if formed is designated the strategy context. The discovery of emergent strategy challenges the traditional concept of management, including environmental management, because the traditional role of management is to implement strategy by coordinative activities in the organization. In an emergent strategy, the management role would shift to crafting the conditions for strategy creation, rather than imposing strategy implementation. An objective of my research is to understand better what this means for environmental management. **Figure 1** shows how cleaner production, emergent strategy and sensemaking together form the basis for the purpose of the research.

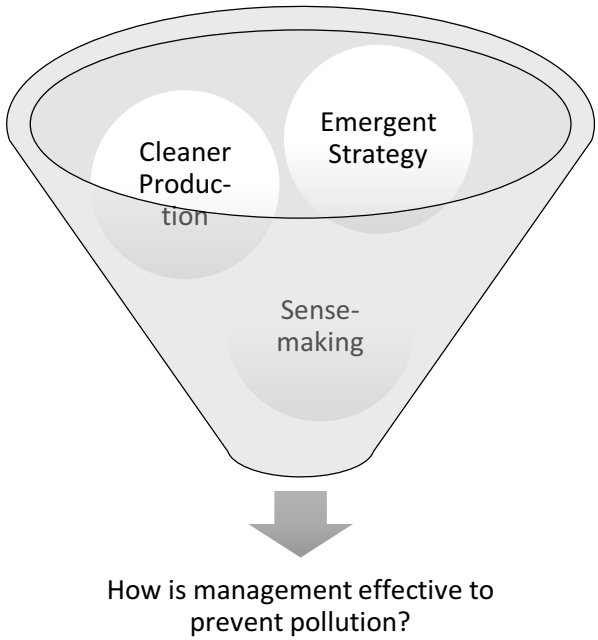

Figure 1: Points of departure for the research
The purpose of the research is derived from the intersection between three bodies of theory, cleaner production, emergent strategy and sensemaking. The research uses sensemaking methodology to explore how management can be effective towards achieving cleaner production in emergent strategy contexts.

Neugebauer, Figge and Hahn (2015) examined formation of corporate sustainability strategies in the context of planned or emergent strategy noting that "in the corporate sustainability literature it is most commonly assumed that sustainability strategies are made in a planned way" and calling this "remarkable". An explicit example of the planned strategy assumption was Banerjee (2001). Neugebauer et al concluded that there existed an "important gap in the sustainability strategy literature" in ignoring the distinction between planned and emergent strategy and recommended further research on the influence of strategy contexts on sustainability strategy formation (Neugebauer, Figge, and Hahn 2015). This research represents such an effort.

Mac (2002) argued against "rationalistic perspectives" when analyzing business behavior in relation to societal environmental agendas and instead recommended sociocultural theories to analyze organizational sensemaking of societal challenges, but sociocultural theory remains underrepresented in environmental management research. One such work explored Corporate Social Responsibility (CSR) as sensemaking (van der Heijden, Driessen, and Cramer 2010). In "Sensemaking and Sensegiving in Strategic Change Initiation", Gioia and

Chittipeddi (1991, 433) stated that "the CEO's primary role in instigating the strategic change process might best be understood in terms of the emergent concepts of 'sensemaking' and 'sensegiving'". Sensemaking (as well as new institutional theory) are based on a (Heideggerian) phenomenological ontology and epistemology (Gill 2014; Weick 1995).

Methodological choices in this dissertation are justified and elucidated in Section 2.2. A secondary objective of this dissertation was to contribute to addressing the deficit in sociocultural environmental management research and to demonstrate how such research, using interpretive methodology, can complement more common methodologies.

1.1 Research objectives

The purpose of this dissertation is to contribute to the development of management techniques that effectively advance implementation of cleaner production concepts and approaches and therefore, to improve environmental performance. The context of the research was that strategies may be emergent, business environments may be dynamic or complex and achievement of organizational goals may require innovations. To achieve this purpose, in this context the main objective of this dissertation is to improve understanding of the effect of environmental management on performance, in the presence of change, complexity and/or an innovation imperative, in order to create a foundation for effective cleaner production management in these contexts. In order to focus the research towards application of this improved understanding, and based on evidence in the literature and available case studies, the following two research questions were formulated:

Research Question #1: What general hypotheses for how effective environmental management is contingent upon the strategy context of the organization can be formulated from identified linkages between effective environmental management practice and strategy context?

Research Question #2: What specific actions can be suggested to improve environmental management efficacy in the respective strategy contexts?

To address the identified gap in in sociocultural environmental management research and contribute to knowledge of interpretive research applications in environmental management, the following research question was formulated:

Research Question #3: How can interpretive research complement other methodologies to improve environmental management results?

The primary audience for this work was the community of researchers in environmental management, energy management and sustainability management. A secondary target group was the membership of the environmental management profession.

1.2 Limitations in scope

The term strategy is used often, and with varying meaning. Competitive strategy is essentially an (arguably normative) application of Economic Theory on the firm as in Michael Porter's work of that name (Porter 1980) famously defining the "Five Forces" that act on the firm. With this dissertation, I did not intend to make a contribution in strategy in that sense. The connection to the strategy discourse is instead that EMS seemed to assume that strategy was deliberate, which begged the question of how to manage if strategy instead is an effect of organization, as in emergent strategy formation. Strategy formation is thus part of the context, whereas the focus of the study was on management.

A concept related to competitive strategy is management effectiveness. The (sole) purpose of management being to deliver return (to shareholders), and management being a significant cost, reducing return, it is of interest to economics to increase the output of management in relation to the cost. This dissertation examines efficacy of management for prevention of pollution, which is not a factor of management performance usually included in management effectiveness. Furthermore, this dissertation does not include an examination of costs. Therefore, it is not a study of management effectiveness. This is a limitation, as one argument for standardized management systems might be that the standardization might lower costs. This has not been examined.

Within competitive strategy, the concept of performance would typically center on economic outcome, or focus upon the "Five Forces" operating on the company (e.g. market position). In this dissertation, the term performance is used, unless otherwise specified, to denote achievement in the prevention of pollution. This is a significant limitation. Other forms of performance from environmental management might be market position or include such elements as license to operate, i.e. legal and/or social legitimacy allowing continued operations (and thereby continued unabated pollution).

Within this dissertation, there is a slight variance in the unit of study. The in-depth case studies use a definition of organization based on shared meaning (see Section 2. Theory and Methodology), but the scope of management systems naturally did not use this definition. The research is based on the assumption that the overlap

between various definitions of the organization is sufficient for analytical validity, but demonstrating this falls outside the scope of the work.

1.3 Document structure

This document is a summary and discussion of five documents that are included in this Ph.D. dissertation, my licentiate thesis (a monograph) and four research articles. To clearly designate when a reference is being made to the included research, these references will be in italics. In the interest of clarity, the works are referred to by their short titles, as follows:

1. Licentiate thesis (T. Parker 1998): *Total Cost Indicators*
2. Research article (Nawrocka and Parker 2009): *Finding the Connection*
3. Research article (T. Parker 2013): *The View from Below*
4. Research article (Parker submitted): *Managing Emergence*
5. Research article (Peck and Parker 2016): *The 'Sustainable Energy Concept'*

This first section of this dissertation introduces the issues investigated in the research and places the research within its context, with a description of the purpose of the research and the research questions in subsection 1.3. Section two defines the phenomena to be studied and describes the selection of appropriate methodology for both this summary dissertation and for the underlying research presented in a monograph licentiate thesis and four full-length research articles. To achieve this, and to supply the methodological context, a brief overview of available theories and methodologies is presented. Section three summarizes the research articles included in this dissertation and briefly discusses each article, so that they are placed in the thread of the research in a coherent manner. One of the research articles is literature review. This is presented in subsection 3.2. Section four contains a reflection and discussion of the research from the perspective of a unified research effort. Validity and reliability are discussed in subsection 4.2.1 and generalizability in 4.2.2. Section five provides conclusions and recommendations from the research to the key audiences and concludes with closing remarks which summarize the answers to the research questions.

2 Theory and Methodology

Research Question #1 concerned a search for linkages between effective environmental management practice and the strategy context of organizations. To address this first question, the five underlying individual research reports are summarized and discussed in relation to a body of literature differentiating between several strategy contexts and demonstrating how strategy development differs in these contexts. This theory is presented in Section 2.1.

Research Question #2 of this dissertation involved an exploratory effort to discover how interpretive studies of environmental management and organization may be helpful in assessing the effectiveness of environmental management practice. This effort requires a presentation of the methodological basis for interpretive research This is supplied in Section 2.2.

Section 2.3 delineates the object and context of study, by defining *management* and *organization* in the newly presented contexts of strategy and interpretative epistemology. In that process, some additional limitations to the scope of the study are clarified. The concepts are introduced in historical and theoretical context, and this elucidates that the definition of the concepts was informed by theory. Consequently, an overview of research theory and methodology is provided, after which the methodology of the research is presented and with it the definitions of the concepts used in this dissertation. **Figure 2** illustrates how unconventional concepts of strategy demand equally unconventional conceptualizations of management. In Section 2.4, the methods used in the underlying research are introduced. Sections 2.3 and 2.4 therefore form a foundation to address *Research Question #3*, which concerned how interpretive research could complement other methodologies to improve environmental management results.

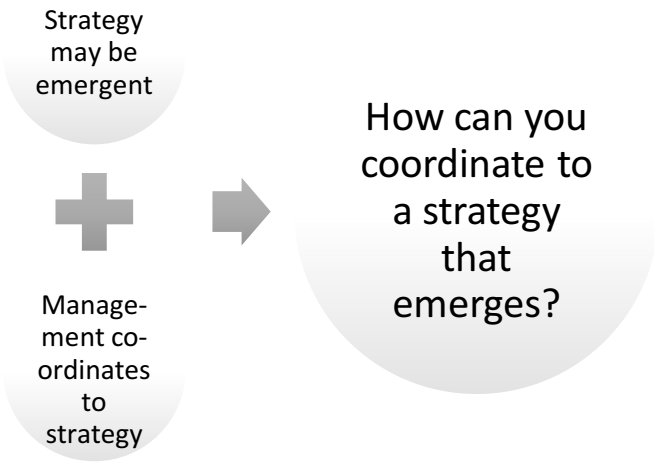

Figure 2: If strategy is emergent, then how can management coordinate activites?

Traditional definitions of management presuppose a planned strategy; the role of management is defined as coordinating activities towards strategic goals. Management in an emergent strategy context must therefore differ from some traditional definitions of management.

2.1 Strategy contexts

As briefly stated in the introductory section, a body of literature has demonstrated that it is not always appropriate to view strategy development as a planned activity done by executives in relation to challenges from the corporate environment. Strategy may instead be "emergent", emanating from the organization as a whole, rather than being imposed upon it (Mintzberg and Waters 1985). Due to complexity or rapid change in business conditions, strategic planning could become a futile effort (Mintzberg 2000). Starbuck (1993) demonstrated that for a sample of businesses, zero correlation between the degree of strategic planning and business performance.

Stacey (1995) analyzed strategy process from the perspective of system dynamics. Stacey identified a "strategic choice school" of strategy that assumes that "environmental changes are largely (but not totally) identifiable" and that organizations "purposively and intendedly adapt" to these, and an "ecology school" where the adaption was by trial and error, with successful strategy emerging in competition much like natural selection (hence "ecological"). The two schools were demonstrated to be similar from the perspective of system dynamics, in that they rely on negative feedback loops to achieve a state of equilibrium. Stacey proposed an "alternative perspective" based on informal networks with chaotic dynamics constrained by the feedback structure (negative and positive) of

the organization. The proposed view was based on complexity, change and social science "in which behavior unfolds or emerges from a dialectical process".

Usefully for the analysis of EMS, Stacey (1995) compared formal and informal systems in organizations, concluding that "formal systems operate in a stable way to secure efficient day-to-day operations while the informal system operates in a destabilizing manner to promote change". In Stacey's view the informal systems are disorderly, which is vital for creativity. "Disorder … is a fundamental property of creative systems and it plays a vital role in that creativity". Stacey's analysis of formal and informal systems in organizations is strikingly similar to the analysis by Strachan (1997) of the then, new, EMS standards compared to learning organizations. In Strachan's view, the standards were highly formal, hierarchical and rigid in contrast to a learning organization which is flexible, experimenting and adaptive.

Whittington (2001) expanded the number of strategy development categories into four, calling them *Classical*, *Evolutionary*, *Systemic* and *Processual*. This dissertation builds upon Stacey's categorization, which is most closely connected to organization and explicitly discusses management systems. However, because Stacey's designations in the strategy typology are somewhat cumbersome, and because the designation "ecological" would be confusingly ambiguous in a discussion of environmental management, the following simplified labels are used for strategy formation types:

- *Deliberate* after Mintzberg, corresponding to Stacey's "strategic choice school" and Whittington's "classical"
- *Evolutionary* after Whittington, corresponding to Stacey's "ecology school"
- *Emergent* after Mintzberg, corresponding to Stacey's "alternative perspective"

Figure 3 summarizes the strategy typology for ease of reference.

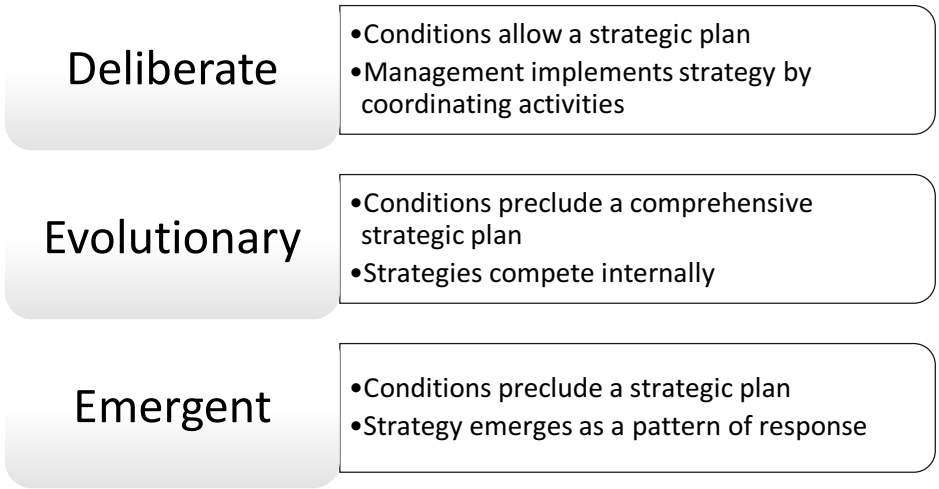

Figure 3 The strategy typology
The strategy typology with characterizations of how the types differ in context and function

2.2 Methodologies for studying management and organization

It is not appropriate to make choices of method, without considering underlying assumptions. The reason for this is that ”all approaches to social science are based on interrelated sets of assumptions regarding ontology, human nature, and epistemology” (Morgan and Smircich 1980, 491). In order to clarify, I provide the background for my choice of method, by reviewing these interrelated sets of assumption from the perspective of the purpose of this dissertation research.

Based on the works of the philosopher Jürgen Habermas three epistemologies of social research can be delineated (Mats Alvesson and Hugh Willmott 1996, 50–51):

- *empirical-analytic* – with the purpose of prediction and control
- *interpretive* – with the purpose of understanding
- *critically reflective* – with an emancipatory purpose

Silverman (2005) divided qualitative approaches along a line of increasing “problematization” of data in a way very similar to Alvesson & Sköldberg (2000), who characterized it as a continuum of increasing reflexivity. Morgan and Smircich delineated a methodological continuum along an axis of separation of the research from the objective to the subjective: ”As we pass from assumption to

assumption along the subjective-objective continuum, the nature of what constitutes adequate knowledge changes" (Morgan and Smircich 1980, 493).

Philosophically, the Morgan/Smircich continuum contrasts with the Cartesian duality of soul and body. Only the material world could be scientifically investigated, which therefore, excluded social science. This evolved to a point where John Locke viewed science as necessarily based on measureable qualities (Molander 2003). An illustration of this strongly held view is evident in a quote from David Hume from 1748:

> If we take in our hand any volume; of divinity or school metaphysics, for instance; let us ask, does it contain any abstract reasoning concerning quantity or number? No. Does it contain any experimental reasoning concerning matter of fact and existence? No. Commit it then to the flames: For it can contain nothing but sophistry and illusion. (Hume and Millican 2008).

In the philosophical vein of Descartes, Locke and Hume, Auguste Comte coined the term *positivism* (Hartman 2004), which is today indicative of an epistemology where numerical measurement was the sole embodiment of scientific data, and an ontology wherein the researcher is external to and objective towards the object of the research and of the research data.

In the twentieth century, several philosophers put forward a contrasting view and delineated a scientific approach to interpreting texts and other works. Wilhelm "Dilthey (1976) argued that whereas, the *Naturwissenschaften* (the natural sciences) aimed at *erklaeren* (explanation) the aim of the human and social sciences [*Geisteswissenschaften*] was *verstehen* (understanding). He pointed out that similar to texts, all social phenomena arise from human externalization (or objectification) of inner feelings and experiences" (Prasad 2002). Dilthey explicitly followed the works of Edmund Husserl in phenomenology and built on the work of Martin Heidegger and Hans-Georg Gadamer. Gadamer rejected the dichotomy of subject-object in social science. Interpretation is process between the object of research and the researcher. The researcher always already has preconceived notions of the object.

In debate with Gadamer, Jürgen Habermas developed hermeneutics into critical theory, the goal of which was no longer understanding, but emancipation. This dissertation does not have an emancipatory aim, but a goal of contributing understanding. Therefore, its philosophical basis for its interpretive view is phenomenology (Husserl and Bengtsson 1989; P. Parker 1999; Easterby-Smith, Thorpe, and Lowe 1991). Phenomenology is a constructivist view. "Thus in this view, information is not *retrieved* from an objective world …, the phenomenological world of the individual is *selected* by interaction with the environment" (P. Parker 1999 emphasis added). Individuals construct their own

life-world. Phenomenological research varies in its view of how individuals construct their life-worlds, and therefore, how they help to construct each other's life-worlds.

A criticism of social constructivism is that it seems unlikely that social interactions could construct life-worlds completely independently of physical reality. A physically restricted form of constructivism is called *biological constructivism*, also called radical constructivism, second-order cybernetics, biology of cognition and enactive cognitive science. It is attributed to Humberto Maturana and Francisco Varela, who attempted to bridge the gap between natural and behavioral sciences (Varela and Maturana 1972). The individual and the environment create each other in a resonant relationship, termed *structural coupling*. So from a view on biology and cognition, they arrived at individual life-worlds, in a way that was quite comparable to Mannheim and Merleau-Ponty (P. Parker 1999). The idea behind biological constructivism was that people construct their worlds by expecting biological and social experiences to be repeated. Merleau-Ponty's phenomenology also starts from the body. Dingwall (1997, 64) summarized biological constructivism by stating that "we cannot make the world any way we choose. We are always constrained by the material conditions of our biological existence and by the responses of those around us."

Individual phenomenological worlds imply, among other things, that "a common world is no longer a prerequisite for communication" (P. Parker 1999, 7), but it is a great leap to go from a view on individual cognition and life-worlds to a view on how groups shape common understanding. A prerequisite for this to happen is that the group must be *operationally closed*. "Any example of individual structurally coupling may be understood to give rise to a domain of interaction that can be characterized as operationally closed, that is, a bounded domain with a recursive dynamic, which produces the structure of the system's interaction" (P. Parker 1999, 59). Within this domain of interaction, life-world and behavior affect each other. This is a notable characteristic of the organizational model used in this dissertation. In the words of Karl Weick, it is "not predominantly a formulation about open systems". The organization "can effectively seal itself off for long periods of time" (Weick 1979, 239). A concept for the shared meaning that develops in a closed system is "intersubjectivity", denoting shared understanding between individuals or a "we-relationship" (Gill 2014).

Inasmuch as an investigation of an organization is an effort to describe a culture, such a study may be termed an ethnography (Silverman 2005, 53). Ethnographies can be based on a variety of methodologies and theory including Grounded Theory and Ethnomethodology (Silverman 2005, 47). Karl Weick researched the connections between ethnomethodology or the methods of social anthropology and organization studies. Weick is best known for coining the concept of

'sensemaking' in organization theory. He was explicit that the word 'sensemaking' was a play on words. While 'making sense' in everyday speech might indicate an act of logical expression, Weick used 'sensemaking' to indicate an act of creating meaning. Sensemaking is an expression of a phenomenological organization view (Weick 1995).

Weick also provided useful delimitations to the sensemaking model, for example: "goal consensus is not a precondition of order and regularity in this model. The common assertion that people organize in order to accomplish some agreed-upon end is not essential to an explanation of the orderliness found in concerted action, nor is goal-governed behavior that evident in organizations" (Weick 1979, 239).

Interpretive researchers have developed concepts and definitions consistent with an interpretive view. For example, "organizations are socially constructed systems of shared meaning" (Smircich and Stubbart 1985, 724). The view of the organization is not so much a legal entity but a set of people who interact with sufficient intensity for a common understanding to develop. "The task of strategic management in this view is organization making – to create and maintain systems of shared meaning that facilitate organized action" (Ibid). For short, this view of management has been christened as "management of meaning" (Morgan and Smircich 1980). These are the conceptualizations of 'organization' and 'management' used in this dissertation. These are summarized in **Figure 4**.

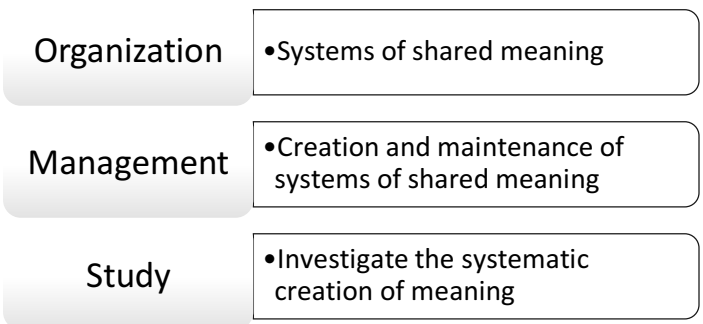

Figure 4: Phenomenological conceptualizations of management and organization
In the underlying research described in this dissertation, the concept of organization was understood to mean an operationally closed social system in which shared meaning is constructed. Management is the creation and maintenance of such systems and the corresponding research an invesigation into the creation of shared meaning.

2.3 Organizational theory

For this research, there was a need to define the objects and context of study, particularly the concepts of *management* and *organization* in the perspective of the

presented strategy contexts and in the chosen epistemological setting. Beginning with management, a traditional definition as taught at business schools was stated as: "the coordination of human, material, technological and financial resources needed for the organization to achieve its goals" (Peter Hess and Julie Siciliano 1996). Put into an historical perspective, the traditional definition of management was based on the Administrative Theory of Henri Fayol from 1916 (although translated to English first in 1949). Fayol also introduced the principles of division of labor and of unity of command. Contemporarily, Frederick Taylor presented Scientific Management, as a process of "scientifically" optimizing each task and then training workers accordingly, thereby putting in place a principle of separation of planning and execution. Peter Drucker introduced Management by Objectives in 1954 (Drucker 1986). Whereas Scientific Management demanded detailed instruction of workers, Management by Objectives instead called for setting objectives and allowing employees to a greater degree of freedom to choose how to achieve them. Studying quality in post-war Japan, the American Statistician W. Edwards Deming, like Taylor, placed emphasis on control in order to minimize variability in output. Deming's 'Plan-Do-Check-Act' is explicitly the basis for ISO 14001 (ISO 14001:2004) (Feng, Zhao, and Su 2014).

Morgan's "Images of Organization" (Morgan 2006) is a seminal work on the differing views of organizations (Heil 2008). Morgan presented eight views, called metaphors. The metaphors were *machines*, *organisms*, *brains*, *cultures*, *political systems*, *psychic prisons*, *flux and transformation*, and *instruments of domination*. Morgan used the word "metaphor", but also stated that "all theory is metaphor". Morgan's metaphors are associated with different theories of social science that differ not only in method, but also in ontology and epistemology. Returning to the three epistemologies of social research, it is clear that these follow a line of development in the philosophy of social science. The three epistemologies were given the names *empirical-analytic*, *interpretive* and *critically reflective*. Making use of a few of Morgan's "metaphors" as illustrations of the epistemologies of organizational research, the machine metaphor corresponds to the empirical-analytic epistemology. The culture metaphor corresponds to the interpretive epistemology. The instruments of domination metaphor correspond to the critically reflective epistemology. Critical studies are designed to "deconstruct" or expose repressive social systems in order to liberate the repressed. The remaining metaphors - organism, brain, political systems, psychic prisons, and flux and transformation represent intermediary positions to machine, culture and instruments of domination, in keeping with Morgan's view of the span of epistemologies as a continuum (Morgan and Smircich 1980). Sensemaking, as an application of social anthropology on organizations is an example of a cultural model of the firm, or social theory. Philosophically, "phenomenological philosophy informed the development of new institutional theory" (Gill 2014). In

relation to new institutional theory, this research is focused on an individual or "micro" level, rather than the firm level.

2.4 Methods

The methodology and theory described previously has informed the conducted research increasingly over the course of the investigations, but the methods employed within that framework have varied. When the research for *Total Cost Indicators* was conducted, the body of literature in Environmental Management was limited, Environmental Management Systems under construction and the framework yet undeveloped. This research was therefore more pragmatic, empirical and exploratory than the later works. It was the results of *Total Cost Indicators* that laid the foundation for the development of the framework. Two of the articles, *Finding the Connection* and *Managing Emergence*, include literature reviews. Finding the Connection uses the term 'meta-study', but because the underlying data was not available, it is more accurately described as a literature review using a Review Matrix. The matrix used included a categorization of the methods used in the underlying study, which proved advantageous in the analysis.

A review matrix was also used in *Managing Emergence,* but in this case the role of the matrix was to extract snippets of text and code into categories in a process of hermeneutic text analysis. The literature selected was used to represent a discourse rather than to describe the state of the art of the discipline. The literature selected described integrating management systems. This selection was chosen to give a body of literature discussing formal management systems in a state of significant change, because change and complexity were two phenomena that the study aimed to capture. The case study in *Managing Emergence* was based on a snapshot of all of the formal management systems of an organization at a given time. The case study also was a text analysis. Interpretation of text to understand the meaning of action can be called hermeneutics (Miles and Huberman 1994, 7). Prasad (2002) divided hermeneutics into classical hermeneutics, philosophical hermeneutics (also called phenomenological hermeneutics), and critical hermeneutics, the characteristics of which are summarized in **Table 1**.

Table 1: Typology of hermeneutics and their characteristics (Prasad 2002)
Each category of hermeneutics is associated with a different research goal, epistemology, founding philosopher and view of language

Concept	Goal	Epistemology	Philosopher	Language
Classical hermeneutics	Correct interpretation, finding the author's intent	Objectivist	Aristotle, Schleiermacher, Dilthey	Unproblematic conveyer of information
Philosophical hermeneutics	Verstehen, author not so important, text as an expression of culture/life world	Interpretive, constructivist, text and interpreter create	Heidegger, Gadamer	Constructs our world – part of interpretation, language is ontological
Critical hermeneutics	Critique, expose power, change power structures	Constructivist	Habermas	Constructs our world – must be changed to alter power structures

Interviews were primarily used in *The View from Below*. The interviews were preceded and informed by an "energy inventory" of the facility, in which energy flows were mapped in detail (material flows were limited at the facility in question). Interviews were semi-structure with an emphasis on 'why'-questions to solicit attributions. The interviews lasted about one hour and were transcribed. The transcriptions were then analyzed as text.

In *The View from Below* and *Managing Emergence*, the two articles in which I was the sole author, the texts were analyzed using of a system of coding. Coding is a process where snippets of text were marked and categorized. In *attributional coding* (Silvester 2004), the focus is on texts that attributed an action to a motive. It was therefore, an appropriate method to explore the causes of actions and thereby the effects of management.

As a method for demonstrating variations in understanding of competence at work, Sandberg (1994) suggested *phenomenography*. Phenomenography is used for "discerning of patterns … in conceptualization" (Miles and Huberman 1994, 7). An educational research group in Sweden developed phenomenography for describing qualitative variations in individuals' experiences of their reality. Their phenomenography attempted to clarify variation in conception, defined as a specific aspect of people's ways of experiencing, or making sense of, their world. Phenomenography was introduced as a visualization of interpretive studies, complementing the rich text descriptions that typified interpretive research, but has been criticized for rendering simplistic imagery. The graphic analysis in the research articles, particularly *The 'Sustainable Energy Concept'*, can be seen as a form of phenomenography.

The case studies used were not selected to fit the research plan, but rather selected based on opportunity. The case studies in *Total Cost Indicators* were all

commissioned research. The later, larger case studies were all performed at Research Infrastructure facilities, that is, research facilities of a scale comparable to infrastructure. This type of facility offers significant advantage for research, being open, academic institutions. The scale of environmental challenges, especially energy use and radioactive waste, is comparable to large-scale industry. However, in a context of strategy and organizational culture, the unusual business of these organizations raises issues of generalizability. This is discussed in Section 4.2.2.

The case studies in both *Managing Emergence* and *The 'Sustainable Energy Concept'* were made in organizations at which I was an employee at the time of the data collection, although I was no longer employed there at the time of completing the analysis and writing. In *Managing Emergence*, rigorous coding was used for transparency and to alleviate bias. In *The 'Sustainable Energy Concept'*, the analysis was performed independently by my co-author, Dr. Philip C. Peck and myself, with very similar results. Despite the rigor, there is no doubt that the research was affected by my pre-conceptions. In a phenomenological epistemology, after all, the researcher "always already" has preconceived notions.

The methods employed in the research have much in common with methods associated with a Grounded Theory approach, especially the use of coding, which might be surprising in interpretive research. In the words of, Miles and Huberman (1994, 8), phenomenologists "do not, for example, use coding". The authors are presumably referring to the rich descriptions typical of ethnomethodology and social anthropology. In this dissertation, *phenomenology* refers to the philosophical basis, not method, similarly, for example, to in *phenomenological hermeneutics*. Herein also lies the difference between interpretive research using coding and Grounded Theory. Despite the rigor of Grounded Theory, it has been criticized for failing to acknowledge the implicit theory that informs the research (Silverman 2005, 71). This contrasts with the phenomenological epistemology, which explicitly postulates that the researcher 'always already' has preconceived notions and that the subject's life-worlds are constructed. The distinction has consequences for the interpretation of the results.

3 Research Roadmap

In this section, my licentiate thesis and each of the four articles included in this dissertation are briefly summarized and individually discussed, to form a coherent argument. The full articles are included in the appendixes. The licentiate thesis is appended as a separate volume, as it is a monograph of 194 pages and was printed in sufficient quantity for its presentation in 1998.

3.1 Total Cost Indicators

Based on commissioned research performed between 1994 and 1997 in Swedish industry (mostly in service industries), my Engineering Licentiate[2] thesis (T. Parker 1998) was titled, "Total Cost Indicators - Operational Performance Indicators for Managing Environmental and Economic Efficiency" (herein referred to as *Total Cost Indicators*). The purpose of that thesis was to provide a tool for environmental accounting that supported the proactive and preventive implementation of approaches of Cleaner Production. **Figure 5** provides a summary overview of *Total Cost Indicators*.

[2] The Licentiate degree in Sweden is a research degree that is exactly half of a Ph.D., corresponding to two years' worth of post-graduate courses, research and thesis.

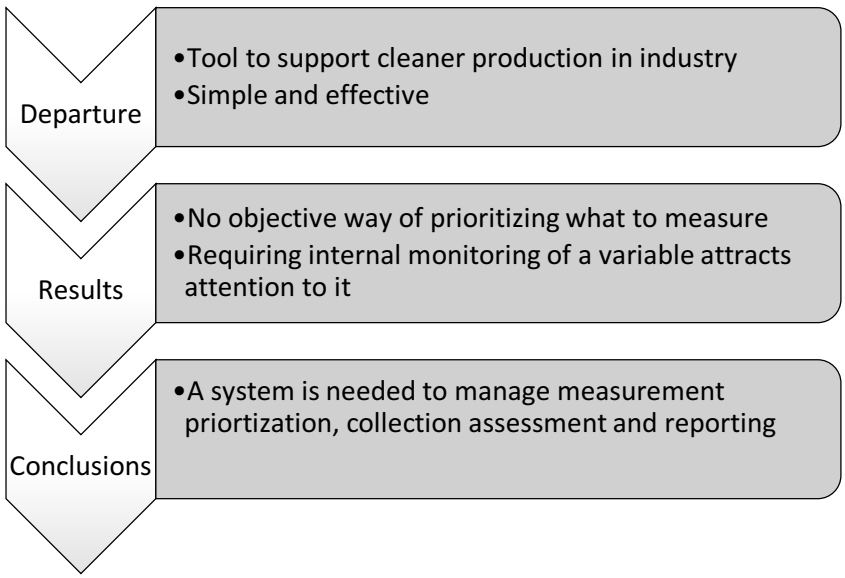

Figure 5: Summary overview of *Total Cost Indicators*
Highlights from the licentiate thesis monograph *Total Cost Indicators – Operational Performance Indicators for managing environmental efficiency* illustrating for the purposes of this dissertation key elements in the points of departure for the thesis, its results and relevant conclusions.

3.1.1 Justification for this research

My master's thesis, for completion of the degree of Master of Engineering Physics, at the Department for Industrial Environmental Economics at Lund University, expanded upon an existing management accounting tool to support industrial implementation of Cleaner Production concepts and approaches. Similar efforts by others preceded and followed, but industry adoption of these concepts and tools was insufficient. A less convoluted instrument was necessary and my attention turned to environmental performance indicators, both for management use and for external reporting, the latter being the focus upon which I had the honor of delivering a Keynote Lecture on Environmental Economics at the Third European Roundtable on Cleaner Production, in October 1996. The subject was "The Finance Sector and Cleaner Production". The focus of that presentation was that the financial sector had reason to interest themselves in the potentialities of industry to simultaneously improve their products, production and profits while reducing their negative environmental and human health impacts via using the preventative approaches of Cleaner Production. In that context, my lecture highlighted how corporate leaders could benefit from development and utilization of environmental indicators and environmental accounts. These two deliveries demonstrate the dual interest at the time in investigating Environmental

Performance Indicators (EPI). These emanated from two perspectives about EPI that were observed among environmental management practitioners at that time. The first perception was that communication using indicators was an effective way to improve environmental performance. The second perception was that a set of EPIs could be objectively established to support public environmental accounting, such that it could be compared and audited similarly to corporate annual reports.

3.1.2 Method

The initiation of 'The International Master's Program,' at the IIIEE provided an opportunity to produce a course guide, in the form of an overview of the literature in Environmental Accounting, which was used during the first years of IIIEE's program (T. Parker 1996). That provided a solid context for my research into environmental performance indicators.

The research methodology was pragmatic and empirical. The proposed tool drew upon "Total Cost Assessment; an Environmental Accounting Approach," published by, the US Environmental Protection Agency. Within the literature of accounting in general, another important foundational document was "Relevance Lost: The Rise and Fall of Management Accounting" (Johnson and Kaplan 1987). The empirical investigations were seven case studies. These were commissioned, not selected, all in Sweden, a variety of businesses.

3.1.3 Results

Total Cost Indicators suggested a pragmatic approach to EPIs to support a Cleaner Production approach to pollution prevention. Beyond that model, four issues were raised that have substantially affected the later research. These were subjectivity, change, complexity and management systems.

The first issue, subjectivity, related to the identified perception that that a set of EPIs could be objectively established to support public environmental accounting. This was refuted by the research, which demonstrated that there could be no objective way of weighting various impacts against each other, as the weighting process would necessarily contain moral judgments that would be subjective. It was found that part of the usefulness of the term 'indicator' derived from the lack of a claim to actually measure an objective truth, which was seen as a distinction between indicators and measurements. The conclusions in *Total Cost Indicators* was that no generally applicable appropriate method was available to calculate a 'total cost' for an organization.

The perception that communication using indicators was an effective way to improve environmental performance was corroborated in the research. The conclusion that indicators could be powerful communicative and motivational tools, had important methodological implications for the ensuing research, which came to be influenced by the view that environmental accounting was not, in fact, measuring an objective reality, but creating an enacted reality by attaching meaning to figures.

The second issued, change, arose from valuations in indicators also being potentially transient. As evaluations necessarily were subjective, they could also change rapidly, for example in reaction to events. No models that adequately addressed change were identified.

A third significant challenge to environmental accounting discussed in *Total Cost Indicators* was the issue of complexity. The research demonstrated that is was impossible to measure all relevant data as well as impossible to objectively aggregate the data. The issue of complexity raised in *Total Cost Indicators* was that of multidimensionality, that is, a multidimensional phenomenon cannot be mathematically described using fewer dimensions than the phenomenon exhibits, without loss of information.

The fourth issue was that implementing a system of environmental performance indicators largely implied the implementation of an Environmental Management System (EMS), specifically one designed to focus on pollution prevention at source. The EMS was necessary to identify and prioritize the environmental issues and to establish systems to collect and communicate data. Availability of data was identified as a significant constraint for indicators.

3.1.4 Discussion and conclusions for environmental management and strategy contexts

In retrospect, the point about objectivity of evaluation may have been over-emphasized, as a subjective evaluation that becomes a social norm among corporate stakeholders would warrant management attention (cf. Hansson and Ding 2015), regardless of epistemological subtleties. However, the issue of subjectivity in evaluation processes led me to utilize qualitative research methodologies and to the use of interpretive methods.

The objectivity or subjectivity of evaluation was thereby carried forward in the research as a methodological position. The epistemological question of whether a researcher objectively ascertain a subject's valuation of an object, and meaningfully represent that valuation in a number is contested. The philosophical position that a researcher can do so is denoted positivism, as noted above in the

section on methodology. In contrast, in an interpretive philosophical position, the very act of measuring is value-laden.

The twin issues of handling change and complexity became thematic in the ensuing research, and led to investigation of emergent strategy and related literature. This indicated, as noted earlier, in section 2.1, that strategic complexity may be present when strategic direction is dependent on multiple variables that are either independent, or characterized by multiple interactions among themselves. Such variations may defy adequate modelling. Another difficulty for modelling are situations requiring a discontinuity of output, such as innovation. A *complex* strategy environment is characterized by a level of intricacy, which defies a deductive planning process. A *dynamic* strategy environment, similarly, is one where the rate of change is too fast for a cycle of planning and implementation.

Because putting in place a system of indicators was demonstrated to require several elements of a management system, and at the same time was a powerful tool in management communication, the scope of the research was broadened to address environmental management more generally.

Total Cost Indicators was published in 1998. Much has happened in the field of EPI since then, such as the publication of ISO 14031 in 1999, the Global Reporting Initiative and almost 19,000 scholarly works, according to a topic search. However, the issues raised in *Total Cost Indicators* are fundamental, and remain unsolved. Efforts continue to address dimensionality and optimization, cf. (Kostin, Guillén-Gosálbez, and Jiménez 2015).

3.2 Finding the Connection: Environmental Management Systems and Environmental Performance

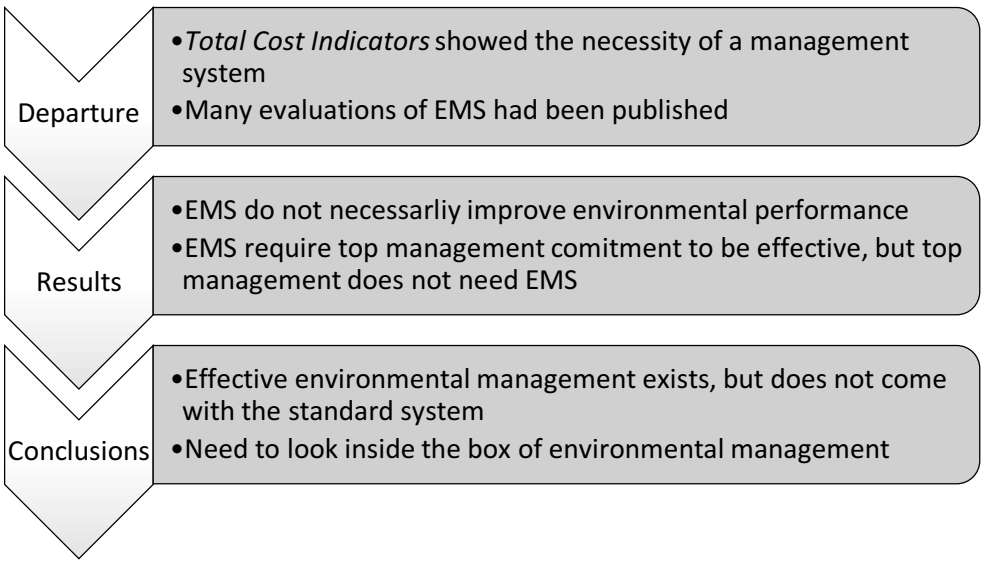

Figure 6: Summary overview of *Finding the Connection*
Highlights from the full-length research article *Finding the Connection: environmental management systems and environmental performance,* by Nawrocka and Parker, illustrating for the purposes of this dissertation key elements in the points of departure for the article, its results and relevant conclusions.

3.2.1 Justification for the research

Noting the extensive adoption of standard environmental management systems (EMS) that had reached 130,000 organizations since the introduction of ISO 14001, the article *Finding the Connection* (Nawrocka and Parker 2009) examined the many studies on the connections between the implementation of EMS in industry and the improvements of environmental performance. The examined studies provided inconclusive or conflicting evidence as to whether or not the adoption of EMS improved environmental performance in industries. By summarizing, analyzing and structuring earlier work, this literature study of twenty-three research articles and publicized reports was designed to provide insight into why earlier researchers had such varying results. **Figure 6** provides a summary overview of *Finding the Connection*.

3.2.2 Results

Two main issues emerged from the analyses in this paper. Firstly, it became apparent that although all the sources examined the EMS and environmental performance, and all had a similar view of what constituted an EMS (basically a certified ISO 14001 system), there was no consensus as to what constituted environmental performance, nor, consequently, what should be considered an improvement thereof. To give two examples that clearly illustrated the difference, authors of some articles defined improved environmental performance as a reduction in poisonous emissions exhibited in the Toxic Release Inventory, a mandatory American environmental reporting scheme. Other authors adhered closer to the definition of the standard, which included improvement of the management system as an improvement for fulfilling the mandatory goal of continual improvement as defined in the system. Demonstrating improvement in this latter sense is a requirement for certification, making the investigation of correlations between EMS certification and environmental improvement trivial.

If the variance of the view among researchers as to what defines environmental performance was problematic, an even greater difficulty, methodologically, was that some authors did not define environmental performance at all, instead they only asked industry representatives for their perceptions of the impacts of the system on improvement of environmental performance. This was an example of the second main issue, that of methodology.

The articles reviewed for this research were sorted into three methodological categories. There were quantitative analyses of public data, quantitative analyses of survey data, and qualitative case studies based upon information derived from interviews. Each category had its limitations. The first method was restricted to available data, which in practice restricted the application of the method to cases in the USA. Fundamentally, the method cannot demonstrate causality. Even if implementation of a company EMS and improved environmental performance were found to be correlated, such correlation could plausibly be explained by both having the same cause, rather than one causing the other. An example of such a cause is commitment by top management to environmental issues, which might lead both to improved performance and a decision to implement an EMS.

In the second methodological category, qualitative analyses of survey data, the papers reviewed were based on surveys that were directed to companies asking about the effectiveness of their EMS. The unsurprising result was that the companies perceived their EMS to be effective.

The third methodological category of papers, included case-studies based on interviews, which provided knowledge about how environmental management systems affected the studied organizations and environmental performance, but did

not necessarily provide generally applicable knowledge. In fact, the literature review, as a whole "supports a hypothesis that the effects of EMS are not general", that the effect of implementing an EMS is not general, but specific to the organization and to the details of the management system implemented, rather than being based upon the standard.

In conclusion, whether or not an organization has implemented an environmental management system says nothing about the environmental performance of an organization. The answer to the question of how to manage for Cleaner Production must therefore be sought by other means.

Another observation from the study was that although top management commitment was necessary for a successful EMS implementation, as stated in the ISO standard, with top management commitment, improved environmental performance could be attained, regardless of the existence of an EMS.

Finding the Connection demonstrated not only that there was no consensus about the relationship between environmental management systems and performance, but also that there was no clear consensual view of how environmental management systems were expected to function. There was no support presented from a perspective of theory of management or organization for the hypothesis that installing an EMS would improve performance. This raised a significant difficulty for the quantitative analyses, whether based on emissions data or questionnaires. With no clear model of the inner functioning of an EMS, it would have been difficult to generate more specific hypotheses to test, and to interpret results in terms of causality. The deficiency in relevant theory of organization and management exhibited in the examined literature was the reason for the theory development presented in this dissertation.

3.2.3 Discussion and conclusions for environmental management and strategy contexts

Finding the Connection corroborated the result from *Total Cost Indicators* that environmental performance evaluation could not be assessed objectively, nor were any generally accepted norms established for judging environmental performance. Despite this difficulty, Finding the Connection demonstrated that for definitions of environmental performance independent from the studied entity, the implementation of a standard EMS with subsequent certification did not necessarily improve performance.

Finding the Connection did not identify any specific variable which might help explain the seemingly heterogeneous results from EMS, for example whether one EMS standard system is appropriate for all sorts of organizations, or whether

different ways of implementing an EMS might be appropriate for different organizational contexts, or if formal management systems in themselves are more or less useful, depending on context. An important conclusion from *Finding the Connection* was therefore the need to generate better hypotheses for the connection between environmental management and performance; the hypothesis that implementation of a standard EMS would improve performance was not supported. Such improved hypotheses required more sophisticated models of the organizational effects of management initiatives than the "black box" model where the effects of the input of an EMS was measured in environmental performance improvement. These new models required a deeper understanding of the effects of EMS in different settings, the effects of various parts of an EMS, and the effect of other management initiatives outside the EMS.

Finding the Connection was published in 2008, and the underlying research is consequently older still. Undoubtedly, the practice of environmental management using EMS has improved during the time since the study. Also, the ISO 14001 standard has been updated twice, the latest one in 2015. It is conceivable that results might differ from *Finding the Connection* in new studies of the connection between implementing an EMS and environmental performance, but this does not change the main conclusion. *Finding the Connection* demonstrated that implementing an EMS did not, in itself, necessarily improve performance. Key questions to bring forward are:

1. Whether there are specific conditions in which EMS are more successful than others;
2. If there are ways of performing environmental management that are more or less effective;
3. How improvement is achieved when it is achieved without EMS.

The methodological analysis in *Finding the Connection* points to the fundamental difficulty with survey-based investigations compared to in-depth case studies. As advanced the statistical analysis of survey data may be, it cannot improve upon the quality of the underlying data. There is an underlying assumption that a meaningful transaction of information is completed with an answered survey (Silverman 2005, 29). This was not demonstrated in the literature reviewed.

3.3 The View from Below – a Management System Case Study from a Meaning-Based View of Organization

Within the field of general management, a few works have been empirical, based on the observation of the actions of managers (e.g. Mintzberg 1971; Carlson 1951). To further investigate environmental management, and rather than following the intentions and actions of managers or formal systems, the article *The View from Below* (T. Parker 2013) took the perspective of those being managed, by observing and interacting with the employees and interviewing them about their reasons for actions. **Figure 7** provides a summary overview of *View from Below*.

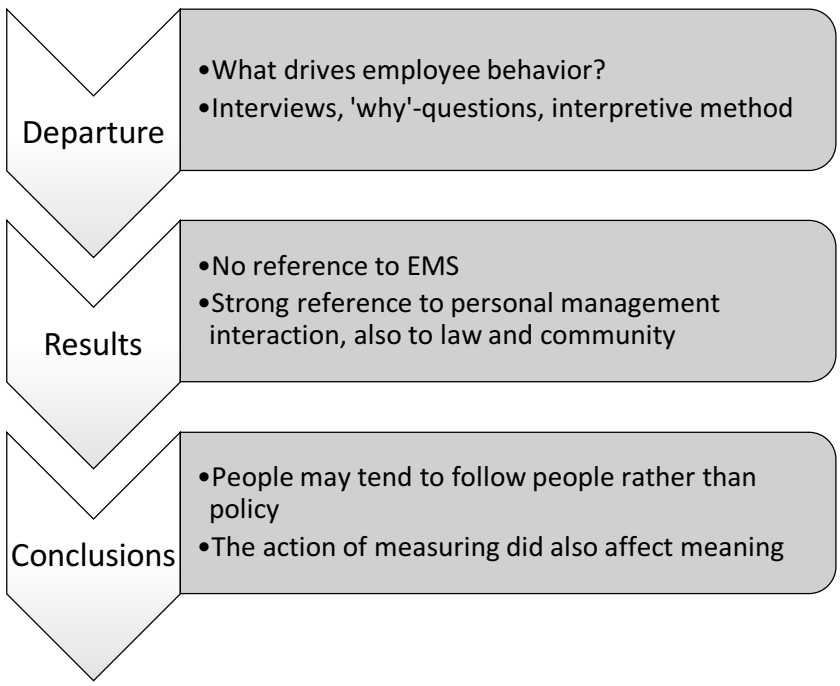

Figure 7: Summary overview of *The View from Below*
Highlights from the full-length research article, *The View from Below – a Management System Case Study from a Meaning-Based View of Organization* illustrating for the purposes of this dissertation key elements in the points of departure for the article, its results and relevant conclusions.

3.3.1 Method

The investigations were performed at the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory (ORNL), where I was a guest researcher for two years. National laboratories in the USA are government funded, organized under the Department of Energy. The SNS was geographically separate from other ORNL laboratories by about three kilometers, although within the large ORNL site at Oak Ridge, Tennessee, a former "Manhattan Project" site. Organizationally, SNS was part of the division for neutron science, which also included a reactor-based neutron source within ORNL. Daily operations were organizationally separate from the rest of ORNL as was the formal EMS.

The methodology was interpretive. Data were collected through observation, participation and interviews. The interview data were analyzed using the method of attributive coding. The use of a coding method was useful in for adding structure and rigor to the analysis. Attributional coding is a method that especially focusses on how responders attribute cause and effect in relation to the actions, and therefore highly appropriate for the research.

3.3.2 Results

The investigation revealed that the formal EMS was not an identifiable driver of actions in handling of environmental issues. The interviewed staff referred primarily to verbal interactions with superiors as the basis for decisions and actions. Face-to-face interactions appeared to have a strong social role.

I also investigated how the energy management and environmental management co-existed in the case. The results revealed that there was no significant overlap between energy management and environmental management in the case. The environmental management was largely oriented towards compliance with regulations, whereas, the energy management was devoted to cost reduction, with the emphasis on reducing price, rather than consumption. A general conclusion from this case was that although energy management may, in general, have a significant overlap with environmental management, is also has significant components unrelated to environmental management, which require a different skill set, such as knowledge of energy markets.

The case study results revealed that the collection and integration of energy and environmental data into an operational control system could lead to improved performance, corroborating the maxim of 'what gets measured gets managed' as well as the conclusion from the licentiate thesis, that measurements are powerful communication instruments, which help to focus attention.

The organization in the case had its specific social environment and culture. It is a scientific facility, with scientific endeavor as its main aim, which was tangible in the organization's discourse. Management and administration was performed mainly by scientists. Engineers formed a large part of the non-scientific employee base. The organization was in the U.S.A and was financed by the federal government. All this and much more formed the organizational culture. Later research, in similar organizations elsewhere, seemed to suggest that this type of community has a special propensity to ignore policy decisions. Thus, the result that the EMS was not identified as a driver of action may be taken as typical of a very specific type of organization. On the other hand, there was nothing to indicate that personal interactions were especially important in this culture. Therefore, the observation that personal interactions strongly affected behavior seems more likely to be general.

3.3.3 Discussion and conclusions for environmental management and strategy contexts

In an interpretive view, e.g. sensemaking *The View from Below* demonstrated meaning creation, primarily through human interaction, especially human interaction with people of authority, representing a hierarchy or respected institution. In a social model of the firm, this is an example of the socialization process, in which social values were internalized by the individual. To a lesser extent, meaning creation by rituals was demonstrated, in the example of implementing energy measurements.

The organization in this case study was selected for its accessibility. This was a large-scale research facility to which I had uninhibited access and which was characterized by openness to research. Being an accelerator-based facility, utilizing nuclear processes, the organization was dominated by engineers and physicists, which might be thought to exhibit strong rational/analytical tendencies, yet there were no decision support tools attempting to demonstrate economic optima of various decisions. Environmental actions and decisions were instead ethical, based on rules and authorities.

The organizations strategy context was plannable, despite challenging technology. The settings should therefore have been fruitful for formal management systems such as EMS, according to Stacey (1995). This is not disproven by the case, because firstly, formal management is more than EMS and secondly, the EMS may have worked indirectly, by setting a foundation that influenced employees through management or training activities. The correct conclusion was that human interaction had a strong influence in this particular case. Whether that effect is general cannot be concluded, although nothing was identified that pointed to the

people interviewed being especially susceptible to this type of influence. Based on the case, practitioners can be recommended to consider using interactions with people of authority as an instrument to cause change. Researchers can be recommended to use interpretive methods in cases, to supply further evidence of management initiatives affecting meaning creation, as much more such evidence is necessary to draw general conclusions. A general conclusion from *The View from Below* was that it matters who sends the message.

3.4 Managing Emergence: Management Systems in Emergent, Evolutionary and Deliberate Strategy Contexts

The *article Managing Emergence: Management Systems in Dynamic and Complex Strategy Environments* (T. Parker 2016) connected management, and specifically, formal management systems, to strategy. **Figure 8** provides a summary overview of *Managing Emergence.*

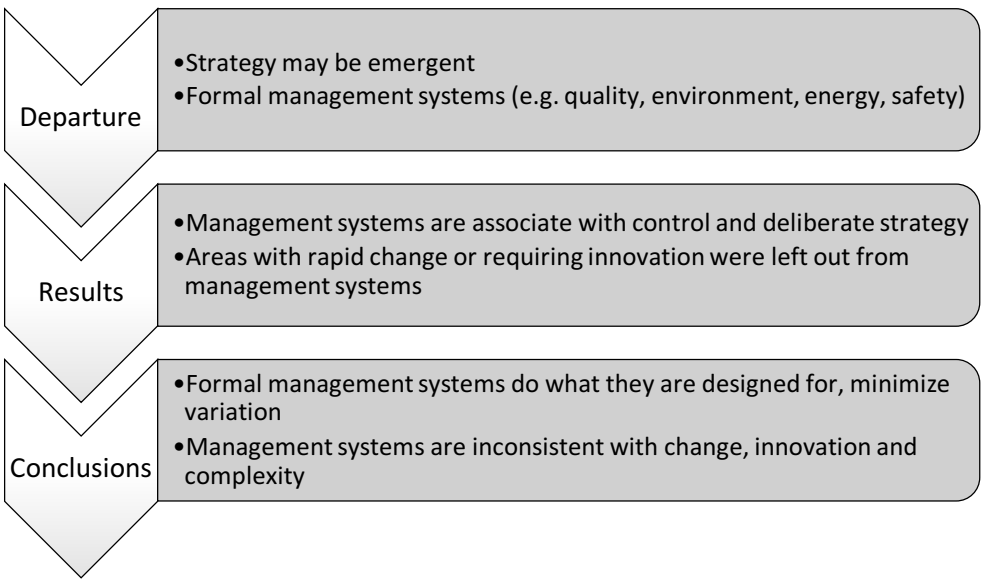

Figure 8: Summary overview of *Managing Emergence*
Highlights from the full-length research article *Managing Emergence: Management Systems in Dynamic and Comples Strategy Environments*, illustrating for the purposes of this dissertation key elements in the points of departure for the article, its results and relevant conclusions.

3.4.1 Justification for the research

Mintzberg and others had revealed that strategy may be emergent, meaning that strategy as a spontaneously organized pattern of action could develop from within the organization in response to input from the environment, in contrast to a deliberate strategy which is developed by management and imposed upon the organization.

Three types of strategy were derived from the literature, called: *deliberate*, *evolutionary* and *emergent*. Deliberate strategies were defined as strategies planned by management and then implemented using internal monitoring. Deliberate strategies were revealed to be based on the premise that the management is capable of collecting and analyzing data sufficiently to formulate the appropriate plan. Environmental Management Systems were also demonstrated to exhibit aspects that evidence a similar perspective. In the evolutionary view, strategic developments could be more diverse with competing views held in an organization, and an internal Schumpeterian 'creative destruction' ensuing. Emergent strategies were described as patterns of action in response to the outside environment that emerge from the organization. In evolutionary and emergent strategy thinking, the article demonstrates that the roles of management must be something other than developing and implementing strategies. Emergent strategies were especially associated with business environments in which the pace of change, the level of complexity or the combination thereof are too dynamic for strategic planning.

Environmental Management Systems and other similar systems were demonstrated to be explicitly based on the Plan-Do-Check-Act cycle attributed to Deming, an American statistician who worked on developing organizational control systems to deliver uniformity, by continually improving their ability to reduce variability of output.

Putting standardized management systems into the perspective of the three forms of strategies, I sought with *Managing Emergence* to provide insight into how systems, which evolved based on Deming's "Plan-Do-Check-Act" can be applied to handle environments of change and complexity, and how those systems can help the corporate leaders to better manage the innovations, which are necessary to adapt and to excel in dynamic and rapidly changing contexts.

3.4.2 Method

The methodology employed to study these diverse approaches was *hermeneutic phenomenology*. Hermeneutics implies the interpretation of texts (although in modern usage that may also apply to other types of 'works', including art). For

developing the article, I used two bodies of text. The first source was the body of literature of integrating management systems, which was selected to be representative of the management system discourse, specifically in a context of change and complexity, because integration of management systems is a significant change and also increases the complexity of the systems. The second source of information were materials that described various management systems in a case study in an environment of complexity, change, and innovations. For the case study, the interpretive process was augmented by use of the 'Attributive Coding,' method which has also been used in *The view from below*, as described in Section 2.2.

For the analyses, observations were structured along two axes. One axis delineated a continuum from control to change/innovation. The other axis delineated a continuum from planning to culture. The axis control-change was called the "why" axis (rather unfortunately depicted horizontally, along the traditional "x"-axis). The "why" axis represented the purpose of management initiatives. The axis planning-culture was called the "how" axis, representing the mechanism of management. Thus managing by use of planning was seen to contrast with management by establishing culture. The two continua were derived from the organization and strategy literature.

The findings were depicted graphically along these two axes. Such a depiction, in an interpretive methodology, is an application of phenomenography, as noted in Section 2.2 (Sandberg 1994).

3.4.3 Findings

The findings confirmed that the chosen axes were valid continua, as findings could be placed unambiguously (if inexactly) along these axes. A strong correlation emerged between orientation towards control as a purpose and planning as a method of management. Similarly, change and innovation as purposes were strongly associated in the texts with culture. However, there were fewer findings in this area, because the texts were largely oriented towards the planning/control quadrant. In the case study texts, areas identified to require innovation such as the very central function of design, were omitted from the management systems. This 'management by omission' demonstrated tacit acknowledgement that the developed systems for management control were seen as inhibitors of innovation.

Standard management systems were applied to areas requiring control, with a goal of minimizing deviation. Areas requiring rapid change and innovation were exempted from control by standard or formal management systems. This was called "management by omission" in the article. The differing forms of management can co-exist in the same organization on every level and field.

Formal managements systems, in such situations are mainly the realm of middle management. They were not a part of the formation of deliberate strategies. Instead, formal management systems seem to best fit a political view of an organization, which are part of an evolutionary strategy formation. That means that the study revealed that formal management systems compete internally to influence emergent strategic responses.

3.4.4 Discussion and conclusions for environmental management and strategy contexts

Managing Emergence corroborated Stacey's (1995) statement that formal systems are associated with control. The ESS case also demonstrated abstention from formal system regulation and control to allow innovation. The concomitance of these two observation demonstrates that strategy contexts can be co-existent. In the case, the formal systems were observed to be mainly in competition, in a political setting, but at the same time exercised regulation and abstained from doing so when that was appropriate.

Applying a political system metaphor to an organization, and viewing management systems as political tools in competing may seem critical, but its purpose is only descriptive, to convey understanding. Such understanding may be utilized for greater management success. For the environmental management practitioner, an analysis of an organization and management systems in this light, might assist in effective system design.

Managing Emergence utilized a diagram with a "why"-axis depicting management purpose and a "how"-axis displaying management method. The analysis demonstrated that both in the literature discourse and in the case study, these axes did not depict an independent variation. Variation along the "why" and the "how" coincided. These can therefore be depicted along the same continuum, as is illustrated in **Figure 9**. Leveraging the data in *Managing Emergence* and the strategy contexts introduced in Section 2.1 of this dissertation, the "why/how"-continuum can be juxtaposed on a strategy context continuum from deliberate to emergent, with evolutionary as an intermediate position. **Figure 9** delineates a management and strategy typology along with the associated strategy contexts and management purpose, along a single continuum, as indicated in *Managing Emergence*

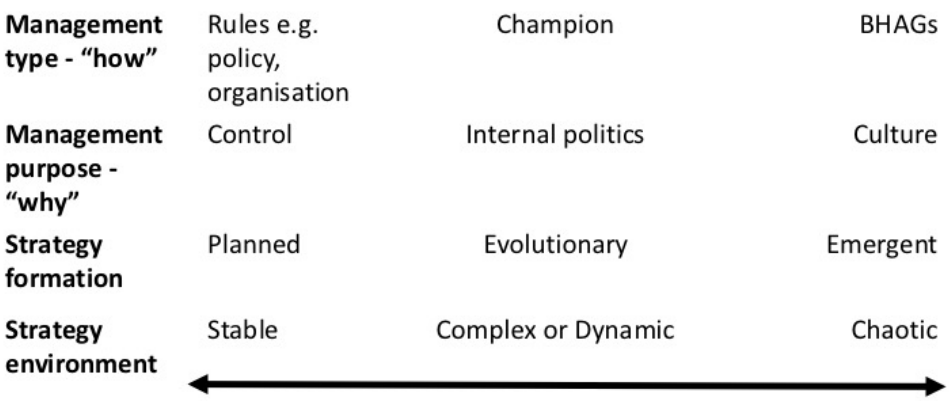

Figure 9: Management and strategy typology
Figure 9 shows strategy formation and management in relation to the three strategy environments (or contexts). BHAG is an acronym for "Big Hairy Audacious Goal", indicating an inspirational goal constituting a huge and unsure effort, in intentional contrast to SMART (e.g. Specific, Measurable, Attainable, Realistic, Time-Based)

3.5 The "sustainable Energy Concept" – Making Sense of Norms and Co-Evolution within a Research Facility's Energy Strategy

In *The 'Sustainable Energy Concept'* (Peck and Parker 2016), illustrated in summary in **Figure 10**, we capitalized on a unique opportunity to study how an energy strategy was developed. The opportunity was presented by a large-scale research facility developing an energy strategy. This type of facility uses energy on a scale comparable to heavy, energy intensive industries. Unlike industry, research facilities are developed in an academic culture, creating extensive trails of detailed reports and frequent conference papers. The opportunity was unique, because this was the first time such a facility had actually developed an energy strategy.

Also, the study was longitudinal, spanning a period of seven years. For six of these years, I was the Head of the Energy Division at the studied entity, the European Spallation Source. This allowed me to identify the prolific documentation used in the research, which, although public, had been mainly made available to the community of accelerator physicists. To remedy this, and to allow other researchers to validate our research, all the cited works have been mirrored in Lund University Publications (LUP), the university repository for scholarly publications.

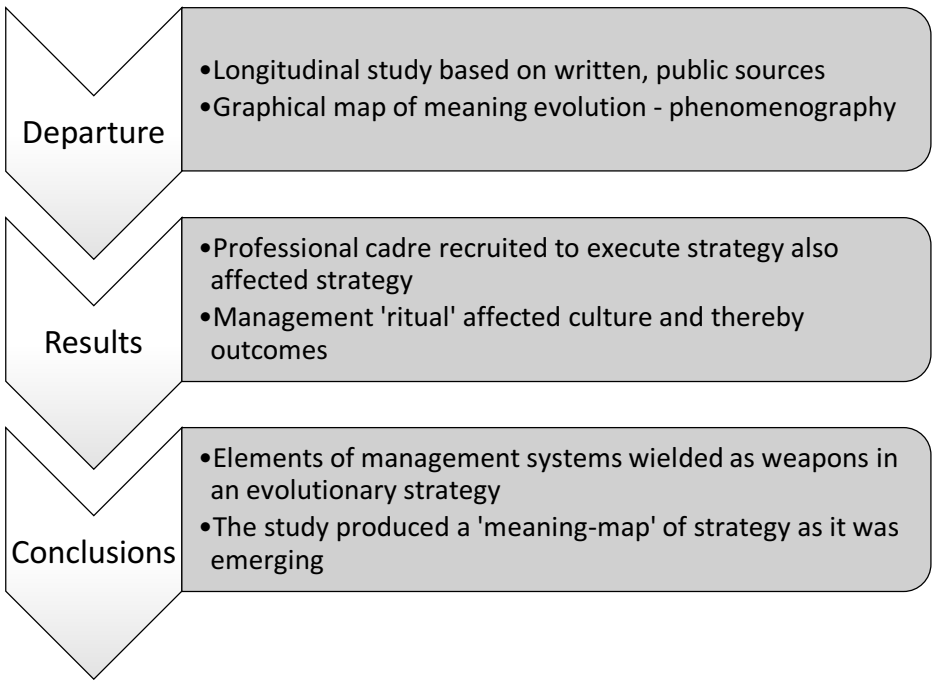

Figure 10: Summary overview of *The 'Sustainable Energy Concept'*
Highlights from the full-length research article *The "sustainable Energy Concept" – Making Sense of Norms and Co-Evolution within a Research Facility's Energy Strategy,* by Peck and Parker, illustrating for the purposes of this dissertation key elements in the points of departure for the article, its results and relevant conclusions.

3.5.1 Methods

In order to assess the energy/environmental/sustainability strategy development, a framework was developed that depicted the strategy at each phase along two axes. One axis was called *input* and ranged from *factual* to *relational*. It was called the input axis because the placement of the strategy along this axis represented the source of data on which goals and performance were based. The relational end of the input continuum represented a strategy based on input from stakeholders. The factual inputs were collected from measurements or estimates, such as of energy use or CO2 emissions. The other axis was called *purpose* and ranged from *instrumental* to *altruistic*. It was called the purpose axis because the placement of the strategy along this axis represented the reason for strategy decisions and actions. The instrumental end of the continuum represented positions and actions taken in order to achieve other, greater benefits to the organization. The altruistic position, conversely, represented positions and actions where the organization accepted a net cost for the greater social good. The various positions on the

framework were derived from differing positions found in the literature, with the greatest influence from works in environmental strategy and stakeholder theory.

3.5.2 Results

The very existence of an energy strategy was an innovation in the field in which the case study organization operated. The content of the studied strategy was radical, committing the organization to responsibilities that significantly expanded its scope. The case was therefore, an example of a change-oriented 'sustainability strategy.' The term 'sustainability strategy' should be understood here as a strategy in an area important to sustainable development, not as a strategy to become sustainable in all aspects. In the case, the explicit goal of the energy strategy was to deliver a "sustainable research facility".

The framework is an analysis founded upon a meaning-based, or phenomenological, view of the organization. The input axis depicts from where the organization derives meaning. The purpose axis exhibits organizational values. Such a two-dimensional, graphical, phenomenological analysis is an example of phenomenography.

A clear pattern emerged from the analysis. Starting with relational and instrumental aspects, the strategy was pushed by external forces towards the factual, and internal forces pushed towards the altruistic. Eventually, the internal forces pushed the strategy back towards the relational, but not as far as its original position. In strategic terms, the energy strategy was at first deliberate. In order to execute the strategy, a professional cadre was recruited to introduce both new knowledge on the input scale and values on the purpose scale. These new energy professionals were equipped with instruments to compete internally in a strategy environment, which had become evolutionary. By the end of the study period, a new energy strategy had emerged.

The analysis demonstrated the effect of agency, exhibiting the effect of a recruitment on culture and on strategy. Evolutionary strategy development was demonstrated and within this, the effect of empowering professionals with 'rituals', the 'ritual' in the case being the Energy Inventory. The repeated action of the Energy Inventory forced repeated assessments of how energy demand developed and reporting on progress. This provided an example of how environmental management actually works in an evolutionary strategy environment and thereby, provided an empirical foundation for design of future management strategy.

3.5.3 Discussion and conclusions for environmental management and strategy contexts

The 'Sustainable Energy Concept' demonstrated agency, meaning that a local champion for a cause can alter strategy in an evolutionary strategy environment. Furthermore, the case demonstrates the use of a specific management instrument, the 'Energy Inventory', to champion a cause. Thus, the case highlights how an element of a formal management system was wielded in internal competition in a political process of agency. Further back in the chain of causation, this case demonstrates the recruitment of professionals as a culture-changing management intervention. The phenomenographical analysis in *The 'Sustainable Energy Concept'* illustrated energy strategy evolution and thereby also demonstrated the capacity of that phenomenography as a method. Returning to **Figure 9**, *The 'Sustainable Energy Concept'* illustrated and corroborated the middle position of complex or dynamic strategy environment, evolutionary strategy formation, competing management systems and management as championing a cause.

Papagiannakis et al (2014) demonstrated environmental strategy being emergent as a part of corporate strategy based on control theory. A feedback loop fed by increasing management awareness of environmental issues was the driving force for the emergence of an environmental strategy. This is a similar theoretical basis to the one used by Stacey (1995) to develop the strategy contexts used in this dissertation, delineated in Section 2.1. Papagiannakis et al complements *The 'Sustainable Energy Concept'* well, highlighting another element of environmental management – increasing awareness – and its role in emergent (including evolutionary) strategy formation. A further comparison can be made with Strachan (1997), which recommended that EMS should adopt a learning organization view. Papagiannakis et al provided evidence of how this can be done.

4 Reflection and Discussion

This section starts with subsection 4.1 to summarize the results in the five included works in a single thread, as a basis for the discussion. Thereafter, in subsection 4.2, the methodology of the research is discussed including the validity and reliability, and the generalizability of the results in subsection 4.2.1 and 4.2.2. Section 4.3, lastly, contains a discussion of how the findings from the research can be applied to environmental management, including EMS.

4.1 Collected summary of results

The first two articles investigated the connections between management initiatives and environmental performance. The second two articles were more specifically oriented towards situations of change and complexity, and corporate strategies associated with such situations. *Finding the Connection* demonstrated that as a whole EMS were not effective in delivering improved environmental performance, as assessed by independent observers. The *View from Below* looked for social clues as to how management worked in practice, and in doing so, documented in a specific case that the EMS was not a relevant reference for the daily actions of employees, but that personal interactions with management had a strong effect.

Specifically, for energy issues, there were indications in the case that integration of energy performance data in operational controls could help focus attention on energy efficiency improvement issues. The management act of causing energy performance to be measured, collected, analyzed and reported seemed to have the effect that employees attached importance to it. This is an example of an element in a 'system of shared meaning'.

Top management commitment is explicitly required in ISO 14001 for successful implementation of an EMS. With the commitment of top management, the studies demonstrate that environmental performance was improved, regardless of whether or not there was an EMS. The evidence indicated that in one case, the existence of an EMS was not directly relevant towards employee socialization. It was noted that the PDCA cycle, on which standard EMS are based, was developed to deliver

conformance, not to improve performance in other respects. Therefore, conformance was a more expected outcome than improved performance.

The Case Study evidence demonstrated effective environmental management that appeared to be entirely separated from the formal, certified EMS. The case gave some indications that what is effective environmental management may be situational. The case also demonstrated a leadership phenomenon. Direct interaction in hierarchical relationships led to actions.

The last two articles addressed contexts of complexity and change, and the connection between management and strategy. *Managing Emergence* demonstrated that management system standards (MSS) were control oriented and could conflict with change and innovation, in accordance with Deming's goal to limit deviation from norm. MSS control for conformity.

In *Managing Emergence,* the management systems were observed to be used to manage events, which were challenging, but could be planned. Innovation was not regulated in systems, even though it was necessitated by the goals and expectations of and for the system. Management systems (both standard and customized) were deployed in the case organizations, within an evolutionary strategy environment, meaning that the systems competed internally to shape the strategies

The case study organization used formal management systems but omitted innovation from regulation in those systems, corroborating the view in the literature that regulation in management systems may inhibit innovation. The omission from regulation in formal systems can be seen as an example of an emergent strategy. It also demonstrated that even when there is significant complexity and change in some areas, others can still be managed in a deliberate strategy and that management by deliberate strategy and emergent can exist within the same organization, indeed within every part of the organization.

The *'Sustainable Energy Concept'* article research revealed that agency can affect strategy, in a case where professionals were empowered with the responsibility to deliver on organization's commitments coupled with elements of management systems. This demonstrated that even if the implementation of a management system, in itself, is ineffectual, such systems, or parts thereof, can be effective tools in an internal strategy battle of an evolutionary strategy. In the studied case, the Energy Inventory was used effectively to affect culture and strategy, but otherwise the Energy Management System went unnoticed.

Collectively, the research articles give evidence supportive of a contingency theory of environmental management. Furthermore, the research demonstrates that strategy context is a contingency factor. **Table 2** shows a typology of management corresponding to the typology of strategy contexts. Each strategy context has a

corresponding organization metaphor and management form, and management systems function differently in the respective contexts.

Table 2: A typology of strategy context, organization and management

Using the same categories as for the strategy typology, the research gives evidence that indicates how business conditiions (the strategy context), organization view, the function of planning, management and management systems can be correspondingly systemetized in the same categories.

Strategy	Deliberate	Evolutionary	Emergent
Business Conditions	Stable, Simple	Complex and/or dynamic	Complex and/or dynamic
Organization Metaphor	Machine	Organism	Cultural
Planning	Results in a plan	Political campaign	Creates shared meaning
Management	Control	Champion	Systems of shared meaning
Management Systems	Followed	Wielded	Encumbering

4.2 Reflection and discussion concerning the methodology and methods used in the research for this Ph. D. dissertation

The methodological framework of all the research was interpretive, reflecting a meaning-based view of the organization and of the individual. This is an underrepresented methodology in environmental and sustainability management research, but continues to be used (cf. Nambiar and Chitty 2014). The methods employed within that framework varied, allowing some method triangulation without methodological inconsistency. The literature of strategy and management served as a theoretical context. The literature of management systems was used as data for analysis, in *Finding the Connection* as metadata and in *Managing Emergence* as text for hermeneutic interpretations. A phenomenological methodology implies a focus on meaning. Organizations were defined as systems of shared meaning.

In an obscure but pointed article titled “Management and Magic” (Gimpi and Dakin 1984) managers were compared to tribal shamans, the point being that since managers were no more able to predict the future than others, the acts that they performed, particularly strategic planning, were comparable to the rituals of a shaman. This might be perceived as pejorative, as was doubtlessly the intent, but in a meaning-based view of the firm, it is exactly the expected role of management – to enact rituals that create shared meaning and thus help to ensure the capacity for coordinated action.

The employed methodology used for this dissertation research resulted in new findings, such as demonstrating that direct interactions in hierarchical relationships can result in constructive actions. The interpretation of this was that such interactions affect meaning for the individual, which leads to action. Conversely, written policies did not appear to affect meaning in the case studies, indicating that, at least in the studied cases, that such documents did not affect meaning.

For rigor, coding was used in the analysis. The extensive literature reviews for the various articles revealed a dearth of rigorous interpretive works in the literature. Therefore, the methods used for this research break new ground in the field by demonstrating new methods that are both effective and rigorous and can be used to investigate organizations and culture.

In both *Managing Emergence* and *The 'Sustainable Energy Concept'*, data were analyzed using frameworks that can be seen as a form of phenomenography. In The 'Sustainable Energy Concept', meaning and values were mapped longitudinally; in *Managing Emergence* the purpose of management and the methods of management were mapped. This form of analysis permitted two-dimensional graphical depiction of findings, demonstrating relationships more powerfully than the rich descriptions typical of interpretive research results. For example, in the change in meaning and values over time could be attributed to management initiatives, thus demonstrating the cultural effects of management.

Viewing organizations as systems of shared meaning, or, using Morgan's metaphors, as a culture (Morgan 2006) also had limitations. Different models or metaphors have more or less explanatory benefits in different settings. In Managing Emergence, the organization studied seemed better described with a political metaphor, based on an analysis of the formal management systems, although the same organization in *The 'Sustainable Energy Strategy'*, a phenomenographical description of strategy formation was fruitful. According to the theory cited in the methodology section, shared meaning requires a sufficiently closed system to appear; the members of the group must interact with each other with sufficient intensity and frequency for a distinct shared meaning to form. A place of work might typically supply sufficient interaction, but large workplaces need not do so. A legal entity could have several places of work, and a place of work may encompass employees from several legal entities. The conclusions and recommendations from this dissertation are valid predominantly for organizations of share meaning, and should therefore be applied with care legal entities not well described by this model.

4.2.1 Validity and reliability

The research case studies for the research articles in this dissertation were based on extensive access to the organizations. The methods of data collection employed included participant observations, interviews, and evaluation of literature, which addressed systems, texts on energy strategies and management which included conference papers, design reports, and reports to stakeholders. However, the cases used for the articles were from the rather limited sector of large-scale research facilities, also known as research infrastructure. This is a limitation. Furthermore, I was an employee of one of these organizations. This greatly facilitated access, but also naturally affected my perspective. This was ameliorated by three factors, the rigor of the methods, a co-researcher and a time lapse between the employment and the analyses.

In a phenomenological context, validity can be assessed by the extent to which the researcher has gained full access to the knowledge and meanings of informants. The depth of access is a significant strength of the research in this dissertation. At the organization at which I performed the research for *The View from Below*, I was at the facility for two years, with free access to the staff. The data collection for *Managing Emergence* and *The 'Sustainable Energy Concept'* was done at a time when I was an employee. Both of these organizations were public and academic, and regular contributors to academic conferences. Therefore, access to data was not a limitation. With access to personnel and documents, access to knowledge and meaning is a matter of method, as detailed in the Section 2 on methodology.

A phenomenological assessment of reliability is whether similar observations be made by different researchers on different occasions. As noted in the methodology section, two methods were used to enhance reliability, a system of coding and collaboration with another researcher. The methodological rigor applied is the main guarantor of reliability as it enforced a structure and created a trail of evidence for each step of the analyses. The effort made to ensure that the data, especially for *The 'Sustainable Energy Concept'*, was made permanently and easily accessible makes it possible for another researcher to repeat the analysis.

The argument thus far concerns the validity and reliability of the underlying interpretive research. Another issue is the validity and reliability of the appended research for the arguments and conclusions of this dissertation. As noted in the discussion on generalizability, this dissertation makes no argument that the observed phenomena are universal, only that the observation of their existence is valid, and that they support a contingency model of environmental management developed based on strategy literature. After the preceding discussion of the validity of the underlying research, that established that the observation on management effects was valid, the remaining issue is the connection to the three

strategy contexts. This is a pivotal point, as the research method does not allow direct observation of strategy contexts, but instead strategy context must be inferred, based on theoretical constructs, by observation of management purpose. For example, the observed need for major technical innovation was used in *Managing Emergence* as a proxy for an unplannable strategy context.

In addition, these observations of management purpose were used to conclude that management corresponding to deliberate, evolutionary and emergent strategy could exist simultaneously. In this case, due to the methodology of the research, the dataset was too limited to enable inference of general correlation. Instead, the research in this respect was hypothesis-generating.

Returning to the literature study in *Finding the Connection*, that study demonstrated that the state-of-the-art research at the time could not validly establish a causal relationship between the management initiative of implementing an EMS and the desired effect of improved pollution prevention. This dissertation describes examples of cause and effect of environmental management in differing strategy contexts. The resulting source for testable hypotheses for general causal relationships is therefore a scientific contribution.

4.2.2 Generalizability

Managing Emergence demonstrated that multiple strategy contexts can coexist for an organization, e.g. technical complexity with an imperative for innovation but regulated, cost-center-based bookkeeping. Two questions arise from this finding: Can environmental management also exist in a plannable strategy context, even as other functions cannot? Can environmental strategy be deliberate, when other strategy is emergent? *Total Cost Indicators* demonstrates that environmental issues are intrinsically complex, and can be dynamic, but that does not mean that they necessarily are unplannable for every organization. Therefore, from the findings and analyses in this dissertation, the answer to both questions would seem to be yes, and this dissertation does not offer any recommendations applicable to all organizations. On the contrary, the argument is that environmental management is contingent upon strategic context.

The three in-depth case studies (excluding the seven limited studies in *Total Cost Indicators*) were completed at only two organizations. These were on different continents, but both in the limited field of research infrastructure. The advantages of this field were noted in the Section 2, on methodology, but a potential disadvantage might be limited generalizability of the results. It is, for example, plausible that strategy contexts work differently in businesses competing for business with other business customers or consumers might differ from organizations competing for government funding and publications. For this reason,

it is not appropriate to apply specific findings on effective management initiatives to organizations in general. For example, the apparent disregard for formal management systems observed in *The View from Below* is not a generalizable observation. Instead, it demonstrates that the research method used could identify that phenomenon and it is of interest not because it is general but precisely because it perhaps is not. The main argument of this dissertation is that effective environmental management practice may be contingent on operating conditions, and that one such condition is the strategy context of the organization. The specific observations in the cases are used as evidence to compare with the reactions to strategic contexts extracted from the literature.

Furthermore, although the case studies were few, and based on unusual organizations, the observations corroborate the literature studies. *Managing Emergence* was based upon a hermeneutic study of a related body of literature as well as the extensive case study material. The results about the use of formal management systems were in agreement.

4.3 Applications of the results

The invention of EMS somewhat preceded the proclamation of the demise of the concept of strategic planning, in the publication of "Rise and Fall of Strategic Planning" (Mintzberg 2000). Moreover, in a parallel to *Finding the Connection*, Starbuck (1993) investigated the correlation between the degree of strategic planning and economic performance. The study, which was quantitative, demonstrated a zero correlation. Mintzberg's book made the point that corporate strategic environments were too complex and dynamic for planned strategic responses. The core process of an EMS is a mimicry of the strategic planning process, applied to environmental issues, and EMS as a whole is based on a "mechanistic model of management", exemplified with "fixed and narrowly defined roles, authority and responsibilities", "hierarchical structure, centralized decision making" and "highly formalized and documented rules and procedures" (Strachan 1997). Is it therefore appropriate to speak of the 'rise and fall' of EMS?

The results of this Ph. D. research corroborate the view, expressed in the literature, that standard EMS are constructed with mechanistic model of management, but demonstrate that such a management model may be appropriate, contingent upon strategic conditions and management goals. Mintzberg's title 'rise and fall' is pejorative. The appropriate question is not whether there has been a rise and fall of EMS, but when is an EMS appropriate and how should it be implemented under various conditions. This dissertation contributes to answering those questions, by arguing that an EMS presupposes plannable conditions and demonstrating that an

EMS may function differently depending on the degree to which a business is plannable. The argument is for a contingency theory of environmental management.

Nonetheless, the results of this dissertation demonstrate that a company with a certified EMS does not necessarily perform better in pollution prevention than a company that does not have and EMS, and also begins to explain why that might be. Does this mean that certification is meaningless? The research does demonstrate that having a certified EMS does not certify the efficacy of the management applied. On the other hand, the meaning-based analysis model employed opens up for the possibility that public commitment from top management and certification may be contribute to establishing shared meaning that includes environmental commitment and thereby affects evolving or emerging strategy.

A meaning-creating role for EMS parallels a view that the benefits of planning are something other than the resulting plan. In the words of Dwight D. Eisenhower "Plans are nothing; planning is everything". In a meaning-based view of an organization, the solution to this apparent paradox is clear. The planning process involves the organization's members in collective interpretation processes. In the meaning-based view, as defined above, the role of management is to create systems of shared meaning. Organizations were defined as systems of shared meaning. Planning is organization-creating. In a complex or dynamic environment, the resulting plans may indeed be useless, but the planning process prepares the organization to respond to its environment in a concerted fashion.

Should then, EMS standards be changed to encompass evolutionary and emergent strategy environments? For example, Feng, Zhao and Su conclude that the way to "efficiency and effective EMSs is characterized by high levels of commitment to learning, shared vision, open-mindedness and knowledge sharing" (Feng, Zhao, and Su 2014). Do such changes demand a change to the standard? The indication from the research in this dissertation is affirmative. The explicit reference to Deming should be dropped, as such a close association with a specific management view limits the applicability of EMS. Specific changes that may be valuable to consider on the basis of this dissertation, together with recommendations from other researchers include:

- Broadening the concept of an Environmental Review to include organization-wide capability to continually identify and assess environmental issues.
- Similarly broadening the concept of defining roles and responsibilities to empowerment of employees in all relevant activities.

- Explicitly acknowledging the impact of recruitment of a cadre of specialists on culture and strategy evolution and emergence.
- Assessing activities to empower specialists and affect corporate culture, such as measurement and public reporting

This dissertation does not encompass an in-depth analysis of the texts of the various standards, the changes made in them over the course of the studies or established auditing procedure in relation to the above recommendations. It is therefore not possible to state, based on this research, what measures organizations themselves can take within the standard framework to adapt their specific EMS implementation. A change in the standards may not be necessary to allow the recommended broader concepts to be included in implementation, but a change is necessary to promote them. Authors of new versions of standards might do well to encompass both negative and positive feedback loops, in the distinction made by Stacey (1995). In control theory, a negative feedback loop is designed to correct deviations, driving conformance, whereas a positive feedback loop amplifies deviation, driving instability including innovation.

This research journey began with an investigation into the use of EPI. *Total Cost Indicators* argued that since no objectively correct measure of environmental performance could be established, organizations should find indicators of total costs, as this would drive pollution prevention. Observations in *The View from Below* tended to corroborate the adage "what gets measured gets managed". In unplannable strategy contexts, this raises the question: If you cannot plan, how do you know what to measure? Furthermore, can the organization establish objectives in such a context? In a meaning-based view of the organization, these questions are unproblematic. Managers introduces measurements based on their perceptions and values in an exchange of meaning that creates shared perceptions and values. The indication from *The View from Below* was that asking an employee to measure something, caused the employee to attach significance to that act of measurement. Attaching significance to the act of measurement caused the employee to interpret meaning into the measurement. Therefore, asking something to be measured is an example of how management can affect meaning. Measurements and objectives are not derived from an external truth, 'the strategy', but part of a dialectic process.

4.3.1 State of the art and research contribution

When the research for this dissertation was conducted, the connection between the emergent strategy discourse and environmental management had not been made in the literature, but a recent theoretical work by Neugebauer, Figge and Hahn (2015) discussed sustainability strategies in an emergent strategy context, providing an

opportunity to reflect upon the results of this dissertation in relation to that work. Three key statements were especially relevant:

1. “In strategy research, there is a consensus that strategy making resides on a continuum from planned to emergent where most strategies are made in a mixed way” (Neugebauer, Figge, and Hahn 2015). The concept of a continuum of strategy formation contrasts with the dichotomy between deliberate and emergent originally suggested by Mintzberg and others (Mintzberg and Waters 1985; Mintzberg 2000).

As visualized in **Figure 9**, this dissertation delineates a strategy context continuum from deliberate to emergent, with an evolutionary strategy context as an intermediate position. Further, **Figure 9** depicts a sequence of continua connecting strategy context, strategy formation, management purpose and management methods. Observation from the case study in *Managing Emergence* corroborates mixed-strategy management methods with empirical evidence, and demonstrates such management for sustainability issues. This is an example of the empirical contribution of the research.

The sequence of continua in **Figure 9** reflects the addition of a perspective of organization theory in this dissertation, compared with Neugebauer et al. As is clear from Morgan (2006), real organizations are not either mechanistic, political or cultural. These concepts are different metaphors or models that are more or less appropriate and useful to describe and understand organizations, and each is connected to distinct research methodology. The other continua should be understood similarly, as complementary models. This dissertation provides the methodological support to broaden the statement in Neugebauer et al that “most strategies are made in a mixed way”, to say that the models along the sequence of continua are not mutually exclusive and are more or less useful to understand and explain strategy formation in individual cases.

2. “Sustainability research seems to overlook most of this development [in strategy research] and assumes instead that sustainability strategies are made in a purely planned way” (Neugebauer, Figge, and Hahn 2015). The literature study in Managing Emergence corroborates that the scientific discourse on management systems predominantly assumes deliberate strategy formation. Also, this dissertation has demonstrated that EMS specifically, explicitly assumes a planned strategy context. Three case studies in this dissertation, in *The View from Below*, *Managing Emergence* and *The ‘Sustainable Energy Concept’*, demonstrate non-planned sensemaking and strategy formation. This is an empirical contribution of this dissertation.

3. “We argue that planned strategy making is expected for salient and non-wicked problems while emergent strategy making is likely for non-salient and wicked

problems" (Neugebauer, Figge, and Hahn 2015). This dissertation investigates change and complexity as contingency factors, compared to problem wickedness and salience, demonstrating that strategy emergence is associated with change and complexity. In Managing Emergence, the need for extensive and challenging innovation is used as a proxy for complexity. This usage may overlap with "problem wickedness", but the concept is not clearly defined in Neugebauer et al. Overlapping or not, this dissertation and Neugebauer et al, together contribute four "contingency factors" that may be used to generate testable hypotheses for large-sample qualitative research that can test frequency of correlations.

5 Conclusions and Recommendations

Returning to the purpose of this Ph.D. research, the analyses provided a basis to draw conclusions and to make recommendations for the key target audiences. The first conclusion is that standard management systems like EMS control for conformity, and are therefore most appropriate for deliberate strategy settings.

The organizations that were studied exhibited a predominantly evolutionary strategy development. In this form of strategy environment, the role of formal management systems is to participate in internal competition and creative destruction of strategy. An internal champion may be empowered by elements of management systems for advantage in internal competition. At the same time, portions of that type of organization existed in a deliberate strategy environment and still others in an emergent one. The roles of the formal management systems differed in the three strategies. In a deliberate strategy, management systems were implemented. In an evolutionary strategy, the systems competed internally. In an emergent strategy, the systems did not play a role. The three strategy types can exist simultaneously in the same organization.

A conclusion from the studies was that top management and empowered employees can alter strategies, even in the face of indifferent stakeholders. This internal agency phenomenon makes recruitment a vital part of environmental management strategy formation and implementation.

5.1 For executives and environmental, energy and sustainability managers of organizations

In order to benefit from the results of this dissertation, managers must assess the strategy contexts of their management briefs, as the appropriate form for management is situational, contingent upon factors such as the rate of change and the degree of complexity in strategic environments.

In a deliberate strategy context, the implementation of standard management systems may improve performance by driving conformity to policy. If conformance to policy is the predominant management objective, managers may be well served by implementing the standards.

Strategy contexts are likely to be mixed. Even in organizations in distinctly complex and dynamic environments, significant portions of the organizations may operate in plannable conditions. It is therefore likely that for established organizations, standard management systems may be appropriate for portions of the operations, even if other portions operated under significant change and complexity.

Although conditions might prevent the development of a meaningful strategic plan, there is theoretical support in interpretive social science for the claims of Eisenhower, Churchill and others that planning is still vital. Planning processes can play a significant role in preparing the organization's members to respond to its environment quickly and coherently. This is applicable to processes such as an environmental review. In evolutionarily or emergent strategy settings, the results of review processes may be less important than who is involved in, and therefore affected by, the review process.

In an evolutionary strategy environment, formal management systems, or parts thereof, can function as tools to empower sector managers in an internal, competitive struggle. The in-depth case study revealed that individual abilities at advocacy coupled with empowerment by policy instruments such as those present in formal management systems can perceptibly affect strategy. For an organization's leader in an evolutionary strategy environment, the choice of a champion for a cause may be of greater importance than the implementation of the relevant management system. Elements of that system can be used to equip the champion with effective weapons of the internal evolutionary battle, as can the recruitment of a cadre of experts that add new skills and values to the organization.

Under complex or chaotic conditions or when major innovation is demanded, managers will need to focus on creating positive feedback loops that encourage change, and inspire, challenge and empower employees.

5.2 For future research in environmental, energy and sustainability management

The implications of emergent strategy on management are profound. Management cannot be defined as controlling an effort towards goals, if the goals themselves are a product of the organization to be controlled. The concepts of management,

strategy and organization thus become intertwined. This dissertation provides significant clues from theory and cases to answer the question of how to manage in cases where strategy is emergent. The case study basis of the research presented in this dissertation is, however, by necessity limited, demonstrating only the existence of phenomena and not their prevalence. Further case study research is urgently needed to understand how management systems interact with other organizational cultures in the various strategic environments.

This research has demonstrated that management systems function vastly differently in different strategy environments. The implication for future research is that it is not meaningful to investigate the function of environmental management systems without taking the strategic environment into account. Other contingency factors may also be worthy of investigating. Further case study research may generate additional understanding of how effective management is contingent on internal and external factors. With appropriate modelling, quantitative large-sample research can then investigate the prevalence and correlation of phenomena.

The research findings highlighted the possible roles of champions as well as stakeholders in evolutionary strategy formation, and therefore, also in management thereby, demonstrating that internal agency can matter. Additionally, the research finding revealed an example of the power of human interactions; in this case in a hierarchical relationship helped to shape the values. This underscored the need for increased research into the formation of organizations from a meaning-based perspective, that is, how interactions create shared values and truths, and thus create a dynamic organization. Formal management systems can be usefully researched by viewing their contents as a collection of rituals that can be used as tools to create shared meaning in an organization.

The research findings documented that methods using phenomenography can be powerful tools for interpretive analysis and communication of results, but should complement rather than replace the rich descriptions that otherwise typify phenomenological research, so that the full depth of the cultural description is preserved. Therefore, both phenomenographical and rich description interpretive management case studies are needed.

The research methodology of this dissertation represents a new framework for environmental management research and its application has led to significant new insights in the field of environmental management, demonstrating that the theoretical framework in itself is a contribution to the field, in addition to the aforementioned new insights on management practice and research methods.

5.3 Closing comments

To close, the results of the research in this dissertation are summarized to answer to the research questions posed and fulfil the stated purpose of the work.

Research Question #1: What general hypotheses for how effective environmental management is contingent upon the strategy context of the organization can be formulated from identified linkages between effective environmental management practice and strategy context?

Based on the linkages demonstrated in the preceding discussion, the following hypotheses are suggested for use in further research:

1. Control-oriented management, typical of EMS, is most effective in plannable strategy contexts and a deliberate environmental strategy.
2. Advocacy-based management, where the environmental manager is a champion the environmental cause competing with other champions is most effective in a strategy context with significant uncertainty and an evolutionary strategy formation.
3. Inspirational management, where the environmental manager might set inspirational goals, is most effective in a chaotic strategy context and an emergent strategy formation.

Research Question #2: What specific actions can be suggested to improve environmental management efficacy in the respective strategy contexts?

1. Identify the strategy context of the organization as a whole, and specifically for environmental issues, remembering that mixed settings are common.
2. In a deliberate strategy context, implement a standard EMS
3. In an evolutionary strategy context, consider implementing a standard EMS as a tool to champion environmental issues, using the requirements to install measures that affect meaning-creation in the organization. Internal and external communication and EPIs may be effective for this. Avoid bureaucracy and unnecessary regulations that may discourage innovation and dampen enthusiasm for environmental issues.
4. In an emergent strategy setting, focus entirely on meaning-creation, eschew regulation and control for exchange of ideas. Set inspirational goals and supply vision.

Research Question #3: How can interpretive research complement other methodologies to improve environmental management results?

By investigating meaning-creation in organizations, interpretive environmental management research can improve understanding of how management initiatives affect meaning and thereby lead to actions. As this understanding increases, with more case studies, environmental management initiatives can be progressively better tailored to organizational situations, improving management efficacy.

This dissertation makes two contributions to environmental management research. Firstly, by demonstrating the usefulness of an interpretive methodology, it opens an avenue to many case studies to improve the understanding of how management initiatives function in practice to affect meaning and actions. Secondly, this Ph. D. research has generated hypotheses for general testing from causal connections found in the research for specific settings.

This dissertation contributes to environmental management practice by demonstrating contingency, demonstrating that improving efficacy of environmental management may be a question of increased differentiation rather than standardization and suggesting a contingency factor and appropriate management measures.

References

Alvesson, Mats, and Kaj Sköldberg. 2000. Reflexive Methodology: New Vistas for Qualitative Research. London; Thousand Oaks Calif.: SAGE.

Carlson, Sune. 1951. Executive Behaviour : A Study of the Work Load and the Working Methods of Managing Directors. Stockholm, 1951. http://ludwig.lub.lu.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat01310a&AN=lovisa.001070600&site=eds-live&scope=site.

Chu, Steven, and Arun Majumdar. 2012. 'Opportunities and Challenges for a Sustainable Energy Future'. Nature 488 (7411): 294–303. doi:10.1038/nature11475.

Dingwall, Robert. 1997. 'Accounts, Interviews, and Observations'. In Context and Method in Qualitative Research. [Electronic Recourse], by Gale Miller and Robert Dingwall. London: SAGE. http://ludwig.lub.lu.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat01310a&AN=lovisa.004263923&site=eds-live&scope=site.

Drucker, Peter F. 1986. The Principles of Management. New York, NY: HarperCollins Publishers.

Easterby-Smith, Mark, Richard Thorpe, and Andy Lowe. 1991. Management Research : An Introduction. London: Sage. http://ludwig.lub.lu.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat01310a&AN=lovisa.001037530&site=eds-live&scope=site.

Feng, Taiwen, Gang Zhao, and Kun Su. 2014. 'The Fit between Environmental Management Systems and Organisational Learning Orientation.' International Journal of Production Research 52 (10): 2901–14.

Gerland, Patrick, Adrian E. Raftery, Hana Ševčíková, Nan Li, Danan Gu, Thomas Spoorenberg, Leontine Alkema, et al. 2014. 'World Population Stabilization Unlikely This Century'. Science, September. doi:10.1126/science.1257469.

Gill, Mj. 2014. 'The Possibilities of Phenomenology for Organizational Research'. ORGANIZATIONAL RESEARCH METHODS 17 (2): 118–37.

Gimpi, Martin L., and Stephen R. Dakin. 1984. 'Management and Magic'. California Management Review XXVII (1): 125–36.

Gioia, Dennis A., and Kumar Chittipeddi. 1991. 'Sensemaking and Sensegiving in Strategic Change Initiation'. Strategic Management Journal. edsjsr.

Hansson, Lars, and Yanqiang Ding. 2015. 'Corporate Governance Responses to Environmental Regulation and Market-Based Instruments'. In The Role of Law and Regulation in Sustaining Financial Markets, edited by Niels Philipsen and Xu Guangdong. The Economics of Legal Relationships. London: Routledge.

Hartman, Jan. 2004. Vetenskapligt tänkande Från kunskapsteori till metodteori (Scientific Thought, from theory of knowledge to theory of method). 2nd ed. Lund, Sweden: Studentliteratur.

Heil, Dominik. 2008. 'Strategic Innovation and Organisational Identity: A Hermeneutic Phenomenological Investigation.' Journal of General Management 33 (4): 1–12.

Hume, David, and P. J. R. Millican. 2008. An Enquiry Concerning Human Understanding. Oxford World's Classics. Oxford: Oxford University Press.

Husserl, Edmund, and Jan Bengtsson. 1989. Fenomenologins Idé. Filosofi Och Samhällsteori: 17. Göteborg : Daidalos, 1989 ; (Uddevalla : Bohusläns grafiska). http://ludwig.lub.lu.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat01310a&AN=lovisa.000468973&site=eds-live&scope=site.

IPCC. 2014. 'Summary for Policymakers'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, et al., 1–32. Cambridge, United Kingdom, and New York, NY, USA: Cambridge University Press.

Johnson, Thomas H., and Robert S. Kaplan. 1987. Relevance Lost the Rise and Fall of Management Accounting. Boston MA: Harvard Business School Press.

Könnölä, Totti, and Gregory C. Unruh. 2007. 'Really Changing the Course: The Limitations of Environmental Management Systems for Innovation'. Business Strategy and the Environment 16 (8): 525–37.

Kostin, Andrei, Gonzalo Guillén-Gosálbez, and Laureano Jiménez. 2015. 'Dimensionality Reduction Applied to the Simultaneous Optimization of the Economic and Life Cycle Environmental Performance of Supply Chains'. International Journal of Production Economics 159 (159): 223–32.

Mac, A. 2002. 'When Firms Make Sense of Environmental Agendas of Society'. Journal of Cleaner Production 10 (3): 259–69.

Mats Alvesson, and Hugh Willmott. 1996. Making Sense of Management A Critical Introduction. London: SAGE Publications.

Miles, Matthew, and Michael E. Huberman. 1994. Qualitative Data Analysis an Expanded Sourcebook. 2nd ed. Thousand Oaks CA.: Sage.

Mintzberg, Henry. 1971. 'Managerial Work: Analysis from Observation'. Management Science. edsjsr.

———. 2000. The Rise and Fall of Strategic Planning. London: Pearson Education Ltd.

Mintzberg, Henry, and James A. Waters. 1985. 'Of Strategies, Deliberate and Emergent'. Strategic Management Journal 6 (3): 257–73.

Molander, Joakim. 2003. Vetenskapsteoretiska grunder Historia och begrepp (Foundations of Scientific Theory History and Concepts). Lund, Sweden: Studentliteratur.

Morgan, Gareth. 2006. Images of Organization. Updated ed. Thousand Oaks: SAGE Publications.

Morgan, Gareth, and Linda Smircich. 1980. 'The Case for Qualitative Research.' Academy of Management Review 5 (4): 491–501.

Nambiar, Prithi, and Naren Chitty. 2014. ‘Meaning Making by Managers: Corporate Discourse on Environment and Sustainability in India.’ Journal of Business Ethics 123 (3): 493–511.

Nawrocka, D., and T. Parker. 2009. ‘Finding the Connection: Environmental Management Systems and Environmental Performance’. Journal of Cleaner Production 17 (6): 601–7.

Neugebauer, Friederike, Frank Figge, and Tobias Hahn. 2015. ‘Planned or Emergent Strategy Making? Exploring the Formation of Corporate Sustainability Strategies’. Business Strategy and the Environment, March, n/a-n/a. doi:10.1002/bse.1875.

Papagiannakis, G, I Voudouris, and S Lioukas. 2014. ‘The Road to Sustainability: Exploring the Process of Corporate Environmental Strategy Over Time’. BUSINESS STRATEGY AND THE ENVIRONMENT 23 (4): 254–71.

Parker, Peter. 1999. Cognition and Social Organisation : A Framework. Licentiate’s Dissertations in Sociology: 1991:1. Lund, 1999. http://ludwig.lub.lu.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat01310a&AN=lovisa.001158140&site=eds-live&scope=site.

Parker, Thomas. 1996. ‘An Overview and Guide to the Literature of Environmental Accounting Issues’.

———. 1998. ‘Total Cost Indicators - Operational Performance Indicators for Managing Environmental and Economic Efficiency’. IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden. http://www.iiiee.lu.se/Publication.nsf/$webAll/7F44850DE7450F18C1256C36004076D9/$FILE/parker.pdf.

———. 2013. ‘The View from below - a Management System Case Study from a Meaning-Based View of Organization’. Journal of Cleaner Production 53: 81–90.

———. 2016. ‘Management Systems in Dynamic and Complex Strategy Environments, an Hermeneutic Literature and Case Study’. Submitted to Sage Open, January.

Peck, Philip, and Thomas Parker. 2016. ‘The “Sustainable Energy Concept” – Making Sense of Norms and Co-Evolution within a Large Research Facility’s Energy Strategy’. Journal of Cleaner Production 123 (June): 137–54.

Peter Hess, and Julie Siciliano. 1996. Management Responsibility for Performance. International Edition. New York: McGraw-Hill, Inc.

Porter, Michael E. 1980. Competitive Strategy. New York: Free Press.

Prasad, Anshuman. 2002. ‘The Contest over Meaning: Hermeneutics as an Interpretive Methodology for Understanding Texts’. Organizational Research Methods 5 (1): 12–33.

Sandberg, Jörgen. 1994. Human Competence at Work: An Interpretive Approach. Gothenburg: BAS ek för.

Silverman, David. 2005. Interpreting Qualitative Data : Methods for Analysing Talk, Text, and Interaction. London; Thousand Oaks, Calif.: Sage Publications.

Silvester, Jo. 2004. ‘Attributional Coding’. In Essential Guide to Qualitative Methods in Organizational Research, 228–41. Sage.

Appendix 1

Finding the connection

Environmental management systems and environmental performance

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Finding the connection: environmental management systems and environmental performance

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ABSTRACT

With more than 130,000 organizations worldwide certified according to ISO requirements, business people, regulatory authorities and other stakeholders have reason to wonder whether the purpose of ISO 14001, which is to help improve environmental performance, is being fulfilled. There is a growing body of literature attempting to answer this question. The results, however, are inconclusive.

This meta-study analyzes a pool of 23 studies connecting environmental performance to environmental management systems. It shows that the reason that earlier studies arrived at mixed conclusions is twofold. Firstly, there is no agreement on what environmental performance is or how to measure it. Secondly, there is neither clarity nor agreement about how or why environmental management systems are expected to aid performance. It is therefore unclear whether the mechanisms that lead to improvement are expected to be the same for all companies or dependent on each implementation.

The authors conclude that it is more fruitful to research how environmental management systems affect performance, rather than whether they do so or not. The recommended starting point for such studies is environmental performance as each organization defines it. This in turn implies a case by case approach and a need for much more research in the field.

1. Introduction and purpose

A significant and growing number of studies have attempted to examine the environmental outcomes of environmental management systems (EMS). Since their development and launch in the 1990s, with the Rio Summit as one motivator, the phenomenon of externally audited environmental management systems has caught on in industry and other organizations and continues to spread. Foremost among environmental management standards is ISO 14001. So far more than 130,000 organizations worldwide have certified their environmental management systems according to ISO requirements [1]. After more than a decade of existence standardized environmental management systems should certainly have a sufficient track record for meaningful evaluation. The stature and success of the standard indicate that such attention is warranted. One pressing line of inquiry is to what extent use of the standard has actually benefited the environment.

The usefulness of EMS as a tool to manage environmental issues in companies is a question of interest to many different parties. One of the most interested groups conceivably are the companies themselves, who invest large amount of resources into the implementation and operation of EMS. As a natural follow up they seek to find out not only their own performance in connection to increased environmental work, but also the general value of the standardized EMS as recognized on the relevant markets. Companies that have invested in EMS want to see a return in whatever terms it was that led to the decision to implement their EMS.

Companies are also interested in environmental management done in other business establishments. One of the reasons is to benchmark with competitors on the market [2]. Another growing trend is to demand ISO 14001 certificate from suppliers. This practice serves as a first step to environmental supply chain management, and also creates new opportunities for businesses that have implemented the environmental management systems. The certification by itself shows that environmental practices are implemented and environmental performance of companies is at least on an acceptable level. There is, however, a large unrealized potential to use the EMS to monitor and manage the environmental performance of the suppliers [3]. Companies using EMS in their supply chain management therefore also require a better understanding of how the aspects of environmental performance important to them are affected.

Governments have an interest in efficient regulatory mechanisms and there is hope that environmental management systems could facilitate this [4]. The very existence of the EMAS regulation

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also clearly demonstrates that governments perceive a regulatory need or opportunity that can be addressed with environmental management systems [5]. Regulatory authorities on various levels are offering possible control relief for environmental front runners. It was claimed as one of the possible benefits for organizations and lately also has become known as a practice to offer regulatory relief for companies investing in the systems compliant to EMAS and ISO 14001 [6]. Now, after years of possible experience gathering regulatory bodies may be interested to find out if such practices are worthwhile, if EMS-oriented organizations are actually performing better than those without EMS.

One very good reason to wish to examine if EMS improves environmental performance is that the enhanced environmental performance is at least part of the reason for the standard. "The general purpose of this standard is to provide assistance to organizations that wish to implement or improve an environmental management system and thereby improve their environmental performance" [7]. This claim must, however, be seen in the light of what may be defined as performance and improvement.

The purpose of this study is to facilitate continued research on the results of EMS by analyzing and summarizing earlier work. This article, based on a meta-study of selected literature, discusses how the outcomes of EMS in terms of environmental performance are first of all perceived and defined. The methodological choices are also focused in order to answer the question of causal relationship between EMS and improved environmental performance. Further, the issue of context dependency of EMS is discussed. The authors hope to contribute to asking the right questions in coming research, but also to increase the clarity of investigations.

This article starts with a brief presentation of some recurring theoretical issues that guide the following sections with findings and analysis. As the last part the authors conclude the study and give recommendations for future research.

2. Problem definition

2.1. Perceptions of environmental performance

As can be seen from the opening remarks, there are many parties interested in environmental management systems and therefore there are also conceivably differing expectations as to what a positive outcome of environmental management efforts would entail.

According to the ISO 14001 standard, the result of EMS is environmental performance, and it is broadly defined as "measurable results of an organization's management of its environmental aspects" [8]. However, specified interpretations may vary depending on the perception of the EMS and its role in the organization. It is plausible to assume that facilities implementing the system may see their environmental performance quite differently from what the general public does. Moreover, the differences in the characteristics of environmental management systems certainly affect the way the environmental performance is defined.

Further, external standards, such as ISO 14001, generally require that facilities establish environmental targets but they do not specify the substantive nature of these targets [8,9], thus the ambition level may vary substantially. Thus, the view of what EMS should improve varies between companies, and does not necessarily reflect the views of other stakeholders.

For example, a business survey carried out amongst Swiss firms identified 14 benefits of implementing an EMS which were considered to be important by at least half of the respondents. The benefits ranged from 'strengthening innovation' and 'customer loyalty' to 'prevention of new environmental legislation', with 'enhancement of corporate public image' ranking highest. Only three of these had a direct relationship with actual environmental impact ('risk minimization', 'certainty of legal compliance' and 'support of ecological transformation of the line of business'), and these were not ranked as the most significant [10]. This illustrates very well both the diversity of EMS as well as perceptions of what the results of the system can be.

Moreover, research on outcomes of EMS such as environmental performance meets practical hurdles such as data collection. For example, there are only few publicly available national databases on emissions, such as in Great Britain, USA and Netherlands, and the data quality and its usability differs. Despite international efforts such as GRI, there is no widely accepted reporting standard for data [11]. The reporting standard relates directly to allocation questions. They pertain to the way the different environmental indicators used for calculations of environmental performance are constructed, and are very much dependent on the individual decisions of companies. Thus when the environmental outcomes of EMS are discussed it is thus important to understand what limitation were brought by the selection of the research method and the quality of data used.

Similarly, the researcher seeking to evaluate EMS must do so by some method. It is necessary to define not just performance, but what is meant by improvement. The choice of method of appraising performance is never entirely objective [12].

2.2. Connecting performance and EMS

The connection between EMS and environmental performance may be examined in a great variety of ways. One of the ways reported in literature is in terms of the expectations and benefits the companies themselves are experiencing. Because of the variety of perceptions of environmental performance, this type of study is easier to conceive as a specific for each organization studied.

Another way might be to seek correlation between the existence of an EMS and enhanced environmental performance as defined by an external party for all companies. In a research constructed in this way, the investigation will seek to answer whether the EMS resulted in improved environmental performance, e.g. defined as reduction of waste generation. Such an approach, even if often used, bears the uncertainty of whether the correlation can show causality, meaning that the improved environmental performance, here minimized waste generation, may not necessarily be the effect of the EMS [9]. Moreover, companies with a better environmental track record may well be more apt to implement and certify an EMS, as a way to capitalize on their environmental achievements and advertise "green" image, as was suggested by other authors [13]. Even when the particular company shows improved performance after putting an EMS in place, this does not confirm that the improvement was caused entirely by the EMS. It is quite plausible that the improvement was achieved with the co-existence of other supporting factors. In fact, the correlation between EMS and improved environmental performance does not show that the improvement would not have been the same without the EMS [14].

Thus correlation alone cannot show causality, but it can certainly strengthen or weaken such an argument. Particularly, if correlation studies are coupled with theory about how environmental management systems are expected to improve performance, a stronger argument can be made if there is correlation between performance, systems and the functioning of the particular mechanism that is expected to have effect. If we are to show that EMS improves environmental performance (or not), it would therefore be helpful to examine the mechanisms that are expected to affect the improvement.

It is thus necessary to focus not only on the question if there is a strong correlation between implementation of the EMS and improved environmental performance, but more importantly on the question how the environmental performance is defined at

each implementing company, supported by investigations on different factors that might have affected the outcomes of EMS.

2.3. Context dependency

For many companies introducing an environmental management system is the first step in controlling their environmental footprint. The ISO 14001 standard requires that an implementing company should take care of its significant environmental aspects.

Environmental aspects are the headlines for the internal environmental work, since a company implementing ISO 14001 builds the system to tackle them. Nevertheless, there is no guarantee that the selected aspects will perfectly reflect the environmental burden of a specific company. According to the standard itself, "There is no single method for determining significant environmental aspects. However, the method used should provide consistent results and include the establishment and application of evaluation criteria, such as those relate to environmental matters, legal issues and the concerns of internal and external interested parties" [8]. This means that selection of the objectives for the environmental work of companies is influenced by many factors, both internal and external to the company. These factors include the understanding of company's operations in the larger context, the level of company's ambition for the environmental work of the company in question and also financial possibilities. It is thus understandable that the outcomes of the EMS, such as environmental performance, will be determined to large extent by the initial scope of EMS.

In the more general case, there may be grounds to evaluate the management methods prescribed in the systems compared to other approaches. For example, it might be expected that the fact of introducing an organized and structured way of managing environmental issues, regardless of its ambition level, might increase the company's environmental performance. Such ancillary effect was reported by some authors, but it cannot be so far broadly generalized [13]. The level of influence of the structure on performance is rather dependent on characteristic of a particular company, including its intangible assets such as culture, values and competitive environment [15].

Although the standards are quite prescriptive in the use of various instruments of management, there is also significant room for adaptation and indeed interpretation. Also, the environments in which the management systems operate vary in terms of corporate culture, legislative environment, and many other factors including, notably, the natural environment. The interpretation of a standard and internal uniqueness of each company creates strong grounds for the assumption that the outcomes of an EMS are context dependent.

3. Study design and data

This research is constructed as a meta-study based on a pool of 23 research articles and reports assessing and discussing the environmental outcomes of EMS. The selected studies appeared to be heterogeneous in the design, focus and methodological approach; however, the common criteria for them were to report on environmental outcomes or benefits related to implemented EMS. The study pool was generated mostly by direct search in academic databases, but also by searching through the references used in the articles found. Despite efforts to ensure that searches were comprehensive, there is always a risk of some imperfection in search methods, language barriers and also there may be issues of limited access to some sources. Three of the studies used in this meta-study are not published in peer-reviewed academic journals. Two of them, the MEPI study [16] and NDEMS [13], are broadly referred to in many academic works. The third one, a report by Bring Procopé and Axelsson [17], was selected since it is important locally and addresses issues relevant for this meta-study. Besides these reports, the meta-study is based on the research articles only. In this case there was no access to underlying data or analysis, other than that which is described in the respective articles. It should be therefore noted that the analysis and conclusions are limited by the scope of underlying studies, which vary in purpose, theory and reporting style.

The studies selected for this research, detailed in Table 1, were published between 1996 and 2008 in 15 different academic journals. Within this pool, the time span of the different studies varied

Table 1
Selected studies and overview of the approaches.

Study	Data type	Research method	Research question/ Measuring object	Environmental performance definition	Context dependency
[4,13,16,20,22,23]	QuaN	Survey, database, 2 studies used mix of databases and questionnaires	Studies are using indicators and are focusing on effects of EMS on plant level performance	Studies, with one exception, are not defining the EP. Implicitly focused on (toxic) emissions, eco-efficiency of the firm	No with one exception
[19,32,38–40]	QuaL	Survey	EMS and impact on EP, management of env. costs, risks, stakeholders, competitiveness; EMS as policy instrument; EMS and expected benefits	Studies, with one exception, are not defining the EP. Implicitly are focused on impact on firm's performance, competitiveness; plant level performance and other benefits.	Yes
[24–27,41]	QuaL	Survey	Economic and environmental benefits of EMS; connection between EMS and environmental behavior; EP	EP is not defined in the studies. Other approaches are employed, such as looking at benefits, adoption of env. practices, and not EP.	No
[42]	QuaL	Case study	The overall impacts of implementation and certification	Study is not defining EP. Implicitly looks at waste minimization, recycling and operational management	Yes
[17,18,30,31]	QuaL	Interview	EMAS and internalization of environmental issues and values, The impact of EMS on EP and other effects of the systems	Studies are not defining the EP. Implicitly they focus on benefits perceived by managers. In one case it is defined as continual improvement in the work with the significant aspects	No with one exception
[6,29]	QuaL	Mix of methods	EMS and regulatory dividend; Effects of EMS on environmental management practices and operations	No definition of EP provided. Implicitly they look at effect of EMS on legal dimension and operational management practices; relation to design, waste management and recycling practices.	No

significantly, from 2 years to just a few months, depending on the research method. Similarly, the number of organizations varied dramatically from just one organization to as many as 1510. Such high variability is inevitably connected to the method chosen for the particular study, from in-depth study to large-scale surveys and investigations of mixed methodology. The prevailing methods in the selected studies were surveys (14 cases); in-depth studies and small-scale studies were used to a lower extent (2 and 7 cases, respectively).

Almost all the studies selected for the overview analyzed organizations operating in one specific country. The countries were mainly European, but also North America, Australia and Asia were represented. Only two reported analyses referred to cross-continental results.

The response rate is connected very closely to the scale of the survey, the larger the study, the lower the response rate. The response rate in the large studies varied from 10 to 50%, while for the other studies it was ranging between 13 and 62%. The high response rate in some studies can be well explained by the nature of organizations responding. The respondents were the organizations with an EMS already in place or in the process of implementing one. They therefore could be regarded as environmental front and as such be less hesitant to reveal their performance results, and thereby perhaps enhance a favorable environmental image. None of the studies with low response rate used a non-response analysis.

When it comes to the method chosen in the selected studies, the great majority was comprised of studies based on the collection of qualitative data, obtained either by interviews or questionnaires. In some cases, the details of the particular methods were not given explicitly. Instead they sometimes could be found throughout the publication text. In the cases where methods were explicitly described, it was possible to find out that the design of the questionnaire was different from case to case, and the same could be said about the interviews, where the questions were structured, semi-structured or open-ended. Where questionnaires or surveys were used to gather data, the answers were weighted by placing them on a Likert scale or otherwise ranked.

Only six of all studies employed quantitative data. Three of them used quantitative measures based on publicly available data. These were focused on developing indicators to measure improvements in operational environmental performance. Three others used mixed methodology, such as broad surveys followed up with interviews. These three studies are also the long-term and large projects, as might be expected when employing two different methodologies.

4. Findings

The number of academic studies analyzing the outcomes of EMS is growing. The results of these studies are, however, so far inconclusive. While some authors claim that EMS leads to improvement in the environmental performance [13,18–20], others show that there is no such connection, at least not in the areas selected for the investigation [21,22]. These evaluations are, dealing with different industrial sectors, companies of different sizes and last, but most importantly, have different preconceptions of what environmental performance is, and apply different approaches to discuss the environmental outcomes of EMS.

Table 1 summarizes the selected studies. It lists them firstly in accordance with the type of data, i.e. if it is qualitative or quantitative. The 23 studies fall into six method groups. For each group, the table lists the objective of the research, the environmental performance definition and the view on context dependency, i.e. measures taken to ensure the connection between the environmental performance and the other factors of possible influence.

4.1. Respondents

In the studied articles, the respondents selected for studies were not always very well specified. Where this information was available, the respondents represented the management staff, in the prevailing cases the environmental managers and sometimes also the top managers. In very few cases did respondents represent groups other than top and environmental management. Other key personnel, community representatives, residents and local governments were thus seldom selected for the studies.

4.2. Perceptions of environmental performance

The definition of environmental performance was formulated differently in every study. Although the content of performance varied, its assessment fell into two categories.

The first category dealt with environmental performance as expressed by the use of operational performance indicators referring to the resource use, waste generation, emissions or water consumption, i.e. "aspects" in ISO 14001 terms. This captures easily measurable short term changes, but leaves aside issues more difficult to quantify, such as internal social benefits, impact on the stakeholders etc. This definition of performance is used in connection with quantitative research methods and use of data facilitating calculations of indicators.

The other quite broad category viewed environmental performance as expressed with the means of various perceived environmental benefits. They can range from compliance enhancement, waste reduction, savings generated by EMS, systematization of operational practices to the complex issue of competitive advantage. Since most of qualitative studies do not rigidly define environmental performance in advance, the response data tends to be richer in variety. The broader scope of what environmental performance can be leads to unique and valuable data when the businesses list what they believe are the most important benefits of EMS, but not to quantifiable improvement.

4.3. Connecting performance and EMS

In general, the selected literature for this study was aiming at discussing the EMS as a tool to manage the environmental issues at companies (see Table 1). Even if the overall purpose of all papers was similar, the specific research questions varied. The respective authors concentrated their efforts on issues ranging from creating a list of benefits the EMS brought to the companies to evaluating the value of implemented systems to measuring environmental performance of the implementing companies. Depending on the research question, the research approach was accordingly diverse. This means that the definitions, sampling and research methods were quite different from case to case.

There are examples of studies based on quantitative approaches where existing databases containing publicly available data were used to assess environmental performance, such as in Matthews [22] or Potoski and Prakash [20] and Anton et al. [23]. Others used self-reported data by the companies taking part in the research projects, such as in Ammenberg [4]. In both these cases the researchers used the data to either find a statistical correlation between the parameters, or to use calculations in order to prove or disprove the propositions of the papers. Environmental performance was then expressed in a numerical way. Therefore, the issues of usefulness of EMS used in these articles were defined to reflect the potential effect the EMS may have on waste generation, resource use, emissions and similar issues.

Some other authors selected large-scale surveys as their primary data collection tool. The research approaches were, however, also very diverse, even within this group. In some cases

the authors used surveys to generate large amounts of data, including self-reporting of quantitative information on company related selected parameters. In this way they were able to perform the correlation analysis between selected values, see e.g. Dahlström et al. [6], Arimura et al. [19], or Potoski and Prakash [20].

Surveys were also used to gather qualitative data and similarly to use it to correlate selected values, e.g. Raines Summers [24], Welch et al. [25], Zutshi and Sohal [26]. Such studies are often referred to in the literature, including by the authors themselves, as studies measuring perceptions [27].

Another interesting approach was to combine different methods. Some authors have made an attempt to triangulate large-scale surveys with field studies, such as in-depth interviews or case studies, e.g. Ref. [28,29]. In the study of Florida and Davison, the survey was supported by interviews with various stakeholders of five selected plants [28]. This measure has resulted in particularly interesting results, where the researchers employed views of not only environmental managers of plants, but also community representatives, residents and local governments. In this way, they have managed to obtain quite a broad spectrum of effects the EMS might have on the plant.

On the other hand there is a substantial pool of studies tending to focus environmental performance or improvements stemming from EMS through other qualitative methods, such as interviews. These smaller scale investigations have limited the researchers in terms of generalization. On the other hand authors brought a richness of in-depth information and managed to shed light on the complicated nature of environmental improvements in the companies. Examples of such investigations are Annandale et al. [18], Bring Procopé and Axelsson [17], Morrow and Rondinelli [30], Pérez et al. [31].

4.4. Context dependency and generality

Within the pool of publications that were analyzed in this study, there are some that explicitly addressed the fact that the outcome of EMS can be influenced by factors independent from the companies themselves. For example, in a report summarizing a longitudinal study in United States, the authors discussed such possible limitations [13]. They recognized that state financial support for implementation of an EMS could positively influence its outcomes. They also acknowledged other issues that might have had similar effect, such as external consultancy help and interest shown by the stakeholders [13]. Pérez et al. looked at forces that may be willingly used by companies and that could have an influence on possible outcomes of the EMS. They found that accommodating for the stakeholders interests while shaping the EMS is an important input. Furthermore this can lead not only to gaining a competitive advantage, but also to creating intangible assets, such as increased communication and commitment of managers, as well as enhancement of their knowledge and skills bank. Thus these intangible assets can play a role in enhancing the environmental performance of these companies [31].

Florida and Davison [28] investigated the issue of external influences and conditions that might influence the potential of the EMS to reduce environmental risks. They asked respondents to identify and rate the importance of factors such as: environmental regulation, business leadership, quality of local government, effective partnerships, active citizen involvement, and active environmental groups. They expanded the usual industrial perspective by interviewing stakeholders other than representing the companies and using their views on the environmental work of the selected firms.

Ann et al. [32] hypothesized that not only the supply chain issues but also past experience with ISO 9000 would affect the level of performance of the firm. Environmental regulations and other possible voluntary agreements other than ISO 14001 can also influence the environmental performance of the companies. Arimura et al. [19] in their study on adoption of ISO 14001 in Japan investigated whether existing Japanese regulatory context can influence the companies to perform better, but found no correlation. These authors also recognized that management attitudes are likely to be correlated with environmental performance, and thus tend to be important endogenous issues.

Most of the investigations were not limited to any selected industrial sector. On the contrary, researchers made efforts to assuring great variability, and by this generality in terms of the sample profile. In most of the studies, many industrial sectors were present, including the particularly environmentally sensitive industries.

On the other hand, the few studies where the sample was limited to just one industrial sector were aiming at assessment of the environmental outcomes of the implemented systems, and a choice of one particular sector was steered by the data availability and by the higher representativeness of the results.

5. Discussion

5.1. Perceptions of environmental performance

Environmental issues, as observed in businesses, have an interdisciplinary character. They cut across different sciences, thus methodologies employed to environmental research require quantitative analyses as well as qualitative explorations. From the previous sections it can be seen that evaluation of environmental performance is quite a diverse process, that depends on what tools are applied and what assumptions and decisions are made. The findings section clearly indicates that selected studies took different approaches to what was the major outcome of the environmental management system.

In the quantitative studies, environmental performance of companies was seen from an outside perspective, with a preference for measurable entities. Therefore we can further assume that quantitative methods of evaluation of EP have a more or less explicit policy perspective. The goals of the studies were oriented more towards general conclusions and broader applicability. A typical method of looking at outcomes of EMS would be to look at plant level emissions and investigate if they are related to implementation of EMS. It is plausible to assume that the advantage of using a quantitative definition of EP helps to simplify the complex issue of EP and therefore facilitates comparing companies to each other.

It should, however, be kept in mind that all perceptual measurements are prone to be biased. One of the important sources of the bias are the respondents. In the selected studies there was a clear overrepresentation of respondents in corporate environmental management. According to Huber and Power the choice of respondents can be of importance for the further interpretation [33]. Depending on their affiliations within the organization, the researcher may get accordingly affected data. There are four reasons why respondents might give inappropriate data:

1. They are motivated to do so,
2. Their cognitive and perceptual limitations result in inadvertent results,
3. They lack crucial information about the event of interest,
4. They have been questioned with inappropriate data elicitation procedure [33].

The overrepresentation of a particular group can probably be explained by the typical limitation of environmental work to the environmental departments and its manager. Relatively few people

from outside this department use to have good information about environmental issues of the company. Moreover, there is often a visible division of labor in companies, where a questionnaire about environmental management might be given to the environmental manager to answer, irrespective of to whom it was addressed. The same sort of issues may arise with respondents for interviews. These raises a difficulty, since it is not just a corporate perspective that is reflected in this approach, but a corporate perspective as interpreted mainly by environmental management practitioners.

5.2. Connecting performance and EMS

It is not entirely clear if all companies will be willing to disclose the information necessary for the research to be generalizable. In current practice, ISO 14001 does not require any public disclosure of environmental information. There are probably few companies that willingly would reveal data which often is regarded as sensitive. Without disclosure, as Metzenbaum discusses, the broad application of ISO 14001 as a policy tool is rather unclear. The other underlying question related to EMS and its possible role as public policy instrument is how the outcomes of EMS are formulated, measured and compared between companies [34].

It should, however, be noted that the quantitative perspective risks difficulties related to causality/attributability. In policy evaluation research, it is necessary to study the causal connection between an intervention and an effect [35]. If environmental management systems are to be seen as policy instruments, one needs to show the attributability between EMS and environmental performance [36]. Is not always easy to conclude that the observed effects were in fact caused by the implemented EMS. There could be very many other influences that lead to the observed effects, meaning that without thorough analysis, causality should not be claimed. This means that there is a need to better understand the question of how EMS affects environmental outcomes in this perspective as well. However, the "how" question can vary between companies. In some cases the effect most relevant to the company itself is the morale leverage and assigning appropriate importance to the environmental issues across all departments, whereas in some other companies the most important is to regulate the waste generation issue. This leads us to suggest that more fruitful view of environmental performance in connection with EMS is that of each individual company. If conclusive evidence of a causal connection on a corporate level could be found, then this would inform about the effectiveness of EMS as a management tool, although it would still be left to a value judgment whether the EMS actually benefited the environment.

On the other hand the "qualitative" category of the studies tends to be more company-oriented, using both corporate perceptions and definitions of environmental performance. In these studies, we see a tendency towards "how" questions. Perceptions, rather than only operational data, are studied, and methods selected for such research are therefore qualitative. These studies approach not just the "yes" or "no" question of whether EMS improves performance, but start the inquiries into what way, under what conditions, and why environmental management systems have the effects they are perceived to have. This type of study may be particularly useful to the companies themselves, as it tends to examine performance, and perceptions of performance, according to the view of the company itself.

5.3. Context dependency and generality

In the study on the effects of environmental management systems, it is plausible to assume that the context in which the companies are operating can have a significant influence both on the shape of the EMS and indirectly on the environmental performance of the company in question.

Conceivably, the success of an environmental management system might vary a great deal, depending not only on how it is implemented, but also on the internal and external conditions of the company. In some companies the beneficial effect of EMS can be related to the fact of structurising of the environmental work or giving it appropriate importance, in other it may depend on the stringent regulations that pushed companies into preventive thinking, in some others it may depend on charismatic leadership. On the other side one needs to be aware that structure and organization of work, which are the inherent parts of the EMS, are also debated as possible hinders to the innovativeness of the companies [37]. In general management literature, current theory on structure in organizations is that extremes might not be beneficial too much of the structure can be as bad as too little. "Especially in changing markets and technologies, extensive structure exacts a price, that price is stymied flexibility and stunted innovation" [15].

6. Conclusions and recommendations

Although the body of research on the connection between EMS and performance included in this work is still inconclusive, the efforts so far can yield some conclusions.

The first conclusion is that the definition of performance used in any study, though varied and subjective, must be clearly stated, since it increases the understanding of what is selected as the object of the research and it has the major impact on the final conclusion one can draw. The authors found that definition was not often clear and explicit. In many cases the only way to get to know the definition was to deduce it from various parts of the text. This could impair the possibilities for the results to be used more broadly. It is especially important to be clear whether the study evaluates EMS according to the company's own objectives or other criteria. Because many studies will be needed to paint a general picture of outcomes of EMS, it is imperative that definitions are clearly described in the presentations of the research.

Secondly, it has to be recognized that all research methods have their own strengths and limitations. Whereas in the pool of selected studies the quantitative methods usually looked at emissions, the qualitative were more directed towards general perceptions or the issues that were of importance to the particular company. All these approaches may usefully serve different purposes and lead to different conclusions. Thus, since the quantitative and qualitative studies will continuously facilitate the knowledge development around EMS and its applications, it is important that thorough context dependency provisions are taken.

Policy makers need to beware that not only may it take some time before the connection between EMS and performance is clear, but also that the results may be mixed. If we ask if EMS leads to improved performance, the answer will quite likely be: "It depends." If we instead ask how EMS affects performance, this will at least generate useful insight for improving the systems.

The variety of results so far supports a hypothesis that the effects of EMS are not general, but dependent on other factors, such as the management style and goals of the particular company, its operating environment, culture and stakeholders. The studies selected for this meta-study have approached the issues rather differently, and only few took sufficient measures to provide for the question of attributability. The authors here suggest that the question to research which will be most fruitful is not whether EMS improves performance, but how, when and why, depending on goals, culture, economy, legislation and so on.

The studies reviewed here are a good start of the research on the effects of EMS, but more data will be needed to understand the causal relationship well enough. Because of the limitations facing

a meta-study such as this, and the need for generating more and broader understanding, further research is an excellent opportunity for collaborative efforts. Research done in parallel in different countries could perhaps benefit considerably from comparison with other ongoing work as the research proceeds. This would allow greater sharing of methodological detail, in addition to comparison of raw data.

The suggested approach will require a great research effort before results in a sufficient variety of goals, cultures, environments and so on can be evaluated. The number and power of interested parties should ensure that the effort is made. Here is a fruitful field for cross-border collaboration in order to achieve comparisons between implementations within studies, as well as between studies. The connection between EMS and performance is a puzzle, of which a few pieces are now in place.

References

[1] ISO. The ISO survey of certification 2006; 2007.
[2] Porter ME, van der Linde C. Green and competitive: ending the stalemate. Long Range Planning 1995;28:128–9.
[3] Nawrocka D. Inter-organizational use of EMS in the supply chain management: some experiences from Poland and Sweden. Corporate Social Responsibility and Environmental Management 2007;. doi:10.1002/csr.150.
[4] Ammenberg J, Hjelm O, Quotes P. The connection between environmental management systems and continual environmental performance improvements. Corporate Environmental Strategy 2002;9:183–92.
[5] EU. Directive 2002/95/EC of the European parliament and of the council of January 27, 2003 on the restrictions of use of certain hazardous substances in electrical and electronic equipment. Official Journal of The European Union 2003:19–23.
[6] Dahlström K, Howes C, Leinster P, Skea J. Environmental management systems and company performance: assessing the case for extending risk-based regulation. European Environment 2003;13:187–203.
[7] ISO. Environmental management systems – general guidelines on principles, systems and suppotring techniques (ISO 14004:2004); 2004.
[8] ISO. Environmental management systems – requirements with guidance for use (ISO 14001:2004); 2004.
[9] Coglianese C, Nash J. Environmental management systems and the new policy agenda. In: Coglianese C, Nash J, editors. Regulating from the inside. Washington: Resources for the Future; 2001.
[10] Hamschmidt J. Economic and ecological impacts of environmental management systems. In: Companies: experience from Switzerland EURO environment 2000, Aalborg, Denmark; 2000.
[11] Hertin J, Berkhout F, Wagner M, Tyteca D. Are EMS environmentally effective? The link between environmental management systems and environmental performance in European companies. Journal of Environmental Planning and Management 2008;51:259.
[12] Parker T. Total cost indicators. Lund: IIIEE, Lund University; 1998.
[13] Andrews RNL, Amaral D, Keiner S, Darnall N, Rigling Gallagher D, Edwards Jr D, et al. NDEMS – National database on environmental management systems. Project final report. Chapel Hill: Department of Public Policy, University of North Carolina; 2003.
[14] Sekaran U. Research methods for business. A skill building approach. John Wiley & Sons, Inc.; 1992.
[15] Brown SL, Eisenhardt KM. Competing on the edge: strategy as structured chaos. Harvard Business School Press; 1998.
[16] Berkhout F, Hertin J, Azzone G, Carlens J, Drunen M, Jasch C, et al. Measuring the environmental performance of industry (MEPI): EC environment and climate research programme; 2001.
[17] Bring Procopé C, Axelsson U. Förbättras miljöprestandan genom miljöledningssystem?: IVL 2003:58.
[18] Annandale D, Morrison-Saunders A, Bouma G. The impact of voluntary environmental protection instruments on company environmental performance. Business Strategy and the Environment 2004;13:1–12.
[19] Arimura TH, Hibiki A, Katayama H. Is a voluntary approach an effective environmental policy instrument? A case for environmental management systems. Journal of Environmental Economics and Management 2008;55:281.
[20] Potoski M, Prakash A. Covenants with weak swords: ISO 14001 and facilities' environmental performance. Journal of Policy Analysis and Management 2005;24:745–69.
[21] Montabon F, Melnyk S, Sroufe R. ISO 14000: assessing its perceived impact on corporate performance. The Journal of Supply Chain Management 2000;36:4–16.
[22] Matthews D. Assessment and design of industrial environmental management systems. Pittsburgh: Carnegie Mellon University; 2001.
[23] Anton WRQ, Deltas G, Khanna M. Incentives for environmental self-regulation and implications for environmental performance. Journal of Environmental Economics and Management 2004;48:632–54.
[24] Raines Summers S. Implementing ISO 14001 – an international survey assessing the benefits of certification. Corporate Environmental Strategy 2002;9:418–26.
[25] Welch EW, Rana A, Mori Y. The promises and pitfalls of ISO 14001 for competitiveness and sustainability: a comparison of Japan and the United States. Greener Management International 2003:15.
[26] Zutshi A, Sohal A. Environmental management system adoption by Australasian organisations: part 1: reasons, benefits and impediments. Technovation 2004;24:335–57.
[27] Hamschmidt J, Dyllick T. ISO 14001: profitable – yes! but is it eco-effective? Greener Management International 2002:34.
[28] Florida R, Davison D. Gaining from green management: environmental management systems inside and outside the factory. California Management Review 2001;43:64.
[29] Sroufe. R. Effects of environmental management systems on environmental management practices and operations. Production and Operations Management 2003;12:416–31.
[30] Morrow D, Rondinelli D. Adopting corporate environmental management systems: motivations and results of ISO 14001 and EMAS certification. European Management Journal 2002;20:159–71.
[31] Pérez EA, Ruiz CC, Fenech FC. Environmental management systems as an embedding mechanism: a research note. Accounting, Auditing & Accountability Journal 2007;20:403–22.
[32] Ann GE, Zailani S, Wahid NA. A study on the impact of environmental management system (EMS) certification towards firms' performance in Malaysia. Management of Environmental Quality: An International Journal 2006;17:73–93.
[33] Huber GP, Power DJ. Retrospective reports of strategic-level managers: guidelines for increasing their accuracy. Strategic Management Journal 1985;6:171–81.
[34] Metzenbaum S. Information, environmental performance, and environmental management systems. In: Coglianese C, Nash J, editors. Regulating from the inside: can environmental management systems achieve policy goals? Washington, DC: Resources for the Future; 2001. p. 146–80.
[35] Tojo N. Extended producer responsibility as a driver for design change – utopia or reality?. Lund: IIIEE, Lund University; 2004.
[36] Speir J. EMS and tiered regulation: getting the deal right. In: Coglianese C, Nash J, editors. Regulating from the inside: can environmental management systems achieve policy goals? Washington: Resources for the Future; 2001.
[37] Konnola T, Unruh GC. Really changing the course: the limitations of environmental management systems for innovation. Business Strategy and the Environment 2007;16:525–37.
[38] Florida R. Lean and green: the move to environmentally conscious manufacturing. California Management Review 1996;39:80–105.
[39] Hui IK, Chan AHS, Pun KF. A study of the environmental management system implementation practices. Journal of Cleaner Production 2001;9:269–76.
[40] Giménez Leal G, Casadesus Fa M, Valls Pasola J. Using environmental management systems to increase firms' competitiveness. Corporate Social Responsibility and Environmental Management 2003;10:101–10.
[41] Sulaiman M, Nik Ahmad NN. ISO 14001 and corporate performance: a survey of certified companies in Malaysia. Available from: <environmentalexpert.com>; 2002. p. 1–12.
[42] Rondinelli D, Vastag G. Panacea, common sense, or just a label? – the value of ISO 14001 environmental management systems. European Management Journal 2000;18:499–510.

Appendix 2

The View from Below

A Management System Case Study from a Meaning-Based View of Organization

Thomas I. Parker

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The view from below — a management system case study from a meaning-based view of organization

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ABSTRACT

This paper reports on a case study, which investigated energy management and environmental management at a large-scale research facility. The author used the perspective of the managed personnel rather than the management, the entity or the management system. The focus of the research was on interpretation of work, particularly how employees' perceptions of priorities were affected by management initiatives. The method used is primarily interpretive. Gathered interview material was analyzed using attributive coding. The background for the interviews was based on studies of environmental issues and energy balances from a proactive, Cleaner Production perspective. The researcher found a reality gap between how the responding employees described their motives and the text of the environmental management system they were responsible for using. The view of the managed placed much greater emphasis on human interactions as a driving force, rather than written policies or instructions, or upon automated training mechanisms. Furthermore, neither the largely compliance-oriented environmental management practices nor the environmental management system had a significant overlap with the energy management in the investigated facility. The case study results revealed that increased attention to the collection and integration of energy and environmental data into computerized operational control systems could result in improved performance.

1. Introduction and goal of the research

Judged from the number of companies choosing to become certified, Environmental Management Systems (EMSs) can be acclaimed to be a great success. However, when EMSs are evaluated on the basis of the environmental improvements they deliver, the results are considerably more mixed. The hypothesis, if there was one, that environmental management systems necessarily lead to improved environmental performance has been falsified, at least if improved performance is taken to mean an independently observable reduction of the negative impacts of the company or organization upon the environment, based upon its EMS (Nawrocka and Parker, 2009). The overall objective of ISO 14001, as stated in the introduction to ISO 14001, is "to support environmental protection and prevention of pollution in balance with socio-economic needs", but a criticism is that "The standards are a blueprint for a centralized, hierarchical and highly formalized system to control and monitor the firm's stated environmental standards and programmes" (Strachan, 1997).

If EMSs sometimes lead to performance improvements, and sometimes do not, it is interesting to investigate if there are particular ways of implementing an EMS that make it more or less successful. An EMS, according to ISO 14001, contains a diverse array of components (i.e. policy, goals, targets, plans, training, routines and instructions) intended to help the implementing company improve their environmental performance. There may also be management initiatives connected to environmental and other issues that are not described in the EMS.

Energy use is a vital part of all environmental considerations. Inevitably, the close connection between energy management and environmental management has led to the question of whether energy management might profit from being integrated into, or modeled on EMSs and thus the energy management could benefit from the structure of the formal and common management approach (Thollander and Dotzauer, 2010; Thollander and Ottosson, 2010). Certainly, the content and methods of energy management overlap significantly with environmental management, in the context of organizational, and particularly corporate, activities. In fact the strong connection between energy and

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environmental management is addressed explicitly in the new standard for energy management systems, ISO 50001. The introduction to ISO 50001, states that "Implementation of this International Standard is intended to lead to reductions in greenhouse gas emissions and to other related environmental impacts and energy costs through systematic management of energy".

However, energy management is not a subset of environmental management; there are other aspects of energy management that do not seem to overlap in a meaningful way. One example is management for price volatility, which can be managed by trading financial contracts that are derivatives of energy spot markets. Security of energy supply is another issue of primary importance for energy management, but not necessarily from an environmental standpoint. In this study, the focus was primarily on energy use, which is of primary relevance for both energy and environmental management and therefore, is relevant to the question of the efficacy of co-managing these issues.

The original research described in this article was undertaken to develop a better understanding of how environmental and energy management initiatives, whether described in the EMS or not, function at the studied facility in order to apply this understanding in the development of EMSs for similar facilities, elsewhere in the world. The studied facility was a government-funded large-scale research infrastructure facility.

The structure of this article is:

- Section 2 is a review of the literature of evaluation of EMS in relation to environmental performance. This section is divided into subsections by the types of research reviewed, starting with quantitative studies that used external data, thereafter quantitative studies using survey data, and lastly case studies are presented. A fourth subsection addresses the relationship of energy management to EMS.
- Section 3 presents the theoretical and procedural methods used in the research, the facility studied in the case study, and the application of the methodology on the case.
- Section 4, presents the findings, grouped according to the research questions, starting with general management, the roles of the EMS, and energy management. A separate subsection on cost control is introduced, as a result of its importance in the findings.
- Section 5 is a discussion of the findings in relation to the theory used in the research, is sub-divided similarly as in Section 5.
- Section 6 contains the conclusions and recommendations to the research questions.

2. Literature review: environmental management systems, environmental performance and energy management

The literature reviewed was selected from peer-reviewed articles, which connected the concepts of EMS with Environmental Performance. Systematic searches for literature were performed at the beginning of the research period, and periodically during the course of the research, i.e. primarily 2009–2010.

2.1. Studies based on external, quantitative measurement of environmental performance

In an early study of ISO 14001 implementation, Florida and Davison (2001) investigated the effectiveness of EMS. Using statistical methods at the plant level to investigate the penetration and success of EMS, they found the following correlations:

a. High environmental performance factories were generally larger and had more associated environmental staff than their peers.
b. High-adopters of environmental management solutions were seen as "significantly more innovative in general."
c. EMS adoption correlated with improved stakeholder relations.

Although there was a correlation between EMS adoption and improved performance in the study, the question of causality was left open. In fact, the study clearly demonstrated that EMS adoption and environmental performance may independently co-vary with other phenomena. The authors concluded that EMS provided benefits in compliance, risk reduction and stakeholder relations (Florida and Davison, 2001).

The difficulty in showing causality was supported in other studies: "A majority of the companies, therefore, maintain that they would have achieved their environmental goals anyway, regardless of the EMS" (Steger, 2000). According to Steger's study, the companies themselves see the EMS as merely incidental to their trajectory toward environmental improvement. The EMS is more a result of environmental goals, than a cause of improvement.

Potoski and Prakash (2005) found that "ISO 14001-certified facilities reduced their pollution emissions more than non-certified facilities." Their study was based in the USA, and compared with changes in the Toxic Release Inventory, weighted for toxicity and thus producing a single measure of performance. The study also controls for "endogeneity issues". By this is meant that reasons that variables may vary in similar ways, without the change in one causing the change in another, i.e. correlation may not be due to causality. An argument of causality, i.e. that improved environmental performance is caused by the introduction of an environmental management system, can be strengthened by checking for factors that may cause both. In this study, endogeneity was checked by controlling for emissions and regulatory compliance histories, as well as a number of measurable variables describing stakeholders, such as state litigiousness, local residents' education level, percentage of minorities and income. The study also checked for evidence of reverse causality and showed that very high or very low performers in environmental compliance seem more likely to join ISO 14001, as are facilities that receive more regulatory inspections. Despite the "endogeneity", the study shows that ISO 14001 facilities had significantly larger pollution reductions.

Based on a rational view of the firm, the authors theorized that "shirking" would be "the most important program failure". The concept of shirking was used to describe a behavior wherein the minimum effort was made to achieve a certain benefit. More specifically, if acquiring a certificate for environmental management in itself conveyed a benefit, it would be rational for the firm to seek the certificate reward with the least possible expense (Potoski and Prakash, 2005).

The findings of Potoski and Prakash were corroborated by Anton et al. (2004), who found that "a more comprehensive EMS adoption leads to lower toxic emissions". Both studies were based in the USA and on the use of the Toxic Release Inventory to measure performance. On the issue of causality, or endogeneity, however, Anton et al. "assumed that a rational firm chooses both the comprehensiveness of its EMS and its level of pollution to maximize its net benefits", but they do not present arguments for the existence of such an ability. The assumption that firms have the perfect understanding of the effects of implementing an EMS that the assumed rational behavior requires, would seem to make the study largely unnecessary (Anton et al., 2004).

Hertin et al. (2008) investigated European companies with EMS, making use of environmental data from the 'Measuring Environmental Performance of Industry' (MEPI) project completed in 2000,

which was a European effort to assess environmental performance. The MEPI project was a study designed to evaluate absolute performance, as well as improvement. Hetin el al. found "no evidence" that EMS necessarily helped environmental performance and pointed out that the choice to implement an EMS was usually made for other reasons than improving environmental performance, implying that there may be little reason to expect such a link. The authors also express doubt to whether a co-variation between performance improvement and EMS would be a sign of causality, but were not able to control for other variables, other than industry sector and size of the company. The authors linked EMS and other "soft instruments" to cognitive approaches, such as sense-making, linking behavior to interpretation rather than "rationally-determined interest". The authors described environmental performance as being complex and multi-dimensional and pointed out that weighing different impacts is "inherently subjective" (Hertin et al., 2008).

Dahlström et al. (2003), investigated EMSs and performance from a regulatory perspective, by addressing the question of whether EMS could replace aspects of regulatory control. Their study was situated in England and Wales and built upon data from a regulatory appraisal scheme, which encompassed six categories. Five of these were process-oriented, whereas, the sixth category assessed occurrences of non-compliance, incidents and complaints. The study was especially interesting because it evaluated the contribution of EMSs to various separate aspects of performance and thus it went beyond debating for or against EMS to discussing what aspects of performance EMS might improve. Environmental management systems were shown to generally lift the poorest performers. A strong correlation was shown between EMS and procedural performance, but no significant correlation with actual improvement in compliance (Dahlström et al., 2003).

Ammenberg and Hjelm (2002) studied companies in Sweden based on their environmental reviews and discussed the basis for auditing continual improvement. While the study revealed that companies made improvements after implementing EMS, it also showed that the basis for verifying continual improvement was questionable and that therefore ISO 14001 certification does not guarantee improved performance (Ammenberg and Hjelm, 2002).

Since some studies find clear connections between EMS and environmental performance, and other studies just as clearly do not, it follows that EMS sometimes help the company to improve performance and that sometimes they do not. The question is why this is so. There seems to be a tendency that early US studies were more positive of a connection. There are plausible explanations for this, such as differences in corporate culture or language. The word "management", for example, does not translate unambiguously to other European languages, and there may be other translation issues in the standards. It may also be an issue of the research, including the timing, the data available and the methods applied.

A limitation, imposed by the use of external data, is that the organization studied is viewed as a black box. There is no investigation of what happens inside the organization. The studies may cast light upon the question of whether EMS lead to improved performance, but cannot address how they do so, or as the case may be, why they fail to do so. The existence of a certified EMS is viewed as a yes-or-no-question. There is no scope to discuss varying implementations of an EMS, as allowed by the standards.

2.2. Studies based on survey data

A survey makes it possible to study organizations for which appropriate public data are not available, and also to obtain insights pertaining to internal questions, such as those relating to strategies, culture or management philosophy.

Based on OECD survey data on Japan, Arimura et al. (2008) investigated the effect of ISO 14001 and environmental reporting on the specific performance categories of natural resource use, solid waste, and wastewater effluent. Noting a lack of agreement among authors on the effects of EMS on performance, Arimura et al. used economic methods to analyze their data. Like Anton et al. (2004), the authors assumed that companies were able to act rationally and optimize adoption of ISO 14001 and reporting according to their net benefit. The study included controls for endogenous variables. Among these were facility-specific factors "such as managers' attitudes toward the environment" and certain categories of customers. They also noted the prevalence of 'Plan-Do-Check-Act' (P-D-C-A) models in Japanese management (Arimura et al., 2008). P-D-C-A is a model of a management process on which ISO 14001 is explicitly based. In this view, the management function is described as a cycle of planning, execution, control and adjustment.

Sroufe (2003) found indications of a correlation between EMS and environmental performance. He theorized that an EMS could lead to efficient compliance as well as cultural change. The study was mainly based on a large-scale survey, although this was complemented with eight field studies, in a grounded theory approach. The survey had a 10% response rate. Of the respondents, 60% stated that they were involved in environmental management (Sroufe, 2003). It is not clear that the respondents were an objective group in relationship to the questions posed. Might these respondents be responsible for, or be significantly empowered by the systems they were assessing? Might greater involvement in the system lead to an inflated view of its importance? This problem was noted by Steger (2000): "we observe perceptions and often perceptions of perceptions. The bias resulting from the perspective (and interest) is obvious".

In a study of 40 companies in Western Australia, Annandale et al. (2004) used interviews to ask whether managers perceived that their environmental management systems and reporting schemes were leading to environmental improvements. That was indeed their perception, across a broad range of environmental issues.

Ann et al. (2006) study the correlation ISO 14001 implementation, economic and environmental performance, commitment, culture and "orientation", using a questionnaire and statistical methods. The authors were very clear that the method only investigated correlations, not causality; they were equally clear that the use of a questionnaire measured perceptions of the variables they have chosen, rather than the variables themselves. They sought causal evidence by investigating hypotheses of what may be intermediary positions and concluded that their study provided "some" evidence of a positive impact of ISO 14001.

In summary, the studies based on survey results reviewed in this section shed some light on the questions of 'how' and 'why', but were inconclusive. There seems to be a serious issue of bias if the questions are not very carefully chosen.

2.3. Case studies linking EMS implementation to environmental performance

It is clear that some EMSs are implemented constructively and some not. It is therefore, of interest to evaluate individual implementations of EMS to understand this difference in performance. Also, an EMS is comprised of a mixture of components, and these may be of varying usefulness for different situations. Parts of an EMS might even be counter-productive, such as rule-based controls that may stifle innovation (Konnola and Unruh, 2007).

In an in-depth case study of a plant that had extensive experience in quality management and was an industry leader in efficiency, Rondinelli and Vastag (2000) used a structured

conceptualization method to obtain a consensus among participants on how ISO 14001 affected the organization. They found that in the case studied, increased environmental awareness was the most conspicuous effect.

Zobel (2008) concluded from the literature that there was no proof that EMS improved performance and theorized that success for EMS depends on "organizational factors", that is, characteristics of the organization. Zobel drew upon theory that emphasized the goal-setting aspects of EMS by connecting EMS with goal-setting theory and Management by Objectives. He suggested that EMS performance could be improved by more focus on process rather than aspects, greater emphasis on measurement and by the use of participative decision-making.

Zobel's conclusions seem to corroborate an earlier, more theoretical analysis. Strachan (1997) applied theory of learning organizations on the then new ISO 14001 standard and found that "more participatory forms of management" were needed.

The case studies cited in this section demonstrate that it can be fruitful to investigate the efficacy of different parts of an EMS. An EMS implementation can contain both effective and ineffective components.

2.4. Conclusions from the literature review

Taken together, the studies in literature show that there is a perception, particularly among environmental managers, that EMS is helpful to environmental performance, but there is not conclusive evidence that implementing an EMS necessarily leads to improvements. Efficacy of an EMS may be dependent on other factors. One dependency may be the specifics of how an EMS is implemented, in relation to the type of organization.

There are a few case studies that shed some light on how the various parts of an EMS have affected different types of organizations. These studies show that this line of investigation can yield interesting results. More research of this sort will be necessary to establish causal connections between choices in how to implement an EMS and system efficacy. A body of case studies can then generate hypotheses for implementation strategies that may be general or specific to a certain organization type. These hypotheses could then be tested with survey methodology.

Building on the earlier research, particularly on the previous case studies, this case study focuses on the how employee understanding is affected by management initiatives, including those stipulated by ISO 14001. A greater understanding of how the EMS implementation affects the organization might lead to new knowledge enabling improved effectiveness of EMS. Together with other similar research, this may create knowledge leading either to general conclusions that could inform future standards, or more case-specific conclusions, which could inform future EMS implementations, and auditing procedures.

3. Methodology

3.1. Research questions

The primary research question posed within this case study research was:

1. What management initiatives inside and outside the EMS were effective in affecting the way the managed employees interpreted their tasks and roles, particularly in relation to issues of the environment and energy?

Furthermore, two secondary research questions were posed:

2. What was the effect of implementing an EMS on environmental performance?
3. How were issues related to energy managed and how were they integrated into the EMS?

The primary research question concerns how the employees' interpretation of their roles was affected by management initiative. It is therefore necessary to establish a theoretical basis for determining this connection, and methods of investigating perception. This is done in Sections 3.2 and 3.3, respectively.

The answer to the second research question is derived from the results of the analysis used for the first question, compared to a description of the EMS. The answer to the third question is also derived from the first, focusing on the subset of issues connected to energy.

3.2. Theoretical basis for the investigation of employee's perceptions

The case study research for this article was focused upon the connection between management initiatives, behavior and issues of the environment and energy. The primary research question connects employee perceptions of tasks to performance. The theoretical basis for assuming such a connection is presented in this section.

The design of the research into the effects of management required theoretical constructs concerning organization and behavior. Weick (1979, 1995) introduced the concept of "sensemaking" as the primary driver in organizations. It is a constructionist view. More specifically, it is interpretive and can be related to new institutional theory (Mac, 2002). Interpretive, or phenomenological studies of environmental management are unusual, but not without precedent, as shown by Balzarova and Castka (2008) with their investigation into the underlying mechanisms in the maintenance of ISO 14001, with the purpose to identify barriers to acceptance in small and medium-sized companies. Similarly, in energy management, Palm and Thollander (2010) noted that studies have repeatedly shown examples of missed opportunities for energy savings in industry, a phenomenon, which is difficult to explain with engineering or economic theory. Instead, they suggested that the social contexts hold the explanation and that the gaps in industrial energy efficiency may therefore, be "better understood in a social and institutional context".

The concept of an organization can be seen as "socially constructed systems of shared meaning" and the concern of strategic management is "organization making – to create and maintain systems of shared meaning that facilitate organized action" (Smircich and Stubbart, 1985).

The pivotal work on organization theory by Morgan (2006) documented how different metaphors of organizations have led to different views of management. The metaphors were machines, organisms, brains, cultures and political systems. The machine metaphor is invoked when management initiatives are described as a "toolkit" and when the correct application of the right tools is expected to give certain results. The organism view of an organization implies that the organization is like a living being, reacting to stimuli from its surrounding environment. Morgan's categories have been applied to the issue of change and EMS in case studies (Herreborg Jørgensen, 2000).

The comparison of EMS and "learning organizations" by Strachan (1997) cited above is an application of what Morgan termed the "brain metaphor", which also encompassed related concepts such as "knowledge management" and "organizational learning". Strachan's predictions that the design of EMS risked causing bureaucracy rather than action seem to be borne out in later empirical works that have shown poor employee involvement

in EMS implementation (Zobel, 2008). Generally for management systems, case studies have shown that a person- and knowledge-based management system, may lead to leaner but more effective management concluding that "The key was empowering the point person – with better information, training, and motivation systems – to take over more responsibility" (Quinn, 1992).

Within the discourse of strategy, a parallel development has been that strategies may be emergent. That is, they may emanate from inside the organization and diverge beneficially from official decisions (Mintzberg and Waters, 1985). This is a parallel because if the best strategy is emergent, the question arises of how the management can act to build upon such emergent strategies, and even facilitate their emergence, rather than ensure that the organization follows the one previously decided? One answer may be by organization making as Smircich and Stubbart (1985) suggested. This means that the main task of management is not to implement a strategy, but to create the organization that will develop a strategy.

Drawing on the abovementioned works, the theoretical framework of the study presented in this article may be called a *meaning-based view of the organization.*

In a meaning-based view of the organization, the key question to organizational behavior is how members of the organization interpret their work, including their roles, responsibility and mandate. This would also include environmental "awareness". An investigation into the efficacy of an EMS would therefore, explore to what extent, and in what way(s) the EMS affected the individual employee's interpretation of their roles. It is an investigation of the managed rather than the managers, of the effect of management, rather than its intent.

3.3. Methods applied in the case study

The three research questions posed required three different methods of gathering and analyzing data. This is because there were three different types of data involved, perception, management systems and environmental performance. The methods applied are detailed in this section.

The primary research question revolved around the question of how employees interpreted their roles, and how this was affected by management initiatives. The key data to answer this question are the interpretations made by the employees. The key methodological question, therefore, is how to collect and analyze interpretations.

For investigations into perceptions based on the theoretical framework presented in Section 3.2 a qualitative approach is recommended (Morgan and Smircich, 1980).

The qualitative field offers enormous variation, often reflecting ontological and epistemological differences (Cassell and Symon, 2004).

The investigation of perception was conducted as a series of twelve interviews, each lasting approximately 90 min. With permission, these interviews were audio-recorded. As strongly recommended by standard works on research methods (Miles and Huberman, 1994; Coffey and Atkinson, 1996), the recorded interviews were transcribed and coded. The coding method used was Attributional Coding (Silvester, 2004). Attributional Coding tracks explicit and implied causal relationships and is therefore, useful for finding answers to questions of "why". In this case, the respondents were asked about their work and its environmental implications, leading to attributions of behaviors and decisions relevant to the research questions concerning what the respondents perceived to affect their actions.

The coding process was started with every attribution, that is, a statement that assigns or implies a cause to an effect, was highlighted in the texts. In the next step, the attributions were grouped into categories, e.g. "costs", "people", "regulations", "goals", "policies", "ethics". This process was done in several steps, as the categories were broadened or narrowed to fit the data. In this process, the patterns that emerged formed the results. Because the results presented in Section 5.2 are patterns that emerged, not anecdotes or quotes from single sources, they are not attributed to single sources or to specific interviews.

With the intent to minimize influence from the researcher, the format of the interview, or the leading nature of the questions themselves, the interviews were intentionally formed as conversations, with a minimum of structure. The intent was exploratory, not a process of gathering facts, but of extracting meaning. Seldom were questions posed about the EMS itself, and when it was discussed, it was intentionally done as late in the interview as possible. The intent was to not influence the respondent to attribute actions to the EMS or anything else in particular.

For comparison with the EMS, in answer to the second research question, only the written description of the EMS was considered. The written description of the EMS was thus taken to define the limits of the system.

To connect the primary investigation of employee perceptions with environmental performance, a secondary methodology was also applied. This was a technical study of the facility's systems, primarily its energy systems. In this study, environmental performance was viewed from a Cleaner Production or Pollution Prevention perspective. That is, flows of materials and energy were viewed from the perspective of preventing or minimizing wastage of these resources via pollution or low-efficiency. In environmental performance evaluations, an input–output analysis of mass flows is a fundamental part (Jasch, 2000). In this case, the mass flows were limited (atomic), but the energy flows were very substantial, and therefore, were an important part of the eco-balancing method. An inventory of energy flows was therefore, the basis for the technical research.

The purpose of the eco-efficiency investigation was to form a view of the environmental performance of the facility. The observations from these investigations were then used to form questions or discussion topics for the interviews. The process was iterative. The information (in the sense of both quantitative and qualitative input) was collected primarily via conversations with the staff of the facility, many of which were held during tours of the facility. They were followed by numerous additional observations, unplanned conversations and communications to clarify various points, particularly concerning the technology, energy balance data, energy and temperature flows, voltages and questions pertaining to choices of technology. For practical, ethical and social reasons, voice or video recording was not used. Results were recorded in evolving field notes, in the form of spreadsheet data for the energy flows and temperatures and in the form of discussion topics for the interviews. There were significant, repeated interactions with the interviewed staff, quite often after the interview but before the coding and analysis had been done.

In summary, the method flowed as follows. Note that each step was part of the analysis:

1. Data gathering, energy flow and balances, background, basic understanding, identify and develop issues and questions, identify people to interview
2. Interview, interaction, recording
3. Transcription
4. Coding
5. Analysis
6. Writing

3.4. Spallation neutron source at Oak Ridge National Laboratory

The research for this paper was conducted as a case study during the two-year period 2009–10. During that time, this researcher had full access to the facility, its staff, and general systems.

The Spallation Neutron Source at Oak Ridge National Laboratory in Oak Ridge, Tennessee, is a facility that produces neutrons for research. Research using neutrons is useful for investigating materials by looking 'inside' materials in real time. Neutrons can show "where atoms are and what atoms do", in the words of the 1994 Nobel Prize citation of Cliff Shull and Bertram Brockhouse, for their work in neutron scattering. Because they have the same mass as hydrogen atoms, neutrons are excellent for investigating light atoms such as hydrogen, oxygen and carbon for which x-rays are not as sensitive. The use of neutrons is therefore especially important for research in issues connected to biological processes and energy. Areas of energy research include improving fuel cells, hydrogen storage and carbon capture and storage. Because neutrons are also magnets, research using neutrons is also useful for investigating magnetic phenomena inside materials, such as superconductivity An aim of this research is to achieve room-temperature superconductivity.

A spallation neutron source is a neutron source that uses a spallation process to produce neutrons for research. Spallation sources are an alternative to a nuclear reactor. A spallation neutron source can provide a more intensive neutron flow than a reactor, and avoids the use of a nuclear fission process with associated environmental issues. Spallation involves the use of an accelerator that sends high-speed charged particles into a target material, which causes a reaction in the target atoms that releases neutrons in all directions. This is not to say that the spallation method avoids all environmental issues. Radiation is created by the accelerator and the target material becomes radioactive.

The Spallation Neutron Source (SNS) is the new and larger part of the Neutron Science Directorate of Oak Ridge National Laboratory (ORNL). SNS was completed in April 2006 at a cost of USD 1.4 billion. The Directorate has about 600 staff and it also includes the High-Flux Isotope Reactor, which was not included in the study. ORNL has around 4600 employees. ORNL has a common, certified ISO 14001 Environmental Management System. ORNL is operated by the organization UT-Battelle for the United States Department of Energy, referred to as "The Customer".

There is good reason to state that the Spallation Neutron Source at the Oak Ridge National Laboratory is a very well-run facility. It is the world's most powerful resource for research using neutrons and holds the world record for neutron production. It is spotlessly clean. It is a massive, ongoing construction project that has had zero lost-time accidents and no notices of environmental violations, since Vice-President Al Gore broke ground on December 15, 1999.

The site of ORNL was established as part of the Manhattan Project during the Second World War, and has been a site for splitting atoms since then, although now as a civilian operation in the service of science. It is a source of pride locally, but also it has a radioactive contamination legacy that is being addressed. It is a remote facility. One reason given for the original location of ORNL was the plentiful supply of hydroelectric power. Today, much of the power is in fact from coal-fired plants. Coal is also plentiful in the area.

The study described in this article focused on issues relevant to both energy management and environmental management. In this case study it was clear that there were important energy issues, but there was no expectation of an explicit energy management approach, such as a specific system or position.

This case study was unusual in that the investigation took place in a large-scale public research facility and not in industry. Large-scale research facilities are generally very energy intensive, but have not been widely investigated within the academic field of Environmental Management. Literature searches on "Environmental Management" and the names of the large research facilities in Europe gave no results. Some of the American labs have nuclear legacy cleanup issues, stemming from previous site histories as well as Native American treaty perspectives, which have been investigated and reported, but these issues were outside the scope of this investigation.

3.5. Application to the research questions

Attributional coding was used to yield results directly relevant to the first research question which was: **"What management initiatives inside and outside the EMS were effective in affecting the way the managed employees interpreted their tasks and roles, particularly in relation to issues of the environment and energy?"**. By letting the respondents freely attribute their actions to causes, the researcher developed an understanding of what mechanisms influenced behavior, in the view of the respondents.

The second research question was: **"What was the effect of implementing an EMS on environmental performance of the facility?"** This question was addressed by noting attributions to parts of the documented environmental management system. Similarly, the answers to the third research question, **"How were issues related to energy managed and how was this integrated within the EMS?"** were found by looking for attributions related to energy issues and comparing them with environmental management practice.

4. Findings: management practices and performance

4.1. Energy flow and management

At the time of the study, SNS was operating at 1 MW of accelerator power, in the process of being slowly increased to the design specification of 1.5 MW. The annual total electricity consumption of the facility was approximately 200 GWh/year. Total power use was 24 MW with the accelerator beam on and 12.7 when it was turned off. Aside from the accelerator itself, large energy consumers were:

- Central utilities (cooling) 28 GWh/year
- Cryogenics (helium supercooling) 24 GWh/year
- Central laboratory and offices (including a large nano tech center) 24 GWh/year

Natural gas use was significant year round, approximately 3.8 million cubic feet per month, equivalent to 1.1 GWh (an average of 1.6 MW). This was due to humidity issues, which are a known difficulty, resulting in the chilling loops being used to reduce humidity in incoming air to sensitive electronic equipment. One chiller unit was in continuous use and the gas was primarily used for re-heating.

There was no unified responsibility for energy issues, nor had any goals or energy use reduction targets been formulated. There was clear responsibility for energy equipment, and each piece was well-run and maintained. Processes for identifying and deciding on improvements of individual equipment or systems were in place. Efforts in improving energy management, made by line management, were attributed to cost savings and successfully reduced costs by controlling scheduling, and thereby, moving peak demand, which was fully half the cost. As the key parameter was the top demand during a calendar month, this did not affect total energy use; it just moved demand from one month to another.

Substantial investments had been made for systems for monitoring energy use, including greatly increased metering and

integration with other systems for maintenance and control. Energy consumption data were seen to be very useful for technical diagnostics.

The investigation of energy flows showed simultaneous, adjacent and substantial heating and cooling processes. This was explained by a need for humidity control. Regardless of outside temperature, the air was cooled for dehumidification and then reheated for comfort. The re-heat was from a natural gas boiler, while the excess heat from the chiller was cooled by cooling towers.

The systems for heating and cooling were necessarily complex. The technology at the facility was based on the use of a superconducting linear accelerator, which requires cooling to close to absolute zero. To achieve the necessary precision in the accelerator, instruments are accurately temperature-controlled to prevent thermal expansion.

4.2. Themes of attributions discovered in the coding and analysis

Themes of attributions found in the analysis were found to fall into the themes of Knowledge, Management, Values, Compliance, Goals, Costs and Technology. The Knowledge theme focused on knowledge processes, such as flows of information and information systems. The Management theme centered on direct management interaction, such as face-to-face instruction and interaction, and management knowledge of operational detail. The duty of management was described to provide facts, to communicate values and to interact personally with the managed.

The Value attributions are references to concepts such as responsibility, expectations, culture and inspiration that were not formalized or documented, but perceived to strongly influence behavior. Compliance was a common theme, and was referred specifically to environmental regulatory compliance but also to more general issues such as public perception, which might influence regulations and thus cause the development of new regulations. Line managers were often referred to as bearers and communicators of values.

Although the Goals theme was stated in plural, only one overall goal was generally invoked for each time period. In references to the earlier construction phase of the facility, the goal referred to was finishing the construction. During operations, the overshadowing goal was availability. The goals were referred to in attributions of behavior of higher management, not as descriptions of the interviewed employees' own motives. The interviewed personnel understood the actions of higher management in the context of the goals.

Costs were often referred to as a driver, mostly as an opposing force to environmental improvement. Although the term "cost" was most often used, and was therefore, chosen to designate a theme, it usually referred to expenditures that would be classified as investments in a 'normal' business setting, such as better windows, insulation or equipment. Energy management efforts were exclusively attributed to costs, never to environmental concerns or environmental management.

The Technology theme was less prevalent than the others. In this theme, attributions were made to the advanced technology of the facility as a special driver for action.

The Environmental Management System was not found to be a discernible theme in the attributions. Only one respondent made explicit attributions to the system as such.

4.3. Use of goals in management

The main goal of the facility was availability, that is, the percentage of the time during which research using neutrons can be performed. This took precedence over the culturally significant goal of increasing the power of the accelerator, and thus the intensity of the neutron beams. Both of these goals were strongly supported by communications, decisions and rituals from the top management. Their relative importance was clarified in a decision to postpone scheduled power increases in the interest of availability. There was no variation in understanding observed among staff about the relative importance of these goals. The goal of availability was generally known and accepted. There was a shared view that the mission of the organization was the research, and the amount of research depended on availability of neutrons.

Availability was elaborately planned and measured against a plan. A substantial non-availability penalty was carefully allocated to the group deemed responsible when that occurred.

The nineteen objectives in the EMS were not referred to by respondents as such. However, references were made to the physical systems that management had put in place, such as a facility for recycling of chemicals and a program to make bicycles and electric vehicles available on site.

4.4. Use of training as a management tool

An automated training system was in place within the Training and Qualification Management System. Each person's access to various parts of the facility was controlled by personal badges and automated locks. Virtual access worked similarly, based on badge number. The appropriate training was required or the door (or site) would not open. The training was often provided on-line, so the process could be almost fully automated. This guaranteed exposure to information. However, the value of this type of training was not held in high regard by the interviewed staff, which only trusted face-to-face interactions. The training was predominately oriented toward compliance with rules and regulations.

4.5. The implementation of cost control and its effect on behavior

Generally, the staff did not expect to be rewarded for initiatives that led to cost savings, and were averse to being associated with projects that might lead to any risk to reliability or that required down time to implement.

Technical shortcomings were generally attributed to the earlier construction phase, which ended in April 2006. Almost all of the personnel interviewed had been involved in the construction phase as well. In this phase, the goals were perceived to be to deliver the specified facility on time and on budget. In order to achieve this, as time and money grew short, various initiatives to cut construction costs were undertaken, seemingly without regard for their future impacts on the operating costs. This was often referred to as "value engineering", a term that was always used derisively. Descriptions seemed to indicate that the decision-making process for an investment (a "line item") was entirely separate from allocation of resources for cost of operations.

The facility ran on a budget, based on costs. Investment decisions were on the level of the total budget, which ran in two-year cycles. Anything with a pay-off of more than two years was therefore difficult to administer. Contrarily, there were stories of the "end-of-money" phenomenon, where money not yet used at the end of a budget period was hastily spent, and, as the story went, not necessarily wisely, because otherwise it would be lost.

There was some interest in reducing energy costs on all levels of management, but without the ability to make investments, there was not a clear path to doing so. An avenue being explored was that of the "Energy Savings Performance Contract", which was a government program in which private contractors could bid for energy performance improving investments. The gain from the investments went to the contractors, however, but the technical

risk of disturbing the process stayed with the facility management staff.

4.6. Environmental management and EMS

The environmental management program document used in the study was dated March 23, 2009, and the system was certified according to ISO 14001:2004. The environmental management system was one of fifteen standard-based management systems in an integrated business management structure. For fiscal year 2010, nineteen EMS objectives were specified, each with a corresponding target.

Certification according to ISO 14001 at SNS (as part of the ORNL system) was seen by respondents to have been pursued for communicative reasons. It was not perceived to have led to any improvement in environmental management or performance. The environmental goals were based on compliance with regulations. The main environmental challenges were perceived to be waste management, including radioactive, hazardous and mixed waste, and control of silt during construction. The extensive management effort to meet these challenges was attributed exclusively to compliance with regulations. Energy use at SNS was not regarded as an environmental issue among the respondents, although both energy use and greenhouse gas emissions were identified as significant aspects in the EMS. In fact, there was a specified goal to reduce energy intensity across ORNL by 30% by 2015.

Transportation to, from and within the facility was predominantly by single occupant cars and small trucks. Respondents identified on-site transportation as an environmental issue that the management was beginning to address by obtaining electric vehicles and bicycles for on-site transportation. Also, a survey on travel habits to learn more about the employees' travel habits and interest in alternatives was in process at the time of this research. These ongoing activities were not identified in conversations as connected to the EMS, but were, in fact, described there. Goals were formulated to reduce use of diesel and to use more biofuel. There were ongoing energy savings activities in other parts of ORNL, but none of these was at SNS. The sizeable electricity use of SNS was not addressed in this context.

A "Sustainable Campus" initiative was in place, which was a campus-wide forum for interested staff to develop and implement sustainability initiatives.

Management success was repeatedly attributed to face-to-face interaction, to high knowledge levels among employees, and to a culture of taking responsibility. Environmental Management relied heavily on knowledge and training. Tasks with serious environmental issues were generally either performed or directly overseen by highly qualified staff.

Toward the end of the investigation period, the top management shared the information that their "customer ", the U.S. government, was interested in seeing a reduction in the carbon footprint of facility operations.

5. Discussion

5.1. Environmental management and EMS

The study presents two strikingly different views of the environmental challenges and management responses. One was described by the interviewed personnel at SNS. In this view, the challenge was compliance and the method was expert handling and one-to-one instruction. The other view was described by the ORNL EMS. Here, challenges included compliance, but also included a full range of issues beyond legal requirements.

In a meaning-based or interpretive view, the organization was given by the group that interacted with such intensity that internally distinct interpretations evolved. The organization was defined as a system of shared meaning. In the studied case, the system of shared meaning seemed to be SNS, a part of the Division for Neutron Science at ORNL. SNS had approximately ten percent of the staff and it is physically separate from the main campus of ORNL. The organizational boundaries for the management system therefore, did not coincide with the organizational unit in a meaning-based perspective.

Nonetheless, the EMS was valid for SNS as well. The EMS was not credited as a driving force for action. This need did not indicate failure. It was not necessary for the success of an EMS that it was identified as such. The personnel may pursue goals and respond to training without reflecting on the system in which they are described. However, it was clear that the greater scope of the EMS did not lead to a broader perspective in the environmentally related work of the respondents. It seemed to be a more plausible explanation of the gap in perspectives that the EMS with its policies, long-term goals and high-level programs was largely irrelevant to the operational staff.

Again, taking the meaning-based view, if the organization was defined as a system of shared meaning, the task of management to organize can be seen as creating and maintaining systems of shared meaning. In the study, the EMS did not noticeably contribute to the creation or maintenance of a system of shared meaning.

The case study revealed another circumstance that seemed to explain why implementation of ISO 14001 might not lead to improved performance. In this case, the use of ISO 14001 was perceived as irrelevant to performance because its implementation neither brought new goals nor new management instruments to attain the existing ones. In this view, ISO 14001 could not cause better performance because the causal relationship between the EMS and performance-enhancing management went the other way. This is an example of one of the problems with studies of environmental management systems and environmental performance described in the literature review presented in Section 2.

The environmental aspects that the respondents were aware of and managed were those directly caused by on-site activity, such as hazardous waste, whereas the significant indirect aspects were ignored, primarily the huge emissions to air and water from the electricity production for the SNS. In this case, actual environmental management activities were always attributed to legal requirements or requirements from the Department of Energy, rather than to the EMS. It therefore, appeared that the focus on direct aspects was a result of the focus on the legal framework.

5.2. Use of goals in management

The Goal theme of attributions seemed to indicate that management's use of goals was effective. In this case, it was one goal at a time for the whole of the SNS facility. No overall ORNL goals were highlighted, nor were there any personal or team goals. This was not a Management By Objectives approach and did not follow the goal breakdown structure described in the ISO systems. It was rather more like the "One Big Hairy Audacious" goal from the popular management literature, especially because the accelerator power goal, put on hold at the time of the study, was an official world record.

5.3. Training/knowledge

Face-to-face interactions were highly valued. This is consistent with the concept of management of meaning; a personal meeting has greater potential of communicating interpretation. It contrasts

slightly with a rationalist view of the firm, where it would be sufficient to present facts. In a Knowledge Management perspective, a personal meeting might communicate tacit knowledge. Early criticism of standard EMS held that "environmental management systems should be fundamentally revised and replaced with more participatory forms of management and organization that push a firm toward a learning organization mode" (Strachan, 1997). In this case, the EMS might have been more effective if it was more participatory and included tacit knowledge, creativity and culture, but education and training are important elements of an EMS. In this case, it may be that the shared awareness of compliance issues in fact was an effect of the EMS, and the corresponding training system, without the respondents identifying this. However, it was also clear that the general training programs were distrusted as vehicles of practically applicable knowledge.

5.4. Interpretation of roles

When the respondents described their work they referred to expectations passed down the management hierarchy. Direct interactions with the line manager seemed to be the main force to form meaning at work. In a meaning-based view of the organization, the organization is defined as a system of shared meaning. In this case, SNS was the organization, the entity in which meaning was collectively formed.

There was a strong culture of compliance. Management showed the importance of compliance by education and training and by allocating specialized resources, such as supplying specialists to handle hazardous waste.

5.5. Energy management and cost control

The observation that one of the main achievements of efforts of energy management was cost reduction by moving, rather than reducing, demand, can serve as an example of how energy management and environmental management can diverge. The case did not generally support the idea that Energy Management might benefit from integration with the EMS, although it was clear that the EMS would have been strengthened by inclusion of energy management objectives.

The case clearly documented that Energy Management greatly and mutually benefited from integrated information systems and by connections to technical diagnostics. The implication was rather that the Environmental Management might benefit from similarly integrated systems for handling other environmental data. The old saying "what gets measured gets managed" was true at the facility, although it is also true in this case as elsewhere that many things must be managed without measurement (Parker, 1998). Particularly, in this case, automated measurement to an integrated data system made effective management possible. Integration of management systems may therefore, have been less important than integration of systems for information and control. In the case of management, in general, this point was made over twenty years ago by Johnson and Kaplan (1987). They observed that accounting systems did not give management access to operational data in other forms than financial and that this warped management.

Recalling early works on Total Cost Assessment and other models of investment calculation (Parker, 1998), this case study clearly showed that such models need to be applied to negative investments, situations where a cost cut is considered, at the expense of increased operating costs, specifically energy consumption. This was a recurring theme in this case study, both regarding laboratory and office facilities and with regard to core activities around the accelerator. In these cases, responsible staff was convinced that cost cuts during construction had led to cost increases that would 'eat up' the construction phase savings in periods of a year or a few years of operation. This may be an issue of particular relevance in governmental projects.

Exacerbating the problem with short-sited savings was the inability to invest on the basis of profitability. This deprived the organization of an important instrument of improvement of performance.

The "end-of-your-money" phenomenon shows how a not-for-profit organization can lack effective cost controls and therefore have less focus on reducing waste. Another important factor in the ability to control waste is proficiency in tracking waste in physical as well as monetary terms, as noted above. Organizations that lack a mechanism to incentivize cost savings and to maximize value added may do well to install such a system internally, perhaps in connection with a Sustainability Management System, as such a system should encompass economic factors as well as social and environmental. Certainly, perceived disincentives for cost savings are important to address for environmental, energy or sustainability management. On the other hand, given that ORNL already had an integrated package of fifteen standardized management systems in place, covering many sustainability issues, it does not seem plausible that an additional management system would be the most effective response.

Integration of standardized energy management would seem to be logical from the management systems perspective in this case. Standardized management systems were the generally preferred management vehicle and energy use was the main concern. From the perspective of the respondents, however, there was no connection. Energy use was managed from a cost perspective, with the focus on scheduling energy use rather than reducing it. The connection was with operations management and cost control.

6. Conclusions and recommendations

6.1. Case-specific conclusions

In order to understand how environmental management with or without an EMS works, and to apply the outcome of this case study to other similar organizations, three research questions were posed. The first research question was: **"What management initiatives inside and outside the EMS were effective in affecting the way the managed employees interpreted their tasks and roles, particularly in relations to issues of the environment and energy?"**

The study showed that the management was effective in using a common organization goal to spread a common sense of purpose. Communication of values through the line of management was effective. Human interactions affected the interpretation of work roles; written policies and procedures were generally not effective.

The organizational scope of the EMS differed significantly from the organizational boundaries found in a meaning-based, i.e. interpretive, view. In the study, the EMS did not noticeably contribute to the creation or maintenance of a system of shared meaning. In a meaning-based view, the EMS did not contribute to improved management.

For management, availability of data was an enabling factor and lack of data a limiting factor. Inability to weigh short and long-term costs was a major limiting factor for effective environmental and energy management.

The second research question was: **"What was the effect of implementing an Environmental Management System on environmental performance?"** The study showed that there was a reality gap between the view expressed in the EMS and the work as interpreted by the respondents. The EMS seemed to have had no effect on the thoughts and behaviors of the personnel, although the results of the study do not exclude the possibility that elements of

the EMS such as education and training had effects that the respondents did not identify.

The case study revealed that the use of ISO 14001, as a whole, in this case was irrelevant to improvements in behavior and performance. Incentives for cost savings and the ability to invest would have meant more for environmental performance than certification. The acts of documenting, formalizing and certifying management initiatives did not add to total effectiveness.

The third research question was: **"How were issues related to energy managed and how was this integrated with the Environmental Management System?"**

The research did not identify any benefits for the energy management from integrating energy management into the formal structure of the EMS. On the contrary, management initiatives outside the EMS structure were no less effective than those described in the EMS.

The research revealed that the collection of operational data at a low-level of detail, into integrated systems for technical diagnostics, control and maintenance may fundamentally enhance the ability to manage energy and environmental issues connected to production.

6.2. General conclusions

The research was undertaken from the background of mixed results from implementation of EMS. The conclusions from the findings point to reasons that some management initiatives were effective, whereas others were not. While there was no reason to believe that this case was unique, neither is there reason to believe that the results were necessarily generally applicable. Generally applicable conclusions require both additional case studies and methodological triangulation, with additional perspectives.

The case-specific conclusions can be used to generate hypotheses for testing in a representative sample. One such hypothesis is that EMS effectiveness improves with the degree of human interaction involved.

Another possibility would be a related hypothesis based on the observation that in this case the organizational boundaries for the management system did not coincide with the organizational unit in a meaning-based view. This hypothesis may be more difficult to test in a large-scale study, as finding the boundaries of the interpretive organization might require case-by-case research, but carefully crafted questions and the use of proxies could mitigate that difficulty.

The importance of human interactions was clearly shown in this case; this revealed the importance of tacit knowledge, as might be expected from a knowledge management perspective. This contrasts with the conclusion on the importance of measurement for management, as well as the importance of a "big hairy audacious goal" for interpreting work. The views contrast but do not necessarily contradict. A degree of complexity is reasonable to expect in models for human interpretation and behavior.

This case study took the perspective of the managed, rather than the managers or the entity, coupled with energy flow analysis as background. The methodology applied was useful in generating new insights into how one implementation of an environmental management systems functioned. The study revealed that an interpretive method is useful in generating understanding of behavior in a meaning-based view of an organization. Further cases studies using similar methods would be productive to generate comparable results and to test the possible general applicability of the method.

References

Ammenberg, J., Hjelm, O., 2002. The connection between environmental management systems and continual environmental performance improvements. Corporate Environmental Strategy 9, 183–192.

Ann, G.E., Zailani, S., Wahid, N.A., 2006. A study on the impact of environmental management system (EMS) certification towards firms' performance in Malaysia. Management of Environmental Quality 17, 73–93.

Annandale, D., Morrison-Saunders, A., Bouma, G., 2004. The impact of voluntary environmental protection instruments on company environmental performance. Business Strategy and the Environment 13, 1–12.

Anton, W.R.Q., Deltas, G., Khanna, M., 2004. Incentives for environmental self-regulation and implications for environmental performance. Journal of Environmental Economics and Management 48, 632–654.

Arimura, T.H., Hibiki, A., Katayama, H., 2008. Is a voluntary approach an effective environmental policy instrument? Journal of Environmental Economics and Management 55, 281–295.

Balzarova, M.A., Castka, P., 2008. Underlying mechanisms in the maintenance of ISO 14001 environmental management system. Journal of Cleaner Production 16, 1949–1957.

Cassell, C., Symon, G., 2004. Essential Guide to Qualitative Methods in Organizational Research. SAGE Publications, London.

Coffey, A., Atkinson, P., 1996. Making Sense of Qualitative Data Complementary Research Strategies. Sage, Thousand Oaks.

Dahlström, K., Howes, C., Leinster, P., Skea, J., 2003. Environmental management systems and company performance: assessing the case for extending risk-based regulation. European Environment 13, 187–203.

Florida, R., Davison, D., 2001. Gaining from green management: environmental systems inside and outside the factory. California Management Review 43, 64–85.

Herreborg Jørgensen, T., 2000. Environmental management systems and organizational change. Eco-management and Auditing 7, 60–66.

Hertin, J., Berkhout, F., Wagner, M., Tyteca, D., 2008. Are EMS environmentally effective? the link between environmental management systems and environmental performance in European companies. Journal of Environmental Planning and Management 51, 259.

Jasch, C., 2000. Environmental performance evaluation and indicators. Journal of Cleaner Production 8, 79–88.

Johnson, T.H., Kaplan, R.S., 1987. Relevance Lost the Rise and Fall of Management Accounting. Harvard Business School Press, Boston MA.

Konnola, T., Unruh, G.C., 2007. Really changing the course: the limitations of environmental management systems for innovation. Business Strategy and the Environment 16, 525–537.

Mac, A., 2002. When firms make sense of environmental agendas of society. Journal of Cleaner Production 10, 259–269.

Miles, M., Huberman, M.E., 1994. Qualitative Data Analysis an Expanded Sourcebook, second ed. Sage, Thousand Oaks CA.

Mintzberg, H., Waters, J.A., 1985. Of strategies, deliberate and emergent. Strategic Management Journal 6, 257–273.

Morgan, G., 2006. Images of Organization. Sage Publications, Thousand Oaks, California.

Morgan, G., Smircich, L., 1980. The case for qualitative research. Academy of Management Review 5, 491–501.

Nawrocka, D., Parker, T., 2009. Finding the connection: environmental management systems and environmental performance. Journal of Cleaner Production 17, 601–607.

Palm, J., Thollander, P., 2010. An interdisciplinary perspective on industrial energy efficiency. Applied Energy 87, 3255–3261.

Parker, T., 1998. Total Cost Indicators – Operational Performance Indicators for Managing Environmental Efficiency. IIIEE Dissertations. International Institute of Industrial Environmental Economics, Lund.

Potoski, M., Prakash, A., 2005. Covenants with weak Swords: ISO 14001 and facilities' environmental performance. Journal of Policy Analysis and Management 24 (4), 745–769.

Quinn, J.B., 1992. Intelligent Enterprise. Macmillan, New York.

Rondinelli, D., Vastag, G., 2000. Panacea, common sense, or just a label? the value of ISO 14001 environmental management systems. European Management Journal 18, 499–510.

Silvester, J., 2004. Attributional coding. In: Essential Guide to Qualitative Methods in Organizational Research. Sage, pp. 228–241.

Smircich, L., Stubbart, C., 1985. Strategic management in an enacted world. Academy of management. The Academy of Management Review 10, 724–737.

Sroufe, R., 2003. Effects of environmental management systems on environmental management practices and operations. Production and Operations Management 12, 416–431.

Steger, U., 2000. Environmental management systems: empirical evidence and further perspectives. European Management Journal 18, 22–37.

Strachan, P., 1997. Should environmental management standards be a mechanistic control system or a framework for learning? The Learning Organization 4, 10–17.

Thollander, P., Dotzauer, E., 2010. An energy efficiency program for Swedish industrial small- and medium-sized enterprises. Journal of Cleaner Production 18, 1339–1346.

Thollander, P., Ottosson, M., 2010. Energy management practices in Swedish energy-intensive industries. Journal of Cleaner Production 18, 1125–1133.

Weick, Karl E., 1979. The Social Psychology of Organizing, second ed. McGraw Hill, London.

Weick, Karl E., 1995. Sensemaking in Organizations. Sage Publications, London.

Zobel, T., 2008. Characterisation of environmental policy implementation in an EMS context: a multiple-case study in Sweden. Journal of Cleaner Production 16, 37–51.

Appendix 3

The “sustainable Energy Concept”

Making Sense of Norms and Co-Evolution within a Research Facility’s Energy Strategy

Philip C. Peck and Thomas I. Parker

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The 'Sustainable Energy Concept' – making sense of norms and co-evolution within a large research facility's energy strategy

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ABSTRACT

The analysis presents an evolving 'Energy Concept' and strategy at an energy-intensive research facility in order to contribute understanding of how organisations may implement renewable energies and improve energy efficiency whilst also delivering broader socio-economic benefits. A framework is developed that infuses institutional perspectives with a micro level view. It facilitates positioning of strategy against instrumental/altruistic and factual/relational extremes and analysis of organisational strategy in the face of internal/external stakeholder, and institutional forces. Applied to a seven-year case this supports understanding of strategy 'purpose' and 'inputs' as they co-evolve along a project time-line. It is found that the energy strategy evolves from a dominantly instrumental but stakeholder-driven position towards approaches aligned with deliberate public good provision in areas beyond direct organizational interests, and that changes required significant redefinition of the design and operational models. Developments are explained as largely the result of internal agency and culture-building influences from an energy department equipped with concrete management tools and autonomy. At the case level, the study concludes that the Energy Concept implementation has sparked a change in energy management at large global research facilities. The work also demonstrates that longitudinal, multi-level institutional analysis can contribute to deeper understanding of strategy development.

1. Introduction

Population and economic growth pose ever increasing challenges for resource availability and environmental quality (Gerland et al., 2014), while climate change constitutes both a serious threat to human well-being and a difficult policy challenge (IPCC, 2014). In turn, energy consumption plays a pivotal role within both resource consumption and climate change (Chu and Majumdar, 2012). Reflecting such concerns, the European Council agreed a new 2030 policy framework with targets in these areas in 2014 (European Council, 2014). Across the EU, these require collective reductions (from 1990 figures) of 40% for greenhouse emissions and at least 27% gains in renewable energy and energy efficiency. Considering that the infrastructure to produce and distribute energy and the industrial production infrastructure that consumes much of it are long-lived, these percentages indicate a level of change that is dramatic. It is not enough that new stock reflects the percentage reductions listed in targets, as averages across entire economies must be reduced. We interpret that this will require combinations of (increasingly) higher efficiency, near 100% carbon free energy supply, and energy recycling.

Indeed, it is considered that we are at a pivotal point of deep change for our energy systems. Around the world, large utilities are rewriting business models, the manner of grid operation is changing rapidly, and renewable and variable generation sources are comprising larger portions of the energy mix (Beckman, 2013; World Energy Council, 2015). This "new energy reality" (Beckman, 2013) is also creates markedly increased volatility in energy markets (World Energy Council, 2015). Logically, industrial and public investments with high-energy footprints and long lifespans will be particularly exposed to such developments.

In this analysis we examine the development of a multipartite European public investment in a large science Research Infrastructure (RI) facility named the European Spallation Source (ESS). As of 2015, it is under construction in Lund, Sweden and will be collectively owned by 17 partner countries. Costing some 1.85 billion euros, it is projected to come online in 2019. Prior to project start, an energy system concept was presented that helped

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differentiate a Scandinavian bid for the ESS placement (European Spallation Source Scandinavia Secretariat, 2008). The article presents a case description, and an analysis of how the energy strategy for the ESS developed over a seven-year period (2008–2015).

Titled the 'Energy Concept' it promised a number of social and environmental benefits but the means to achieve these ends reach far beyond that which could be considered 'established norms' within similar organisations (cf. Hallonsten, 2012; Kaiserfeld and O'Dell, 2013). Such include the building of formal 'energy culture'; improved energy efficiency; 100% renewable sources; and the recycling of waste heat (European Spallation Source Scandinavia Secretariat, 2008).

However, the manner in which the ESS departs from established RI morphology, technical function and operational praxis, may pose challenges for the organisation. Both internal management goals, and external public expectations (including censure) play an important role in how organizations behave. Many leaders of organizations, be they public or private, recognize the importance of operating so as to achieve or maintain a 'social licence' and the conditions expected by 'social licensers' may be considerably more demanding that those imposed by regulation (Gunningham et al., 2002). On the one hand, demands from social actors for reduced resource consumption, and reduced carbon footprints are escalating (cf. Lilja, 2009; While et al., 2010) as part of this social licence. However, on the other hand, such efforts will increase technical and management complexity, create new resource dependencies with external parties, and require an organisation to perform against non-traditional goals. When viewed from institutional and resource dependency perspectives (cf. Oliver, 1991) this can be expected to generate institutional tensions within the organisation across a range of circumstances.

Consequently, this analysis examines how approaches, capacities, and norms emerged – and how strategic context evolved – as the ESS worked to achieve the project and its Energy Concept. The framework developed to structure analysis also contributes to knowledge of strategy emergence and evolution as management priorities shift along the life cycle of a project to conceptualise, design and build an energy system. From a broad perspective, the analysis addresses efforts by an organisation to ameliorate its contribution to environmental crises that result from humankind's "extract, expend and expel" resource use pathways (Connelly, 2001). Thus, the discussion addresses contexts well beyond RIs and is relevant to wider audiences. Similar challenges are shared by other energy intensive facilities that pursue environmentally oriented management strategies with intent to deliver private and public goods.

Regarding "expend and expel" resource use patterns, this work is relevant where efforts are being made to retrofit industrial systems so that society can benefit from systemic energy efficiency (cf. Dovì et al., 2009; Majozi, 2009; Worrell et al., 2009). Regarding public good provision via work that extends beyond the direct interests of the organisation, this analysis aligns with the precepts of Corporate Social Responsibility (CSR) efforts (McWilliams and Siegel, 2001; cf. McWilliams et al., 2006).

Three interlinked areas are given special consideration in this article. The first concerns the basis for energy strategy development. This is a complex issue for energy intensive facilities that must address matters such as price volatility, climate discourse evolution, public opinion and policy shifts, and dynamics in security of supply concerns (Tan et al., 2009; World Energy Council, 2015). The second concerns how management mind-sets, accountability, agency, and priority setting can change along a project life cycle, and how such factors affect energy strategy evolution and implementation. The third theme relates to technical management issues; and how they are related to the norms and/or behaviour of actors in both traditional and newly created management roles. This area is especially affected by energy quality considerations, energy recycling opportunities and the increased management complexity that delivery of an energy strategy for the future may entail.

Key audiences can include practitioners involved with technical ventures requiring large amounts of energy (e.g. in the RI field and in energy intensive industries), researchers studying such efforts, and analysts in the field of social and organizational change. This work provides the first two groups a detail rich longitudinal case that provides insights into how proponents of clean and efficient energy systems may be empowered to achieve far-reaching change, and how the political economy of energy initiatives can change markedly through a project life cycle. It provides the latter group a framework for analysis of the interaction of organisational strategy and management, different interest groups within the organisations, broader institutional forces, and stakeholder influence as they co-evolve along a project time-line. Although policymakers and others with a desire to steer industrial energy strategy are not a primary target group, the analysis of how strategy develops – and the role of policy within such development will be pertinent to such actors.

1.1. Case study background

In 2003, after more than a decade of advocacy and lobbying by organisations such as the European Neutron Scattering Association (ENSA),[1] a design concept was adopted for a neutron source research facility heralded as the most ambitious and broad-based spallation source in the world – the European Spallation Source (ESS). The ESS is to support a diverse range of methods to extract subtle information about the properties and behaviour of many materials.[2] Spallation involves the displacement of neutrons from atomic nuclei using a particle accelerator to generate a neutron stream that in turn is directed at materials being researched. Measuring 'neutron scattering' when the neutrons interact with substances is vital for the development of materials and products across many technological fields: fuel cells; superconductors; structural engineering, transportation, and food technologies; pharmaceuticals; medical devices, and clean, or low carbon electricity or heat technologies. In this way, many scientists see "quality of life" in modern society as inextricably linked to the research outputs of a spallation source (OECD, 1998). The ESS is expected to employ some 450 staff and support a 5000 strong user community. Between 2000 and 3000 scientific-user visits will be hosted each year.

Fig. 1 provides an overview of the operational sequence for the ESS: acceleration of protons in a half kilometre linear 5 MW accelerator (1,2); the 'spallation' of neutrons from a tungsten target (3), neutron scattering and measurement processes in 22 (planned) instruments (4,5,6) and research data management (7).

In the period 2003–2008, a competitive European selection process played out that left three locations vying for the project: Lund, Sweden; Debrecen, Hungary; and Bilbao, Spain. Lund was chosen as the preferred site in May 2009. Central to this discussion is that the theme of 'sustainability', particularly related to energy issues figured significantly in the Scandinavian[3] proposal. 'Sustainability' themes were used to differentiate the Swedish project

[1] ENSA is an affiliation of national neutron scattering societies and committees that facilitates discussion and action. See http://neutronsources.org/neutron-centres/europe/ensa.html.

[2] Neutron scattering enables the study the structure and dynamics of atoms and molecules over an enormous range of distances and times: from micrometres to tenths of nanometres, and from milliseconds to picoseconds. Neutron scattering provides a unique combination of structural and dynamic information.

[3] Only Sweden and Denmark were represented in "Scandinavia", although Norway was part of the promised financing. Sweden hosts the spallation source research facility, while Denmark will host the data management centre.

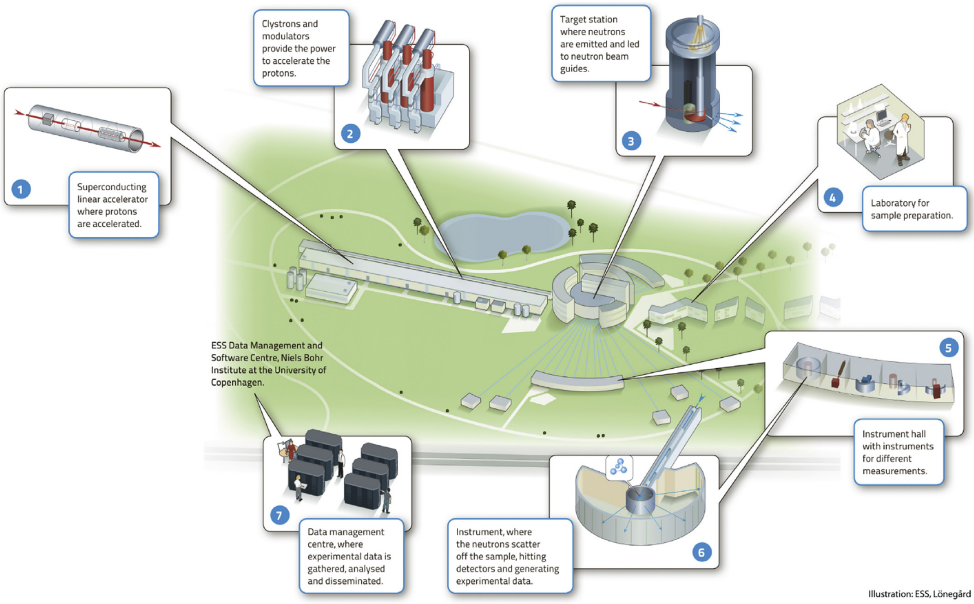

Fig. 1. Schematic overview of the proposed European Spallation Source (ESS) (ESS AB, 2011).

bid (Malm et al., 2008); to garner support in the host countries, and to defuse concerns/pre-empt opposition in the host community (Agrell, 2012, p. 199).

A new form and function for the ESS energy system was conceptualised to deliver environmental benefits not usually associated with such facilities. The measures would also interlink with local infrastructure and economic activities to provide additional socio-economic benefits to the host community; again in ways normally unrelated to the realm of neutron based scientific research.

Specific undertakings in *The ESS Scandinavia submission to the ESFRI Working Group on ESS siting (2008)* included:

- achieve a "*climate neutral facility*";
- "*purchase sufficient wind generating capacity to cover the integrated annual electricity use of the ESS*";
- "*maximally*" recycle into the Lund's district heating and "*avoid the need for cooling towers*";
- "*reduce the load to 35 MW or lower (270 GWh p. a. or lower)*";
- "*achieve the control of energy use and the implementation of an energy culture*";
- create an energy inventory as "*the central tool in this culture*";
- apply an organisational structure where"*an Energy Manager will be a member of the ESS Scandinavia Management team from the outset*".

Pursuant to these, the project defined a 'sustainable energy' concept comprised of three distinct energy-related targets as their standard communication. Against a reference case from 2008 (350 GWh power consumption, no energy recycling, energy dissipation via cooling towers, and standard grid electricity), it was promised that the system would be:

- RESPONSIBLE – achieving 20 per cent reduction[4] in energy consumption,
- RENEWABLE – with 100 per cent utilisation of renewable energy,
- RECYCLABLE – with 60% of the utilised energy being recovered and recycled.

1.2. Problem definition

The 'base case' against which the Lund ESS Energy Concept is compared is the 2003 definition of a new spallation source for Europe produced for the ESS Council (Bohn et al., 2003). We consider this representative of standard practice for large scale accelerator facilities at the time of project commencement. The Energy Concept as a whole, and its energy 'recycling' components in particular, constitutes a significant departure from the technical systems delineated in that report. As the ESS energy system is inextricably and critically linked to the entire process of neutron science, the promises place new demands upon the management of an already complex task to realise the ESS project.

Importantly, undertakings to recover, and recycle rather than expel energy require a range of technical changes. This demands the replacement of a standard cooling concept with a permanent link to a more complex and dynamic system – a city's district heating system. Achieving ESS energy targets also demands new forms of inter- and co-dependency with the surrounding

[4] The target for the first goal was worded inconsistently throughout the project, eventually arriving at a target of 270 GWh or less in the Energy Policy of June 2013.

infrastructure systems and activities. These are akin to those described within the concept of Industrial Symbiosis (cf. Chertow, 2000).

However, Sagar and Frosch (1997) indicate challenges with such arrangements. Reflecting upon Kalundborg in Denmark, long seen as a seminal example of resource and energy efficiency efforts achieved by linking industrial facilities to utilize waste materials and heat (Ehrenfeld and Chertow, 2002; Jacobsen, 2006), they argue that 'flexible and dynamic' industrial ecosystems:

> … *are not captured in the 'industrial symbiotic' model such as the one at Kalundborg, which seems to have developed locked-in, rigid relationships by virtue of the process by which that systems grew (e.g. the appearance of hard-piped connections between firms that are specifically designed to use particular wastes/outputs from other firms).*

They hold that 'hard-piped' links and locked in inter-dependencies, such as those defined in the ESS Energy Concept, can be technically, financially, or operationally problematical in the long run, as the evolved design is based on a static optimisation that can be both difficult and expensive to adapt to new market conditions.

The interlinkages with other actors required by the Energy Concept thus also appear likely to introduce uncertainty, complexity, and risk (cf. Kleineidam et al., 2000; Lambert and Boons, 2002, p. 476). When compared to the 'base case', an initiative demanding new resource dependencies can be anticipated to: increase the number of stakeholders the organisation is beholden to; 'lock-in' a number of such dependencies; demand management effort outside traditional science-based areas of operation, recognition and reward; increase its external dependence on stakeholders, reduce management discretionary power and expose an organisation to new types of institutional goals and requirements. Oliver (1991) suggests that such changes can be expected to stimulate varying degrees of active resistance.

We note however, that the phenomena present within this case span several areas of theoretical discernment and a particular theoretical perspective is difficult to elucidate in the first instance; a situation where a specific case can be useful (Eisenhardt, 1989). Case study methodologies have been used on numerous occasions to build from a position where preordained theoretical perspectives are absent or where a number of potentially important variables need to be identified utilizing extant literature, without being bound to certain theoretical perspectives at the outset of the work (cf. Eisenhardt, 1989). A number of perspectives we see as relevant to this work are briefly introduced below.

At the start of the project, the ESS can be seen to be largely a 'paper entity' that is enfolded, and thus defined to some extent, by an existing institutional field at a macro-level (DiMaggio and Powell, 1983); that of RIs. Within this field, efforts to conform to a range of social norms and expectations can be anticipated (Baum and Oliver, 1991; DiMaggio and Powell, 1983). A guiding logic being that the organization will need to conform to the rules and belief systems prevailing in the environment if it is to be successful in its field (DiMaggio and Powell, 1983; Meyer and Rowan, 1977).

However, while the institutional field exists at a macro-level (Powell and Colyvas, 2008), the ESS is yet to build an organisation within it. At project start, the ESS exists as a small project team facing a reality that it will need to grow to many hundreds of employees, establish management structures and routines, and presumably build an 'identity' or 'accepted mental models' (Weick, 1979a,b). An appropriate model to view organisational cultural processes at this higher level of resolution is 'sensemaking' (Weick, 1979a,b, 1995) which examines how people enact order and coordinate action, convert circumstances into action through the reciprocal interpretation of who they are, and understand their environment. Identity, the enacted world, and accepted mental models are all key to this perspective (Weick, 1995). Importantly considering the existence of an established institutional field, such phenomena exist as a micro-level processes that can link with 'macro-processes of institutionalization' (Powell and Colyvas, 2008). Moreover, insights can also be drawn from this area to more explicitly account for how organisational actors make sense of, and enact, technology systems within their local context (cf. Jensen et al., 2009).

As noted, the project start-up phase has defined situations where the organization has undertaken to provide social goods in areas that appear to lie outside the direct interests of the operation of the research facility. This can be seen as a parallel to behaviour from a corporate entity that engages in CSR; namely 'actions that appear to further some social good, beyond the interests of the firm and that which is required by law' (McWilliams and Siegel, 2001; McWilliams et al., 2006). Here, an appropriate lens is provided by Stakeholder Theory (SHT); as the ends of cooperative activity and the means of achieving these ends are critically examined in SHT in a way that they are not in many theories of strategic management (Phillips et al., 2003). Further, the importance of attention to the interests and well-being of those who can assist or hinder the achievement of the organization's objectives is the "central admonition of the theory" (Phillips et al., 2003, p. 481).

Another aspect of potential importance is that the project was given a timeline of at least a decade before it would operate. Emergent co-evolution of the stakeholder identity and the project over time must be anticipated (Eskerod and Vaagaasar, 2014; Missonier and Loufrani-Fedida, 2014). Related to this longitudinal issue, others (cf. Parmar et al., 2010) call for improved insights into how organisations manage stakeholder relationships over time.

Pursuant to the issues above we present a case that can contribute deeper understanding of how organisations, particularly those responsible for energy intensive facilities, may pursue strategies for increased implementation of renewable energies and improved energy efficiency.

1.3. Purpose and line of inquiry

This work examines how the Energy Concept work developed and then scrutinizes implications for broader management and institutional change. Its purpose is to contribute to understanding of how organisations can pursue strategies for more widespread implementation of renewable energies and improved energy efficiency whilst also delivering ancillary benefits. The context includes situations where internal and external stakeholder relationships and interdependencies co-evolve over time in an energy intensive facility. Within this, there is particular interest in examination of three lines of inquiry:

- how the ESS Energy Concept has developed over time;
- the rationale behind various stages of the evolving strategy, particularly the interaction between the strategy, the management and the organisation;
- implications the Energy Concept development might have for strategy and management in the broader RI field and in energy-intensive industry.

1.4. Scope and limitations

This study examines the development of strategy for energy efficiency and renewable energy, in a research infrastructure

project. While it is held that the ESS context is shared by other organisations, and that the work should be relevant to several audiences, a number of limitations exist.

Firstly, while the interaction of strategy with organisation and management are examined in some detail, and the fact that an energy team with discretional power was formed is important to the case, the processes of management are not examined in detail.

A second item lies with the use of term 'sustainability'. Reference to this concept is unavoidable in that it has been applied in ESS communications throughout the project. In general it has been applied in a fashion similar to that presented by the Swedish consortium bidding for the project where they referred to as a "*vision of a sustainable research facility*". (ESS AB et al., 2013). The ESS presented their energy concept and energy strategy as efforts that would "*contribute greatly to the sustainability of the facility*" (ESS AB, 2012). This work however, does not seek to examine the applicability of the term in this context, its scope of use or meaning in society, or how application may have changed over time within the project. Nor is it the intent to communicate that a sustainable solution has been achieved. Further, this analysis focuses principally upon energy related issues and does not examine the contribution of the facility and its research outputs to 'sustainable development', nor any potentially negative aspects that may be related to its conduct of business.

A third area of simplification and limitation lies in the technical sphere. Technical parameters and issues are examined only to the extent that they impinge directly on the implementation of the strategy or serve as simple examples. This leaves many phenomena-rich issues aside.

2. Method, materials, and analytical approach

This section presents the development of a framework that supports improved understanding of how strategy is conceived, and develops over time, as the organisation interacts with its business environment.

2.1. Theoretical perspectives

Within this sub-section, we juxtapose different perspectives regarding the nature of the forces acting on the organisation, and the nature of the responses to such stimuli, at different times along the project life cycle. While a "deliberate strategy" seeks to guide this interaction; an "emergent strategy" develops from the same interaction (Mintzberg et al., 1998). In either case the strategy and the organisation interact via management. It is that interaction that is the focus of investigation here.

2.1.1. Stakeholder issues

Regarding strategic management of stakeholder issues during the bid process, a political science analyst Agrell (2012, p. 199) wrote the following regarding the strategic arguments posed by the ESS:

> *The wider domestic context presented the ESS proponents with a dual challenge. Firstly, they had, as all proponents of costly large-scale research projects or facilities, to find simple convincing arguments to influence decision makers and interest groups that materially would influence the outcome. However, the proponents also had to consider the necessity of wider popular support, or at least acceptance, given the considerable resource that would be spent on the facility and the local and regional impact. … Secondly, the proponents had to counter, or as it turned out, largely pre-empt, criticism concerning waste of research resources, negative environmental impact, and unforeseen risk in a complex and untried facility.*

As the Energy Concept requires involvement with a range of external stakeholders that 'normally' may be much less involved in such a project, the undertakings related to the 'sustainability efforts' expose the organisation to new stakeholder interdependencies. The presence of (normally) external stakeholders as new important actors for the ESS, introduces a new facet to the complexity mentioned above, aspects of which can be elucidated using SHT.

SHT is distinct because it addresses morals and values explicitly as a central feature of managing organizations. Thus, managing for stakeholders involves attention to more than simply maximizing benefits to owners. The ends of cooperative activity and the means of achieving these ends are critically examined in SHT in a way that they are not in many theories of strategic management (Phillips et al., 2003). Attention to the interests and well-being of those who can assist or hinder the achievement of the organization's objectives is the "central admonition of the theory" (Phillips et al., 2003, p. 481). Thus SHT places much more explicit focus on other parties involved.

Following the importance of stakeholders to this case, we see CSR as situations where an organisation goes beyond compliance and engages in 'actions that appear to further some social good, beyond the interests of the firm and that which is required by law' (McWilliams and Siegel, 2001; McWilliams et al., 2006). These authors hold that SHT is the dominant paradigm of CSR. As the undertakings in the Energy Concept indicate explicit intent to deliver social goods beyond the direct interests of a neutron science facility, it has strong parallels with stakeholder focused CSR. Reflecting the relevance of stakeholders, this analysis draws on one of the most influential (dyadic) perspectives in SHT (the stakeholder identification and salience framework of Mitchell et al. (1997)).

2.1.2. Evolution of stakeholder issues and institutional issues over time

Most projects to deliver large pieces of societal infrastructure are conceived and built over a considerable length of time. However project management literature in particular indicates that management applications of stakeholder perspectives to projects inadequately account for dynamic and on-going (longitudinal) processes (Eskerod and Vaagaasar, 2014). Related to this longitudinal issue, Shropshire and Hillman (2007) note significant intra-firm variability in stakeholder management across project-time, while others (cf. Parmar et al., 2010) call for improved insights into how organisations manage stakeholder relationships over time. Analysts also point out that many stakeholder assessments overlook phenomena such as the emergent co-evolution of the stakeholder identity and a project over time (Missonier and Loufrani-Fedida, 2014). As the Energy Concept appears strongly coupled to stakeholder issues and develops over a significant period, longitudinal co-evolution of the Energy Concept and stakeholder issues is relevant. Further, as evidence of both external and internal pressures on management priority setting are present, it is useful if analysis encompasses categories of normative (e.g. internal and connected) stakeholders and derivative (external) stakeholders (Phillips et al., 2003, p. 489).

In order to account for institutional issues over time, this work infuses aspects of both SHT and institutional theory. While authorities such as Freeman et al. (2010) note that SHT and institutional theory are not traditionally used together, they state (2010, pp. 151–152) that SHT and institutional theory are conceptually

similar and that many opportunities exist to utilise these together. Indeed, they refer to work by Campbell (2007) where the relationship between economic conditions and organisational behaviour is affected by a range of institutional conditions. These include: public and private regulation, institutionalized norms for appropriate organisational behaviour, associative behaviour among organisations, and organized dialogues among such bodies and their stakeholders; aspects of which all appear within this case.

2.1.3. Institutional and resource dependency issues

Viewing the ESS context from institutional and resource dependency theory perspectives, we start with the importance of the socio-political context of the ESS project, and the need to satisfy the expectations of a number of different constituencies. Institutional theory (IT) examines the influence of the institutional environment on organizations. With emphasis generally on conformance to social norms and expectations (Baum and Oliver, 1991; DiMaggio and Powell, 1983) with a guiding logic that organisations must conform to the rules and belief systems prevailing in the environment to survive (DiMaggio and Powell, 1983; Meyer and Rowan, 1977). Oliver (1991) infused IT with resource dependency perspectives and delineated conditions where organisations may employ strategic behaviours as direct responses to institutional processes toward conformity – predicting a range of different organizational responses depending upon the nature of pressures. She posits that increases in demands or pressures imposed on an organisation, such as discretionary constraints; constituent multiplicity; external dependence on constituents; and inconsistency with traditional organisational goals will likely increase organisational resistance. The validity of these views has been strengthened in a number of ensuing studies (Bansal and Roth, 2000; Hoskisson et al., 2000).

2.1.4. From institutional to internal cultural scales

Undertakings in the Lund ESS bid required that an ESS energy culture be created, implying that 'energy norms' within the ESS were to emerge and grow within the new organisation, and then increase in strength so as to influence processes. However, there is considerable evidence (cf. Oliver, 1991; Suchman, 1995) that a range of institutional and cultural issues would be encountered if actors within a relatively limited part of an organisation were to seek to build and maintain an entirely new form of internal (energy) culture, and impose aspects of it upon the organisation.

The concept of Sensemaking (Weick, 1979, 1995) appears as an appropriate model to describe sociocultural forces that affect how an organisation interprets a socially focused agenda (Mac, 2002) such as the Energy Concept. It describes a process in which members of an organisation in a collective process create a shared understanding of the organisation, its environment and purpose (Weick, 1979a,b, 1995). Relevant to this case, sensemaking has also been used to describe and analyse processes of implementing CSR (van der Heijden et al., 2010) and to investigate the effectiveness of environmental management as it develops at an RI (Parker, 2013). Phenomenological studies sharing the same philosophy have also been used investigate broader environmental and sustainability management (cf. Balzarova and Castka, 2008; Mac, 2002).

Importantly considering that the ESS was called for, and financed, by high level actors embedded in an established institutional field, Sensemaking can be also be directly coupled to institutional theory:

> *Firms derive meaning through communicative processes and experiences, through relations and expectations. These sensemaking processes indicate that firm's experiences, its relations to other actors and its expectations are quite decisive for the concrete interpretation and management. The overall interest in the new-institutional theory is how phenomena become problems and how the understanding of problems turns into regulative, normative and cognitive structures* (Mac, 2002).

Sensemaking can thus enrich higher level institutional perspectives and can more explicitly account for how organisational actors make sense of and enact the technology oriented Energy Concept in their local context (cf. Jensen et al., 2009; Powell and Colyvas, 2008). As different parts of this case span over the organisational field, the organisational/group, and individual/socio-cognitive levels, a combination of the two theoretical perspectives facilitates a much richer interpretation by linking macro- and micro-levels of analysis (Jensen et al., 2009). Powell and Colyvas reinforce this view; they argue that many micro-processes represent local instantiations of macro-level trends, and thus sensemaking, as a 'micro-concept' links with 'macro-processes of institutionalization'.

> "*Institutions are sustained, altered, and extinguished as they are enacted by individuals in concrete social situations*" (Powell and Colyvas, 2008).

2.2. Analytical framework

Fig. 2 shows the framework for analysis of strategy positioning created to support this analysis. Descriptive phrases for dominant strategy inputs are provided for each extreme on the axes. Sections 2.2.1 and 2.2.2 provide details of the guiding logic and theory.

The vertical axis represents a continuum between extremes we describe as *factual* and *relational*. Labelled the *input* axis, it indicates how the entity understands and interprets the outside world based upon the types of input that influences those who formulate or enact strategy. Thus, it portrays the dominant input to decision-making and describes 'who or what decision-makers are listening for'.

The horizontal axis shifts focus from the content of decision calculi in-data to how an organisation perceives its purpose in relation to stakeholders. Benefits, and to whom one perceives one should deliver benefits to, are central to decision-makers. This axis represents a continuum between extremes we describe as *instrumental* and *altruistic* and is labelled the *purpose* axis.

2.2.1. Vertical axis: a factual/relational continuum

The *relational* extreme is inspired by modern SHT (cf. Laplume et al., 2008) pursuant to Freeman (1984). Freeman drew upon works in the areas of strategic management, corporate planning, systems theory, organization theory, and corporate social responsibility to help identify and model the groups that are stakeholders of a corporation (Freeman and McVea, 2001). SHT both describes and recommends methods by which management can give due regard to the interests of those groups.

At this *relational* extreme, stakeholders are deemed to have dominant influence on the success (or failure) of projects. Decisions are strongly influenced by behavioural science, or by views shaped by ethics, values, morals, and norms. An important difference in application of SHT concepts here is that this analysis portrays the relative importance of stakeholder relations for decision calculi, juxtaposed to 'factual' evidence available from the 'natural sciences' (cf. Sackett et al., 1997). A decision-maker at this extreme would believe that successful project delivery is strongly influenced by the appropriateness of interactions between stakeholders. From this view we extract the key norm descriptions as shown at the top of Fig. 3.

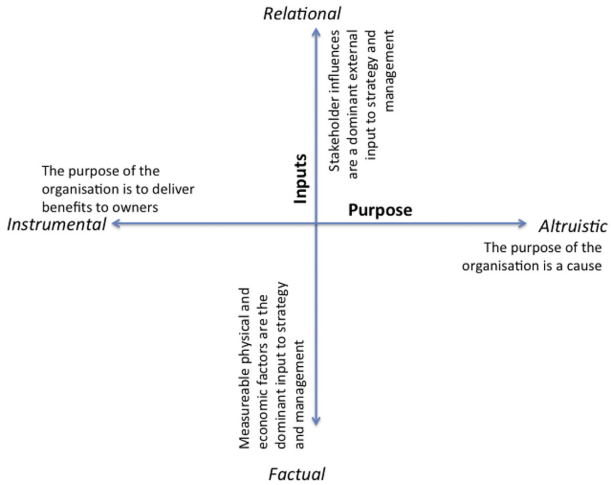

Fig. 2. Framework for analysis of key strategy drivers.

The *factual* extreme represents processes where decision-makers consider that project delivery is dominantly influenced by directly observable and measurable scientific evidence understood in terms of norms from the natural sciences (Sackett et al., 1997). Decision-making at this extreme would treat 'evidence' and 'scientific method' as if they were neutral, value-free descriptions (Morell, 2008) and would make limited use of behavioural science evidence base (Refer to Pfeffer and Sutton, 2006; Rousseau, 2006; Walshe and Rundall, 2001 for discussions in the context of a related area, Evidence Based Management). From this view we extract, key norm descriptions as shown at the bottom of Fig. 3.

2.2.2. Horizontal axis: an instrumental/altruistic continuum

The *instrumental* extreme draws upon the basic precepts of instrumentality reflecting the perspective that the only obligation of an organisation is to maximize benefits for its shareholders via provision of goods and services that meet the needs of its customers (Friedman, 1970). An instrumental view is described to the left in Fig. 3.

The *altruistic* extreme represents a perspective where CSR is a valid approach for management (R.E. Freeman, 1984), and we see implementation activities that go beyond compliance and engage in "actions that appear to further some social good, beyond the interests of the firm and that which is required by law" (cf. Lantos and Cooke, 2003 for discussion of various positions). Here responsibilities are extended actively to non-owner interests and would not be classified as privately responsible as delineated by Friedman (cf. Friedman, 1970). Special attention is given to the manner in which management actors in the organization attach value to, and pursue, the Energy Concept's capacity to deliver positive external environmental and socio-economic benefits (a.k.a. 'ancillary benefits'). Following the logic that shifting from proven technical systems and management models to accommodate the Energy Concept introduces additional complexity and risk, we hold that an important metric of 'attaching value' is the degree to which represents the management appears willing to bear risk, or contingent costs associated with new activities, in order to deliver such ancillary benefits. For this analysis, it is chosen to delineate the extreme as encompassing purposeful action where the organisation engages in activities that are non-beneficial – and even incurring contingent or real costs – in order to benefit others – as shown at the right of Fig. 3.

3. The ESS and its sustainable energy concept

An important factor underlying Lund's (and Scandinavia's) winning bid was the vision presented for a sustainable research facility (ESS AB et al., 2011). Lund's ESS contrasted markedly with the other spallation facility design proposals, and with established accelerator facilities.

In 2013 the (then) Managing Director of the ESS reflected on the process of preparing for the bid (ESS AB et al., 2013):

> *Facilities like ESS would, in the future, enable scientists to understand and create new materials that in turn would ensure future products left a smaller environmental impact than products of the day.*
>
> *Less thought however, had been given, on how to power research facilities, since they will actually need large amounts of electricity. If we connect them to the electrical grid without considering the source of the power, and if we just vent their waste heat out in the air or into water, a serious paradox appears: meeting the need for new and better products with increased air pollution and CO_2 emissions would clearly contradict the aim of the science performed at the research facilities.*

The proposal's Energy Concept pledged an operational model that reduced greenhouse gas emissions, wastage of useful energy, and exposure to electricity price and supply volatility. It also identified a number of areas where socio-economic gains could be leveraged, and stressed the importance of sustainability commitments within the 2009 siting decision (ESS AB et al., 2013):

> *One factor underlying Scandinavia's winning bid was the city's vision of a sustainable research facility. In contrast to other research facilities – and previous ESS design proposals, ESS Scandinavia had*

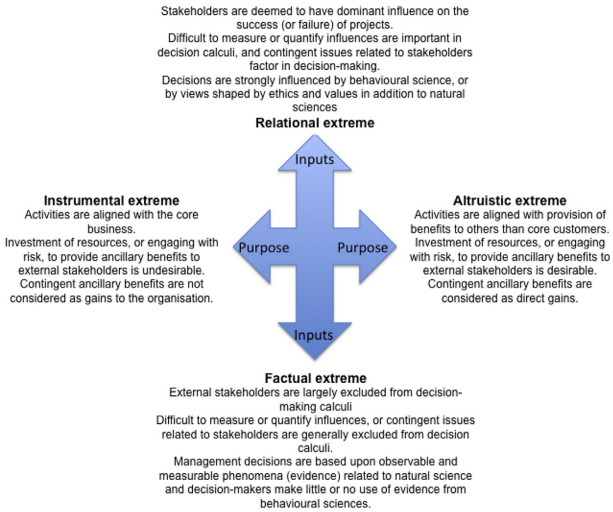

Fig. 3. Descriptions of extreme views in the input/purpose framework.

established an Energy Concept comprised of the following three distinct and demanding energy targets: RESPONSIBLE – 20 per cent reduction in energy consumption,[5] *RENEWABLE – 100 per cent utilization of renewable energy, and RECYCLABLE – 60% of the utilised energy being recovered and recycled.*

3.1. Diverging from RI norms

Fig. 4 shows yearly energy flows demanded in the original design concept for the ESS defined by the European Strategy Forum on Research Infrastructures (ESFRI)[6] in 2002. Notably, the power fed into the envisaged facility is large (610 GWh); and nearly all of this energy is rejected as waste heat to the environment.

In contrast, Fig. 5[7] portrays the ESS energy concept. Fundamental differences are evident: the supply is dedicated, renewable and reduced to 270 GWh/year, rejection of waste heat is now replaced with recovery and recycling; and the facility is now interlinked with the host community's energy system. Heat recovered from the facility is now also classified into three different 'qualities' (low, medium and high temperature), a change that in practice demands a completely new suite of design considerations.

The competitive bid-proposal from the Scandinavian consortium promised renewable energy supply, heat recycling, ongoing demand reductions in the design process, and the creation of an 'energy culture'; details are provided in Table 1.

Many uncertainties remained at this stage of the project. Technical changes required to meet concept goals (e.g. new energy system operating conditions, new operating specifications for equipment, and unique cooling system morphology) had no precedent in the RI field and were then beyond the organization's ability to deliver. As of 2009, substantial parts of the concept remained as 'paper constructions' Technologies to deliver the concept, particularly the cooling chain, needed to be iteratively modelled, designed and costed; new iterations contributing new insights into changes required for the energy system, and even for the accelerator design itself. As the concept required actions beyond established practice in their peer field, goal setting in the energy area at the ESS reflect the concept of "Big Hairy Audacious Goals" (BHAGs) outlined by Collins and Porras (1997). These authors claim that visionary and emotionally compelling goals of this type are important to align employees of the business so as to work together more effectively.

As design work advanced, recognition grew that changes to the energy system could exacerbate risks of disruption to the operation of the research facility. Reflecting the imperative of reliability in the energy system, and that the concept and its technical changes added levels of complexity and risk, a fourth principle was added in 2011 – a design requirement that energy must also be '*RELIABLE – the stability of the energy system must not jeopardise the potential to conduct research*' (ESS AB et al., 2011). This also played a role in increasing confidence among financing countries – many which had not yet fully committed to the project.

By 2012, a marked technical difference between the aforementioned 'standard' modus operandi and the ESS energy balance can be readily seen by comparing Figs. 4–6. The latter communicates both the form of the new concept, and areas where waste heat (ejected heat in cooling circuits) is generated. Relative 'quality' parameters (temperature and annual energy content) for the recovered/recyclable heat streams are now also shown.

Shifting focus to the building of an 'energy culture' within the ESS, the launch of the ESS Energy Concept initially communicated a desire or intention to influence behavioural norms regarding energy within the organization but over time the scope of publicly expressed undertakings grew. By 2012, communications embodied not only the delivery of scientific results but now also explicitly

[5] In this case a 20% reduction on the 350 GWh design concept was included in the Lund bid.

[6] ESFRI is a strategic EU instrument to develop the scientific integration of Europe and to strengthen its international outreach. See: http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri.

[7] Also at http://europeanspallationsource.se/ess-energy-concept.

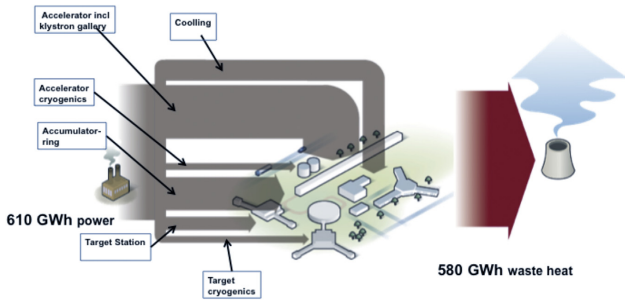

Fig. 4. ESS energy inventory – 2002 design (Parker, 2012).

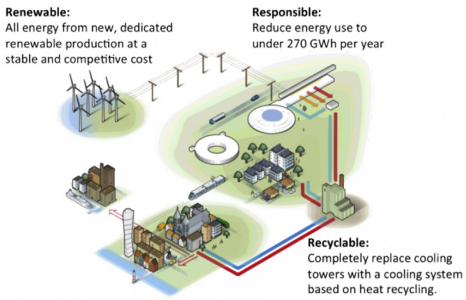

Fig. 5. The ESS energy concept (ESS AB, 2012).

communicated an intent that it sought to set a new standard for how such facilities are built and operated. (ESS AB, 2012)

> "… *ESS will set a new standard for large-scale research facilities by fulfilling its strategy, while the research done at ESS will put Europe in the lead of sustainable development.*
>
> … *ESS is a long-term commitment that will benefit coming generations and contribute to manage global environmental challenges both by scientific results and how the facility itself is built and operated. Setting a new standard for how research infrastructures are managed over their lifecycle is an important development for the future.*"

3.2. Development of the energy concept

After the 2009 placement decision, a process of human resource building and work to operationalize undertakings proceeded (cf. Table 1). The CEO's first step was the recruitment of an experienced energy sector professional to the management team (Parker, 2010). The energy manager then built an energy team and fostered collaborative work with local energy sector actors. Although none of the ESS energy team had previously worked with accelerator laboratory energy systems, they undertook the complex task to define an operational energy system in this new field. Among other things, this required work to: review and collate energy parameters and practice within peer installations; iteratively define and create an energy inventory and management process; conceptualise and model new methods for energy efficiency and energy recycling; and delineate, model and cost options for renewable energy supply. Work also explicitly addressed the building of an 'energy culture' based upon the guiding principles listed in undertakings, and the specific content that they built into their energy inventory tool (ESS AB et al., 2011).

From 2011 forth, a series of (commercial) profitability arguments for the Energy Concept appeared. An example can be seen in Fig. 7 that shows scale estimates for CO_2 reduction along with estimates of financial benefit associated with the design (cf. European

Table 1
Key parameters of the Lund ESS bid's Energy Concept.

Key undertakings in submission to the ESFRI	Additional information or details (European Spallation Source Scandinavia Secretariat, 2008, p. 3, pp. 40–41)
Ownership of generating power by renewable means[a]	"An investment of ≈120M€$_{2008}$ will purchase sufficient wind generating capacity to cover the integrated annual electricity use of the ESS"
Maximal recycling of waste heat	"… [energy] maximally recycled into the Lund district heating system. Cooling towers that would normally vent this heat into the atmosphere will not need to be built."
Reduction in energy consumption as compared to reference design	"By the use of green architecture and an energy flow inventory we aim to reduce the load to −35 MW or lower (−270 GWh p. a. or lower)"
The control of energy use and the implementation of an energy culture.	"An Energy Manager will be a member of the ESS Scandinavia Management team from the outset" "An energy inventory will be created and would be the central tool in this culture This would include accounting for user and staff transport." "… Innovative methods in energy control will be implemented" "A low environmental impact, blending with Swedish environmental care will be the goal of ESS"

[a] Later revised to the creation of a special dedicated purchase agreement.

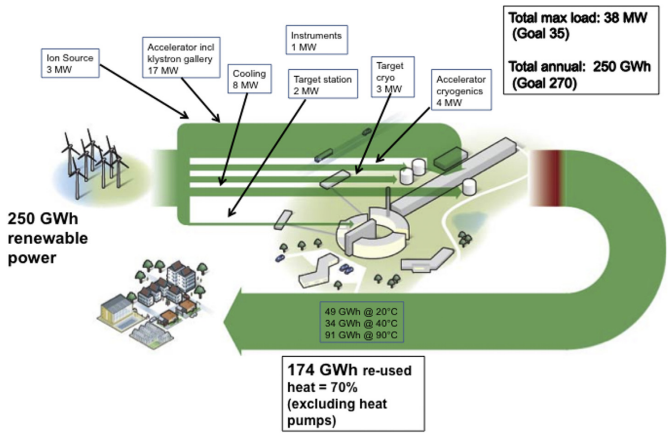

Fig. 6. Energy inventory 2012: Conceptual Sankey diagram for heat recovery streams (Parker, 2012).

Spallation Source ESS AB, 2013 for more detail). The economic rationale for the Energy Concept becomes a recurring theme and the concept of a 'business plan' is later used to describe and compare options for heat recycling and renewable energy supply. The economic perspective is apparent in the documents produced in collaboration with energy companies E.ON and Lunds Energi, and is also connected to the lack of an earmarked budget for investments for implementing the Energy Concept. Options analysed within these documents also provide insights into the processes of energy team negotiations with scientific, engineering and financial actors in ESS management structure as work towards the design progressed. Comparison against base cases also document the degree of divergence from the 'standard' approaches required in order to valorise 'waste' energy.

3.3. Uptake of the energy concept

As the energy system form clarified in engineering terms, efforts to disseminate the ESS Energy Concept to peer organizations intensified. Examples included neutron science community conference contributions (Parker et al., 2010) and presentations to broader RI-community events (Carlile, 2012). A significant milestone was enacted in October 2011, when some 150 international experts on energy and representatives from research laboratories and future large-scale research projects attended a *Workshop on energy management for large-scale research infrastructures* in Lund. The event was hosted by the ESS in collaboration with CERN and The European Association of National Research Facilities (ERF). A core topic examined was how different RIs could mobilize their resources and technical skills to deal with energy challenges outlined at the start of this case description (Section 3). In the workshop material these were collectively referred to as the "Grand Energy Challenge".

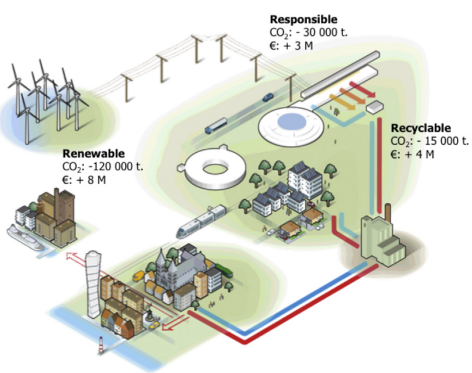

Fig. 7. Indicative carbon dioxide and operational cost savings implications of the ESS design concept (European Spallation Source ESS AB, 2013) (Parker, 2012, 2013).

There were however differing approaches among organizations (Cf. ESS AB, 2011 for details of all presentations and material). Only the ESS presented an energy strategy at the workshop. In contrast, CERN was more focussed on pushing the role of work, such as that embodied in the Energy Concept, in technology development relevant to the field. ERF, a type of 'industry association' for European RIs, used the gathering for two purposes. First, it utilised the opportunity posed by a gathering of member associations to convene its annual meeting. Second, it extended this by inviting the assembled laboratory directors to learn more about what the future would demand of them. This can be seen to fit within the ERF commitment to "develop mechanisms and best practice for international provision of large-scale research facilities" (ERF, 2005, 2007).

Some differences in mindset across the field were also in evidence. As a pointed example, a delegate from CERN, the European high-energy physics laboratory near Geneva, delivered a lecture demonstrating that heat recycling at CERN was impracticable based on the assumption that cooling to 40 °C must be achieved, thus providing an insufficient temperature difference from ambient conditions. At the same event, delegates from the ESS and the neighbouring Swedish facility Max IV presented their plans to implement heat recycling (based on innovations in high-temperature cooling) and set a new standard. A prime example of 'standard solutions' at this time is also provided by a related facility in the US. Fig. 8 shows the energy balance for the spallation source

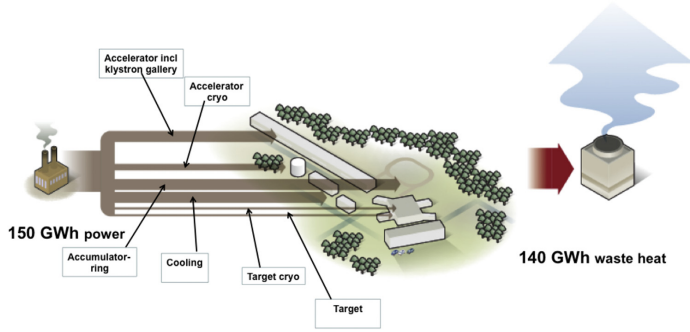

Fig. 8. Energy inventory – Spallation Neutron Source at Oak Ridge National Laboratory (Parker, 2012).

at Oak Ridge National Laboratory where cooling is performed to 40 °C and all 'waste heat' is ejected to the environment.

Indeed, few facilities recycle any of their heat – and instead burn fossil fuels or draw additional grid electricity to heat and cool. CERN for example, generates waste heat at 40 °C and ejects it to the ambient environment. While this could be used for space heating, the facility uses pressurized water at 120 °C instead. Although US national laboratories are obliged to reduce their emissions by 28% of 2008 levels by 2020; plans in place to achieve this goal mostly involve increasing energy efficiency or relying on renewables. Ongoing projects include biomass heat and energy co-generation at Savannah River,[8] and biomass steam generation at Oak Ridge. Somewhat counter-intuitively considering that the Oak Ridge figure represents established practice in the US, heat recycling is not mentioned in the Department of Energy's Strategic Sustainability Performance Plan (U.S. Department of the Interior, 2015).

Despite the existence of differences, there was immediate evidence of a resonance for the Energy Concept throughout the RI field at the workshop. In concluding remarks at the workshop, the head of ESFRI referred to ESS and Max IV as setting the example for others to follow. After the workshop, representatives of the three convening organizations issued a joint publication. It outlines a suite of areas where delegates agreed the RI-energy community should increase their efforts, and promotes the theme that RIs have a role to further develop and demonstrate methods and techniques for the sustainable use of energy elsewhere (Bordry et al., 2011). An article in published in Nature (Parker, 2011), following the workshop and spotlighting the ESS Energy Concept also disseminated the idea to wider audiences.

In early 2013 the comprehensive ESS Energy Design Report (European Spallation Source ESS AB, 2013) was published along with a popular version (ESS AB et al., 2013) that also served as an executive summary. The technical document formally proposed the form of the system in engineering terms, and provided a detailed inventory of the energy flows. While the shape, size, and key parameters of a number of the ESS Energy Concept items communicated in earlier years had been altered, the undertakings embodied in the Energy Concept still largely reflected their original form. The report also makes explicit reference to the implementation of an Energy Management System (EnMS), revolving around the biannual performance of the Energy Inventory. Evidence of environmental management activities in this area can later be seen in presentations on the technical development of accelerator systems (cf. Weisend et al., 2014). Another important milestone was achieved on June 13, 2013 when the ESS Energy Policy (European Spallation Source, 2013) was approved by the ESS board. This document confirmed and clarified the organization's commitment to the Energy Concept.

Another new development in the Energy Design Report is a suggestion to apply innovative new uses for low-grade heat. This, and associated activities conducted by ESS personnel to move the idea of 'hybrid cooling cycles' forward, represent tangible extension of the original Energy Concept (Lindström, 2014). Fig. 9 provides indications of the scope and ideas for food production systems based on this. In addition to expectations of the technical viability of utilizing 'waste heat' streams in a manner as has been demonstrated elsewhere in Sweden (cf. Strömkvist, 2013) and abroad (Andrews and Pearce, 2011), there was also explicit recognition in the ESS document that such developments offer a pathway to proactively counter a patter of emerging resistance towards large scale construction projects on Southern Swedish farmland (cf. Agrell, 2012, p. 204).

The alternative heat recycling possibility was pushed with increasing effort since after the Energy Design Report. The increased effort in this area coincides with the finalization of collaborative design work with the companies Lunds Energi and E.ON. New recruitments were also made to the ESS Energy Division in order to carry work forward. One key recruit was the author of the chapter delineating alternative heat recycling in the Energy Design Report. This actor now leads the exploratory project – the 'Recycling Energy Collaboration' (REC).

A second *Workshop on Energy for Sustainable Science at Research Infrastructures* was convened in October 2013 at CERN, this time with around 300 delegates. Again, the meeting was called by the ESS, CERN and the ERF (Museo Nazionale, 2013). The scope of this event was broadened to cover more topics to identify additional areas of best practice. Other leading global facilities such as KEK (The High Energy Accelerator Research Organization, Japan), Fermilab and Brookhaven National Laboratory also presented their strategies for energy management, efficiency and sustainability.

At the opening of the workshop, the Director General of CERN declared (in a written statement presented on his behalf) that from this point forward, responsible energy approaches would have a new status within their organization. First a role of facility energy coordinator was to be formed; and second new requirements would be put in place demanding that all future design reports

[8] The Savannah River Site (SRS) is an very large US nuclear research site in South Carolina, southeast of Augusta, Georgia.

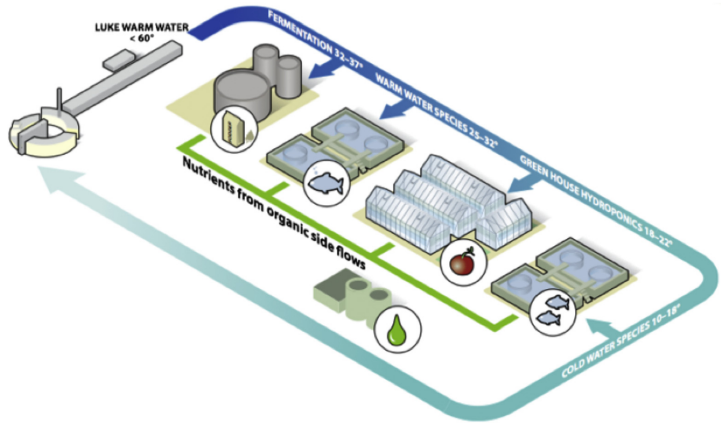

Fig. 9. Heat recycling concept – aquaculture (SLU in Parker, 2014a).

must contain a chapter on energy (thus, an 'energy plan' for all new infrastructure investments). This effectively forces the organization to include energy issues in all phases of design, much like ESS (Parker, 2014b).[9] A senior manager, previously at the prestigious Atlas experiment, was named Energy Coordinator.

As concrete evidence of uptake of ideas associated with the ESS Energy Concept, a suite of 'energy for sustainable science' projects was presented at the workshop by different RIs (see Appendix A for a tabulation of projects hyperlink to Appendix A). Additional evidence of the growing legitimacy of such work, and of the Energy Concept in the RI sphere, a year later, at the 'Higgs Factory' conference in Beijing, the "Green ILC" project in Japan was announced. Within Beijing presentations (Suzuki, 2013), and in later documentation ("The Green ILC Project – Green ILC," 2015), there is explicit reference to Japanese participation at the second energy workshop, and the ESS Energy Design Report, as two main inspirations.

4. Analysis and discussion

This analysis places the case findings in the conceptual framework developed in Section 2. The development and evolution of the ESS Energy Strategy is first presented as a phased but overlapping series of activities. The strategic purpose of each phase is then examined and visualised within the framework.

4.1. Evolution of activity types

The model for the ESS energy system evolves from a 'concept and promise' through a process of technical examination into a commercially viable proposition. In parallel, the evolution is supported by efforts directed towards legitimization and dissemination (a summary and timeline of dissemination efforts is provided in Appendix B – *Dissemination timeline: Energy Concept*) (Appendix B).

[9] General Director Heuer expressed regrets that he could not be present at the workshop; he was attending the international event to mark the occasion of the 'discovery' of the Higgs Boson.

Descriptors and a timeline for six general activities embodied within the evolution are provided here along with identifiers that relate them to approximate positions in Fig. 10. More details of the analysis process are provided in Appendix C – *Rationalization of strategic evolution* (Appendix C) – that includes a detail description of reasoning, and a tabulation supporting Fig. 10 in Section 4.2.

Commitment (2008) A_1, A_2: The strategy is presented as an effort to differentiate the Scandinavian bid to host the ESS, and appeals to audiences beyond those interested in research with neutrons. It embodies three themes: Renewable, Responsible, and Recyclable.

Technification (2009-) B_1: A specialist energy team tasked with delivery of the energy concept focuses attention on technical challenges and implementation of an energy management system. Technical and economic challenges for energy recycling lead to a focus on high-temperature cooling innovation while energy management efforts are directed towards delivery of the promised Energy Inventory. "Reliable" appears as a technical bound on Energy Concept undertakings, apparently to reassure scientists, and funders that the energy strategy would not interfere with facility functionality.

Commercialization (2010-) B_1: ESS is handed down its design brief and budget. This constrains energy activities as no funds are allocated, beyond the normal cost of a traditional cooling system, to provide for renewable energy production and heat recycling. Energy group efforts now evolve towards a quasi-business development effort focused on achieving 'commercial viability' for the Energy Concept.

Dissemination (2011-) B_2, C_2: ESS takes on a proponent/missionary role that started with the first Energy for Sustainable Science workshop. An article in Nature describing ESS efforts reinforces this. Dissemination throughout the RI field continues via a second workshop, and numerous appearances at conferences.

Legitimization: (2013-) C_1C_2: The seminal Energy Design Report, modelled on the ESS Conceptual Design Report, establishes the status of the Energy Concept within the organization and conference contributions further dissemination to the global accelerator physics community. Glossy public documents directed to local and domestic audiences are discontinued indicating a shift of focus from such stakeholders. Tangible evidence of a growing audience in the RI field is provided by invitations to present ESS work in a range

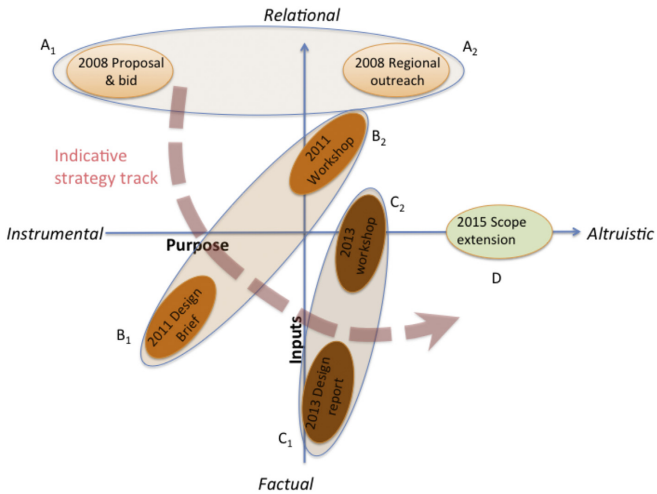

Fig. 10. The ESS energy strategy mapped over time.

of fora, notably an invitational presentation by the ESS at the EuCARD conference at CERN on the future of accelerators. At the second workshop event in 2013 evidence of mimetic behaviour from other accelerator facilities exists. Others such as the Paul Scherrer Institute (PSI) had adopted heat recycling for space heating and high-temp cooling. A number of RIs now present their own versions of an energy strategy.

Exploration (2013-) D: Innovative options for low-grade heat recovery with potential to improve overall internal economic benefits (ESS) and deliver additional external benefits are presented in the Energy Design Report and obtain senior management approval for follow-up. Exploration that follows moves clearly beyond the original scope of the Energy Concept.

4.2. An evolution from relational-instrumentality

In Fig. 10, phenomena are placed in the framework proposed to analyse drivers of strategy. Four points in time are chosen to represent the evolution of the Energy Concept within management strategy. Within the first three time frames a range of management strategies is noted ($A_{1,2}$; $B_{1,2}$ and $C_{1,2}$). The trend arrow is shown closest to A_1, B_1 and C_1 as these are judged to be the dominant positions. Position D represents 2015 developments.

4.3. Organizational rationale

This sub-section shifts focus to identification of an overarching 'imperative' or 'focus task' for each stage in Fig. 11. It communicates how work was directed towards strategic goals.

Imperative descriptors used in the figure are as follows: *'achieve license to operate'* indicating the making of commitments to achieve the site decision; *'ensure reliability'* indicating the introduction of the *'reliable'* prerogative to not interfere with the science; *'save costs'* representing the constraint introduced by a budget with no extra, or discretionary, provisions for the Energy Concept *per se*; *'inventorise energy'* to indicate the process demanded by the inventory listed in bid undertakings; *'build energy culture'* to indicate the promised active formation of an energy culture within the organization; *'embrace complexity'* implying growing organizational acceptance of increased complexity as an inherent part of the delivery of the Energy Concept; and *'move beyond promises'* indicating the efforts to move beyond the original commitments. A brief rationalization of how a number of these items link together is provided below.

As detailed in the case, a '*license to operate*' was required from European governmental actors (the site decision), and from host communities and domestic authorities (a social licence at local, regional and national levels). This is seen as the dominant goal at strategy conception. The granting of the ESS siting to Lund (goal achievement) then removed portions of this dominant driver, leaving somewhat of a vacuum. However, a suite of quasi-contractual obligations to stakeholders remained, with potential to 'haunt' management at a later date should there be marked retraction from the apparent conditions for their 'social licence'. Moreover, the Energy Concept still had the commitment of its original protagonist, the CEO.

Important legacy items from original undertakings included explicit commitments to perform a regular 'Energy Inventory' exercise and with it establish an 'Energy Culture'. Dealing with these items required the recruitment of an energy team – an 'Energy Manager' being a distinct role outlined in bid promises. The CEO recruited an energy professional from outside the RI field to management, and this actor in turn hired energy sector professionals to carry the concept forward. A distinct energy cadre grew, with their roles defined by a clear work area, with distinct goals to strive for; namely the Energy Concept and its widely disseminated undertakings. Importantly, this role had significant 'on paper' legitimacy.

In parallel, the absence of discretionary funds to ensure delivery of the energy concept – itself evidence of apparent disinterest from other parts of ESS top leadership – served to focus energy activities. This demanded immediate action from the energy team to inventorise energy and costs and to show evidence of 'cost savings'. A

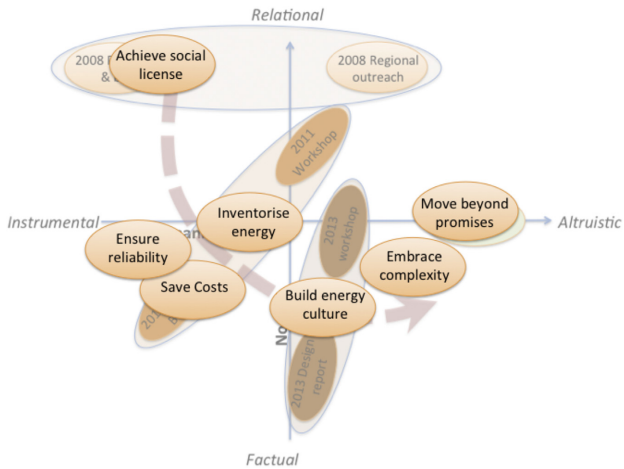

Fig. 11. Specific milestones in the ESS energy strategy evolution.

process that when successful served to add 'on the ground' legitimacy to their work.

Within this analysis, the energy manager, inventory and culture undertakings together are seen as a critical 'foot in the door'. From an institutional perspective we perceive distinct normative change influences from within the ESS. In particular, there is evidence of collective efforts from the energy professionals to define the conditions and methods of their working, to control the manner in which the organization delivered their outputs, and to establish a cognitive base and legitimation for their occupational autonomy. In short, they were empowered sufficiently by the concept undertakings (e.g. apparently granted adequate autonomy and cognitive legitimacy) to be able to drive change. Moreover, the ESS had introduced new personnel that brought with them inter-organizational networks spanning that may be termed 'energy for energy efficiency and renewable energy fields'. As these actors entered the ESS there is evidence they introduced a different suite of professional norms. Moreover, evidence is found in the case study material to support a view that the energy team pursued the original energy promises with degrees of agency – and then pursued more far-reaching energy innovations 'beyond promises' in the period post 2013.

5. Conclusions

This analysis set out with a purpose to contribute to the understanding of how organizations may pursue strategies for more widespread implementation of renewable energies and improved energy efficiency in ways that can also deliver ancillary benefits. The early part of this paper applied the predictive power of institutional and resource dependency theories to establish a point of departure; this being that many precursors of 'resistance to institutional pressures' could exist in the chosen setting (energy intensive endeavours that undertaken to engage in the provision of social goods beyond the direct interests of the operation). The ESS case study was then developed, and it was found that issues such as constraints upon organization discretion, additional external resource dependencies, and the introduction of non-traditional goals were present. Thus, significant challenges were anticipated.

Yet the energy effort did not fail or substantially fall short of initial goals. To the contrary, much of the 2008 envisioned Energy Concept is now embedded in designs and is a substantially advanced work in progress as of the latter part of 2015. At this point in the discussion it is possible to draw conclusions from the analysis that address apparent inconsistencies, and to build on an improved understanding of developments in the case to relate to theory and future research needs.

5.1. Explaining the progress of the energy concept

Reflecting on the factors that were the most influential on the development of the Energy Concept, and recalling that Stakeholder Theory was a point of departure, a first possibility to examine might be that the initial undertakings directed to stakeholders during the bid process were so important that the licence to operate conditions they outlined were immutable. Here, the case evidence suggests that stakeholder demands were important at the start of the project timeline and that it would not be feasible to retract the original promises.

However, in the period 2009–2015 this analysis finds limited evidence of stakeholder interest in the finer details of promises or their delivery. The analysis also develops a position that the relational drivers within the organization reduced markedly post site granting. A relational nature of strategy is shown growing steadily from a low point in 2011, but it has been argued that this was largely internally driven, not a result of critical stakeholders demanding delivery of the concept. Rather, the case evidence shows that actors within the organization were those pursuing and communicating this theme. Thus, the Energy Concept was pursued internally – not monitored and enforced by others.

A second explanation that can be examined is that the 'timing was simply right' for an initiative of this type when viewed in the light of escalating social and economic pressures on such endeavours. The study highlights a number of resource-based concerns for energy intensive facilities. These include risks and uncertainties regarding fuel or electricity prices, energy supply stability, and climate performance – and the relationship of such items to social licence. Interest from other RIs demonstrated by their engagement

in the 'Energy for Sustainable Science' initiative also provides evidence that peer organizations in the RI field shared concerns in these areas and was 'ready' for such work.

However, this idea of higher-level institutional alignment leading to a 'seamless uptake' also appears as unrealistic. Importantly the case provides evidence that different groups within the ESS attached differing levels of value to the concept and that proponents pursued their own agenda (principally delivery of the concept) to varying degrees. In the first instance, the CEO is seen as an agent of change with substantial commitment at the outset – yet when it came to (contingent) allocation of any additional financial resources to cover up-front costs for the energy concept, there is evidence that the ESS as an organization was not committed. No additional funds were available. Pursuing the promises, the CEO defined a clear role and goals for the concept, and then recruited key resources to work on delivery. These actors then clearly worked towards the goals within the conditions granted them, and then extended the bounds of the concept, again apparently as motivated change agents.

Thus an overarching conclusion we draw is that no single issue alone is sufficient to explain success. However, we do choose to attach greatest importance to the inter-relationship between the undertakings as they were framed at the project bid stage, and Energy Concept resources. A situation was created where a senior energy professional was recruited from outside the RI field and explicitly tasked with the establishment of a new professional organizational corps. The manager was tasked and granted sufficient autonomy to infuse this group, and the broader organization with a new set of norms regarding 'the way we manage energy here'. The targeted norms lay beyond compliance with regulations, and beyond established praxis in equivalent organizations. Moreover, the Energy Manager was empowered with a recurring, culture-creating management exercise, the Energy Inventory. As it was posed in bid undertakings we perceive that it entered into being with tangible legitimacy and could be applied immediately in a role aiding the introduction of new cultural norms *vis a vis* energy. The case clearly shows substantial effort, both from the founding CEO and from the energy department, to establish legitimacy and credibility in the host culture using the tool.

Pursuant to the evidence found in this case, and in the enfolding theory, we also attach importance to the fact energy personnel were introduced from outside the established RI field. It is arguable that they did not share (preconceived) views of 'what is normal here' in an accelerator facility. Such actors are less likely to be bounded in thinking by established practice.

5.2. Addressing lines of inquiry

Three lines of inquiry were presented at the start of this article. First, to examine how the ESS Energy Concept evolved, second, to trace the rationale behind various stages of the evolving strategy, and third to discuss the implications the Energy Concept might have for strategy and management in the broader RI field and in energy-intensive industry.

The evolution of the Energy Concept and its rationale was mapped in detail in Sections 4.1 and 4.2. Focus was placed on the nature of various stages, and their relative positions within the conceptual framework. The argumentation, and Fig. 10, display how the organization enacted the concept differently as its meaning changed. In particular, they highlight how shifts in strategy followed project evolution, and how external drivers were shifted to internal. Within internal processes, the biannual Energy Inventory is taken forth as a recurring enactment of a factual 'truth' of the Energy Concept as important. This phenomenon is presented as a key builder of legitimacy for the concept.

The rationale behind various stages of the evolving strategy is presented in Section 4.3. Here an overarching 'imperative' or 'focus task' for each stage communicates how work was directed towards strategic goals. Again, a continual focus on energy data helped the ESS to attach meaning to the concept and establish norms to relate to it – in other words 'develop a culture'. Thus, we conclude that the inventory became a driver of the meaning and norms within an Energy Culture and that the Energy Culture became a force in itself, allowing its proponents to first pursue promises. First those made within the Energy Concept, and then later, delivery of items beyond the form of the original concept and strategy. The nature of the focus tasks presented thus shift from work of a techno-economic nature (e.g. *ensure reliability*, *save costs*) to more socially orientated and creative processes (e.g. *embrace complexity*, *move beyond promises*).

Regarding the implications the Energy Concept might have for strategy and management in the broader RI field and in energy-intensive industry, the evidence presented in Sections 3.2 and Section 3.3 establish both a broader strategic relevance to the RI field and uptake of the concept by other RIs. The CERN management adjustments – employing specialists, and mandating that energy plans be created for all new projects – indicate an acceptance that energy issues may no longer be ignored. We also consider that this analysis shows that the achievements of the energy strategy for the ESS have opened up a new possibility for RIs. It is now feasible to make one of their weak points – a large-scale, one way consume-expel model for energy use – into a new positive. Excellence in energy management, renewable energy application, and delivery of services from waste heat, offer pathways to achieve instrumental gains such as reduced energy system bills and more secure supply, as well as the potential to cement or improve social licence.

In the industry sphere, we point to ubiquitous dissipation of waste heat to the environment as a shared context. The scales of energy usage in single facilities can are often similar as are the existence of challenges to achieve a 'licence-to-operate' (or indeed, approval to locate a facility) in the face of escalating stakeholder expectations. The sources of revenue differ, but the need to demonstrate adherence to policy on sustainability challenges may not.

5.3. Contributions to knowledge

These works utilized well-established theoretical perspectives to contextualise and problematize the ESS case study. It thus also addresses more general situations where organizations may pursue strategies for more renewable energy and improved energy efficiency in ways that deliver ancillary benefits. It also outlined how (potential) organizational resistance could be related to specific intra and inter-organizational changes required by initiatives such as the Energy Concept. The utilization of Institutional, Resource Dependency and Stakeholder Theory in this manner constitutes application of theory in a new setting.

The opening of the paper also noted a knowledge gap in stakeholder related project management literature (a lack of longitudinal studies that can cast light on processes of emergent co-evolution between stakeholder forces and a project), and an opportunity to enrich Institutional Theory with insights from Sense-making (how micro-level processes can link with higher-level institutionalization). Together, these provide insights into how organisational actors make sense of, and enact, technology systems within their local context.

A more substantial contribution is the analysis framework presented in Sections 4.1 and 4.2. This accommodates representation of micro level phenomena and higher-level institutional factors, and facilitates visualisation of the evolution of strategic drivers along a project lifecycle. Its application yields insights into the

interaction of organisational strategy and management, the presence of differing organisational viewpoints, and shifting institutional forces as they co-evolve.

The application of the framework to the findings in the case helps demonstrate the role that internal, micro-level forces can play in the shaping of an energy strategy. We see from the case, that an external commitment made to stakeholders, made necessary the recruitment and empowerment of an energy cadre. This group eventually became the driving force for energy sustainability, beyond both promises and stakeholder expectations. We hold that the signs of active agency would have been difficult to elucidate in a macro-level investigation. A 'black-box' view of an organization, ignoring internal forces would not capture this process. The case analysis was also able to rationalise how some specific actions of organizational actors, as they made sense of and enacted their technology system, could be related to higher-level institutional phenomena. As a case in point, the storytelling around the Energy Concept and the actions of the ESS can be directly linked to mimetic behaviour displayed by other RIs. The framework and the case have thus helped to highlight how concrete social situations can serve to alter institutions.

5.4. Key messages and areas for future study

Three audiences were targeted with this article. First, practitioners involved or embarking on technical ventures requiring large amounts of energy, particularly where consumption processes are followed by rejection of waste heat to the environment. And secondly researchers working to study such efforts, one concrete example being those working with industrial symbiosis. A third group encompasses analysts in the field of social and organizational change.

Relevant for all audiences in the context of energy intensive facilities, this discussion shows that the pursuit of strategies for renewable energy, energy efficiency and increased provision of ancillary benefits is timely. It highlights examples of where it is, or will be, advantageous for organizations to address issues such as price volatility, an evolving climate discourse, security of supply issues, and shifts in public opinion and policy, via work embodying principles similar to the ESS energy concept. Analysis has also shown that interactions between the organization and the enfolding socio-economic environment can be complex. Consideration of stakeholder, institutional and resource perspectives can be useful for all when seeking to design or understand such strategies.

For the first two groups, this paper provides a detail rich longitudinal case. It delivers evidence that proponents of clean and efficient energy systems, within established institutions, can indeed be empowered to achieve far-reaching change. It also highlights areas how barriers and constraints may arise if an initiative is out of line with the established practice of an organization. Through analysis of an apparently successful approach to defuse or overcome such constraints, it shows that such initiatives can be framed strategically for the good of the organization, and can be granted tools and degrees of organizational legitimacy that can aid their progress. The case also demonstrates how the political economy of energy initiatives should be expected to change markedly through a project life cycle as different strategic imperatives arise at different project stages. This however, remains as a single example; we hold that such audiences can be helped by further case study work where the framework is tested in differing contexts. An example of a setting for such work is the CERN effort to infuse an energy culture (cf. Section 3.3) where there are quite different institutional conditions (e.g. long established organisation, an internal appointment, and a coordination role rather than management). Assessment of the significance of these differences (if any) would provide a useful test of this analysis and framework.

For the analysts in the field of social and organizational change, this work confirms the presence of many of the phenomena predicted by theory. However, it also has demonstrated and clarified an Energy Concept outcome that would appear difficult to achieve in an *ex ante* assessment of organizational considerations. The framework provided by this work can provide inspiration for further analysis and guidance of organizational strategy and management, and deeper understanding of the interactions of different interest groups within the organizations, broader institutional forces, and stakeholder influence as they co-evolve along a project time-line. Actors in this area would benefit from studies, that delve deeper into the links between micro and macro change processes in management and culture within long-term projects, to more concretely establish relationships indicated by this work.

5.5. Closing comments

With society at a pivotal point of time in development of energy infrastructure and energy use practices, inspirational examples of changes to deeply established institutional practice are important. This paper has shown how deliberate strategies pursued by change proponents may contribute to such evolution. For all actors in such processes, whether in industry, government, research or NGOs, improved understanding of the interaction of drivers affecting an organisation energy strategy can only help the task of shaping stakeholder pressure, regulation, governance and management practice necessary to support change.

Abbreviations and acronyms

CERN	European Laboratory for Particle Physics; Geneva, Switzerland (Organization Européenne pour la Recherche Nucléaire)[10]
CSC	IT Center for Science – Finland
CSR	Corporate Social Responsibility
DESY	Deutsches Elektronen-Synchrotron
DLR	German Aerospace Centre
EnMS	Energy Management System
EMS	Environmental Management System
ESRF	European Synchrotron Radiation Facility
ESFRI	European Strategy Forum on Research Infrastructures See: http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri
ESS	European Spallation Source
ILC	International Linear Collidor
ITER	International Thermonuclear Experimental Reactor
LNCM	Laboratoire National Des Champs Magnétiques Intenses – France
LNF	Lunds Naturskyddsförening (Lund's Society for Nature Conservation)
LRI	Large Research Infrastructure
Max IV	Microtron Accelerator for X-rays IV
MNC	Multi National Corporation
ONERA	Office National d'Etudes et de Recherches Aérospatiales (French Aeronautics and Space Research Center)
PSI	Paul Scherrer Institute
RI	Research Infrastructure
SKA	Square Kilometer Array
SMES	Superconducting Magnetic Energy Storage

[10] Renamed from Conseil Européen pour la Recherche Nucléaire, but acronym retained.

SSNC Swedish Society for Nature Conservation
TRIUMF Tri-University Meson Facility
UBC University of British Columbia

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jclepro.2015.09.121.

References

Agrell, W., 2012. Selling big science: perceptions of prospects and risk in the public case for the ESS in Lund. In: Hallonsten, O. (Ed.), In Pursuit of a Promise: Perspectives on the Political Process to Establish the European Spallation Source (ESS) in Lund, Sweden. Arkiv Academic Press, Lund, pp. 173–189.

Andrews, R., Pearce, J.M., 2011. Environmental and economic assessment of a greenhouse waste heat exchange. J. Clean. Prod. 19, 1446–1454.

Balzarova, M.A., Castka, P., 2008. Underlying mechanisms in the maintenance of ISO 14001 environmental management system. J. Clean. Prod. 16 (18), 1949–1957.

Bansal, P., Roth, K., 2000. Why companies go green: a model of ecological responsiveness. Acad. Manag. J. 43 (4), 717–736.

Baum, J.A., Oliver, 1991. Institutional linkages and organizational mortality. Adm. Sci. Q. 187–218.

Beckman, K., 2013, October 22. RWE Sheds Old Business Model, Embraces New Energy Reality: Renew Economy. Retrieved August 11, 2015, from. http://reneweconomy.com.au/2013/rwe-sheds-old-business-model-embraces-new-energy-reality-52967.

Bohn, F.H., Bongardt, K., Carsughi, F., Claver, A., Clausen, K.N., Desailly, C., et al. (Eds.), 2003. The ESS Project. Technical Report, vol. III. ESS Council, Jülich, Germany.

Bordry, F., Parker, T., Rizzuto, C., 2011. Main Findings of the First Joint Workshop on Energy for Large-scale Research Infrastructures 13–14 October 2011 Lund, Sweden (Summary Report). CERN, ESS, ERF, Geneva. Retrieved from. http://europeanspallationsource.se/sites/default/files/executive_summary.pdf.

Campbell, J.L., 2007. Why would corporations behave in socially responsible ways? An institutional theory of corporate social responsibility. Acad. Manag. Rev. 32 (3), 946–967.

Carlile, C., 2012, March. "Neutrons from wind" the energy inventory of European spallation source. In: Plenary Presentation Presented at the International Conference for Research Infrastructure, Copenhagen, Denmark. Retrieved from. https://www.eiseverywhere.com/file_uploads/9bf5b3b386b2158b39d243611589294f_22marts_ThematicSession_Part1_Energy_Carlile.pdf.

Chertow, M.R., 2000. Industrial symbiosis: literature and taxonomy. Annu. Rev. Energy Environ. 25 (1), 313–337.

Chu, S., Majumdar, A., 2012. Opportunities and challenges for a sustainable energy future. Nature 488 (7411), 294–303. http://dx.doi.org/10.1038/nature11475.

Collins, J., Porras, J., 1997. Built to Last: Successful Habits of Visionary Companies. Harper Collins, New York.

Connelly, L., Koshland, C.P., 2001. Exergy and industrial ecology–Part 1: an exergy-based definition of consumption and a thermodynamic interpretation of ecosystem evolution. Exergy Int. J. 1 (3), 146–165.

DiMaggio, P.J., Powell, W.W., 1983. The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. Am. Sociol. Rev. 48 (2), 147–160.

Dovì, V.G., Friedler, F., Huisingh, D., Klemeš, J.J., 2009. Cleaner energy for sustainable future. J. Clean. Prod. 17 (10), 889–895.

Ehrenfeld, J., Chertow, M.R., 2002. A handbook of industrial ecology. In: Ehrenfeld, J., Chertow, M.R. (Eds.), Industrial Symbiosis: the Legacy of Kalundborg. A Handbook of Industrial Ecology. Edward Elgar Publishing, Cheltenham, pp. 334–348.

Eisenhardt, K.M., 1989. Building theories from case study research. Acad. Manag. Rev. 14 (4), 532–550.

ERF, 2005, June 8. Preliminary Agreement to Form the Association. Retrieved August 23, 2015, from. http://www.europeanresearchfacilities.eu/spip.php?article7.

ERF, 2007, June 8. ERF Charter. European Association of National Research Facilities. Retrieved from. http://www.europeanresearchfacilities.eu/IMG/pdf/ERF_Charter_with_signatures.pdf.

Eskerod, P., Vaagaasar, A.L., 2014. Stakeholder management strategies and practices during a project course. Proj. Manag. J. 45 (5), 71–85.

ESS AB, 2011. Workshop 2011: Energy for Sustainable Science [Summary of Conference Website]. Retrieved August 23, 2015, from. https://europeanspallationsource.se/energyworkshop.

ESS AB, 2012. The ESS Energy Concept. Retrieved from. http://europeanspallationsource.se/ess-energy-concept.

ESS AB, E.ON Sverige AB, Lunds Energi AB, 2011. Energy for Sustainable Science: ESS Energy Solution September 2011. European Spallation Source ESS AB, Lund, Sweden, p. 28. Retrieved from. http://www.lundsenergi.se/Global/Lunds_Energikoncernen/Pdfer/ESSrapport_engelska.pdf.

ESS AB, E.ON Sverige AB, Lunds Energi AB, 2013. Proposal for a Sustainable Research Facility. ESS Energy Concept Final Report 2013. European Spallation Source ESS AB, Lund, Sweden, p. 31.

European Council, 2014. Conclusions – 23/24 October 2014 (2030 Climate and Energy Policy Framework) (No. EUCO 169/14). European Council (General Secretariat), Brussels, pp. 1–10. Retrieved from. http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf.

European Spallation Source, 2013, June 13. ESS Energy Policy: Doc. 0002126. European Spallation Source, AB.

European Spallation Source ESS AB, 2013. ESS Energy Design Report: Outcomes from the Collaboration between ESS, E.ON and Lunds Energi 2011–2012 (No. ESS-0001761), p. 195. Lund, Sweden.

European Spallation Source Scandinavia Secretariat, 2008. The ESS Scandinavia Submission to the ESFRI Working Group on ESS Siting. Lund University, Lund, Sweden, p. 57.

Freeman, R.E., 1984. Strategic Management: a Stakeholder Approach. Pitman, Boston.

Freeman, R.E., Harrison, J.S., Wicks, A.C., Parmar, B.L., De Colle, S., 2010. Stakeholder Theory: the State of the Art. Cambridge University Press, New York.

Freeman, R.E., McVea, J., 2001. A stakeholder approach to strategic management. In: Hitt, M.A., Freeman, R.E., Harrison, J.S. (Eds.), Handbook of Strategic Management. Blackwell Publishing, Oxford, UK, p. 716.

Friedman, M., 1970, September 13. The Social Responsibility of Business Is to Increase its Profits. New York Times.

Gerland, P., Raftery, A.E., Ševčíková, H., Li, N., Gu, D., Spoorenberg, T., et al., 2014. World population stabilization unlikely this century. Science. http://dx.doi.org/10.1126/science.1257469.

Gunningham, N., Kagan, R.A., Thornton, D., 2002. Social Licence and Environmental Protection: Why Businesses Go Beyond Compliance (discussion paper). Centre for Analysis of Risk and Regulation at the London School of Economics and Political Science, London, UK, p. 25.

Hallonsten, O., 2012. In Pursuit of a Promise: Perspectives on the Political Process to Establish the European Spallation Source (ESS) in Lund. Arkiv Academic Press, Lund.

Hoskisson, R.E., Eden, L., Lau, C.M., Wright, M., 2000. Strategy in emerging economies. Acad. Manag. J. 43 (3), 249–267.

IPCC, 2014. Summary for policymakers. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., et al. (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, pp. 1–32.

Jacobsen, N.B., 2006. Industrial symbiosis in Kalundborg, Denmark: a quantitative assessment of economic and environmental aspects. J. Ind. Ecol. 10 (1–2), 239–255.

Jensen, T.B., Kjærgaard, A., Svejvig, P., 2009. Using institutional theory with sensemaking theory: a case study of information system implementation in healthcare. J. Inf. Technol. 24 (4), 343–353.

Kaiserfeld, T., O'Dell, T., 2013. Legitimizing ESS: Big Science as a Collaboration across Boundaries. Nordic Academic Press, Falun.

Kleineidam, U., Lambert, A.J.D., Blansjaar, J., Kok, J.J., van Heijningen, R.J.J., 2000. Optimising product recycling chains by control theory. Int. J. Prod. Econ. 66 (2), 185–195.

Lambert, A.J.D., Boons, F.A., 2002. Eco-industrial parks: stimulating sustainable development in mixed industrial parks. Technovation 22 (8), 471–484.

Lantos, G.P., Cooke, S., 2003. Corporate socialism unethically Masquerades as "CSR": the difference between being ethical, altruistic, and strategic in business. Strateg. Dir. 19 (6), 31–35. http://dx.doi.org/10.1108/02580540310472135.

Laplume, A., Sonpar, K., Litz, R., 2008. Stakeholder theory: reviewing a theory that moves us. J. Manag. 34 (6), 1152–1189.

Lilja, R., 2009. From waste prevention to promotion of material efficiency: change of discourse in the waste policy of Finland. J. Clean. Prod. 17 (2), 129–136.

Lindström, E., 2014, April 28. EuCARD-2 Workshop on Cooling and Heat Recovery. Retrieved August 23, 2015, from. https://indico.esss.lu.se/indico/event/148/material/slides/.

Mac, A., 2002. When firms make sense of environmental agendas of society. J. Clean. Prod. 10 (3), 259–269.

Majozi, T., 2009. Minimization of energy use in multipurpose batch plants using heat storage: an aspect of cleaner production. J. Clean. Prod. 17 (10), 945–950.

Malm, M., McFaul, K., Carlsson, P.W., Vettier, C., Carlile, C., 2008. Focus Lund. The ESS Scandinavia Submission to the ESFRI Working Group on ESS Siting. European Spallation Source Scandinavia.

McWilliams, A., Siegel, D., 2001. Corporate social responsibility: a theory of the firm perspective. Acad. Manag. Rev. 26 (1), 117–127.

McWilliams, A., Siegel, D.S., Wright, P., 2006. Corporate social responsibility: strategic implications. J. Manag. Stud. 43 (1), 1–18.

Meyer, J.W., Rowan, B., 1977. Institutionalized organizations: formal structure as myth and ceremony. Am. J. Sociol. 340–363.

Mintzberg, H., Ahlstrand, B., Lampel, J., 1998. Strategy Safari: a Guided Tour Through the Wilds of Strategic Management. Prentice Hall Europe, Hemel Hempstead, UK.

Missonier, S., Loufrani-Fedida, S., 2014. Stakeholder analysis and engagement in projects: from stakeholder relational perspective to stakeholder relational ontology. Int. J. Proj. Manag. 32 (7), 1108–1122.

Mitchell, R.K., Agle, B.R., Wood, D.J., 1997. Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. Acad. Manag. Rev. 22 (4), 853–886.
Morell, K., 2008. The narrative of "evidence based" management. J. Manag. Stud. 45 (3), 613–635.
Museo Nazionale, 2013. CERN 2013-International Relations – the Museum – Museoscienza. Retrieved March 15, 2015, from. http://www.museoscienza.org/english/museum/international-relations/cern2013.asp.
OECD, 1998. Report of the Neutron Sources Working Group (Submitted to the 13th meeting of the Megascience Forum), p. 9. Retrieved from. http://www.oecd.org/science/sci-tech/2751510.pdf.
Oliver, C., 1991. Strategic responses to institutional processes. Acad. Manag. Rev. 16 (1), 145–179.
Parker, T., 2010. Responsible, Renewable, Recyclable. An Energy Management Strategy for the European Spallation Source.
Parker, T., 2011. Sustainable energy: cutting science's electricity bill. Nature 480 (7377), 315–316. http://dx.doi.org/10.1038/480315a.
Parker, T., 2012. Greening big science. In: Labs21 Annual Conference 2012: Presentations. International Institute for Sustainable Laboratories, San Jose, California.
Parker, T., 2013. The view from below – a management system case study from a meaning-based view of organization. J. Clean. Prod. 53 (6), 81–90.
Parker, T., 2014a, March. The World's Brightest ESS – a World-leading Research Center and an International Collaboration. In: Presented at the Nordic Cleantech Camp, Trolleholm Castle, Sweden.
Parker, T., 2014b, October 30. Project Revisions Meeting/interview.
Parker, T., Steuwer, A., Carlile, C., Vettier, C., 2010. Energy for Sustainable Science European Spallation Source.
Parmar, B.L., Freeman, R.E., Harrison, J.S., Wicks, A.C., Purnell, L., De Colle, S., 2010. Stakeholder theory: the state of the art. Acad. Manag. Ann. 4 (1), 403–445.
Pfeffer, J., Sutton, R.I., 2006. Management half-truths and nonsense: how to practice evidence-based management. Calif. Manag. Rev. 48 (3), 77–100.
Phillips, R., Freeman, R.E., Wicks, A.C., 2003. What stakeholder theory is not. Bus. Ethics Q. 13 (4), 479–502.
Powell, W.W., Colyvas, J.A., 2008. Microfoundations of institutional theory. In: The Sage Handbook of Organizational Institutionalism. Sage Publications Ltd, London, pp. 276–298.
Rousseau, D.M., 2006. Is there such a thing as "evidence-based management"? Acad. Manag. Rev. 31 (2), 256–269.
Sackett, D.L., Straus, S.E., Richardson, W.S., Rosenberg, W., Haynes, R.B., 1997. Evidence-based Medicine: How to Practice and Teach EBM. Churchill Livingstone, Edinburgh.
Sagar, A.D., Frosch, R.A., 1997. A perspective on industrial ecology and its application to a metals-industry ecosystem. J. Clean. Prod. 5 (5), 39–45.
Shropshire, C., Hillman, A.J., 2007. A longitudinal study of significant change in stakeholder management. Bus. Soc. 46 (1), 63–87.
Strömkvist, S., 2013, February 5. Här är spillvärme grogrunden för odling. Retrieved August 23, 2014, from. http://www.sydsvenskan.se/sverige/har-ar-spillvarme-grogrunden-for-odling/.
Suchman, M.C., 1995. Managing legitimacy: strategic and institutional approaches. Acad. Manag. Rev. 20 (3), 571–610.
Suzuki, A., 2013, November. Colored ILC. Plenary Presentation Presented at the International Workshop on Future Linear Colliders. The University of Tokyo. Retrieved from. http://agenda.linearcollider.org/event/6000/session/11/material/slides/1?contribId=36.
Tan, R.R., Ng, D.K.S., Foo, D.C.Y., 2009. Pinch analysis approach to carbon-constrained planning for sustainable power generation. J. Clean. Prod. 17 (10), 940–944.
The Green ILC Project – Green ILC. (2015). Retrieved August 23, 2015, from http://green-ilc.in2p3.fr/home/.
U.S. Department of the Interior, 2015. Strategic Sustainability Performance Plan [US Government Website]. Retrieved August 23, 2015, from. https://www.doi.gov/greening/sustainability_plan/.
van der Heijden, A., Driessen, P.P.J., Cramer, J.M., 2010. Making sense of corporate social responsibility: exploring organizational processes and strategies. J. Clean. Prod. 18 (18), 1787–1796. http://dx.doi.org/10.1016/j.jclepro.2010.07.024.
Walshe, K., Rundall, T.G., 2001. Evidence-based management: from theory to practice in health care. Milbank Q. 79, 429–457.
Weick, K.E., 1979a. Cognitive processes in organizations. Res. Organ. Behav. 1 (1), 41–74.
Weick, K.E., 1979b. The Social Psychology of Organizing. McGraw-Hill, Inc, New York.
Weick, K.E., 1995. Sensemaking in Organizations, vol. 3. SAGE publications Inc., New York.
Weisend, J., Darve, C., Gallimore, S., Hees, W., Jurns, J., Köttig, T., et al., 2014. Status of the ESS cryogenic system. In: Advances in Cryogenic Engineering: Transactions of the Cryogenic Engineering Conference?. CEC (AIP Conference Proceedings), vol. 1573 American Institute of Physics, pp. 633–638. Retrieved from. http://dx.doi.org/10.1063/1.4860761.
While, A., Jonas, A.E., Gibbs, D., 2010. From sustainable development to carbon control: eco-state restructuring and the politics of urban and regional development. Trans. Inst. Br. Geogr. 35 (1), 76–93.
World Energy Council, 2015. 2015 World Energy Issues Monitor. World Energy Council/Conseil Mondial de l'énergie, London, UK.
Worrell, E., Bernstein, L., Roy, J., Price, L., Harnisch, J., 2009. Industrial energy efficiency and climate change mitigation. Energy Effic. 2 (2), 109–123.

Appendix 4

Managing Emergence

Management Systems in Emergent, Evolutionary and Deliberate Strategy Contexts

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Managing Emergence: Management Systems in Emergent, Evolutionary and Deliberate Strategy Contexts

Abstract

Using interpretive methodology, this article elucidates how change, complexity and innovation are viewed in standard management systems. The objective of the research was to provide better understanding of the interaction between management systems and strategy in order to facilitate the future implementation of management systems appropriate for the strategic environment of various organizations. Three views on strategy that differ in relation to change, complexity and innovation were derived from the literature and labelled: deliberate, evolutionary and emergent. The methods employed included a discourse analysis and a hermeneutic text analysis with attributional coding, within an interpretive methodology. The collected data were compared with strategy and management views in relationship to the axes control-change and planning-culture. The research revealed that the evolutionary strategy view was dominant in standard management systems, and that such systems function differently in different strategy contexts, so that in an evolutionary strategy context, management systems competed internally to shape culture, whereas in an emergent strategy context, management systems could hinder innovation and change. Different strategy contexts were demonstrated to exist simultaneously in the same organization.

Keywords: Management Systems, Emergent Strategy, Business Strategy, Complexity, Change, Interpretive Methodology, Environmental Management

1 Introduction

Despite earlier predictions to the contrary, the population of the world continues to increase, placing increased demands upon resources to supply food, water, energy and goods (Gerland et al., 2014). Despite gains in efficiency of production and some evidence of decoupling in rich-world consumption, economic growth combined with population growth to tax resources and cause increasing climate-change and other types of damage, which in turn are having detrimental effects on resource availability (IPCC, 2014). Industry and commerce collects, develops and distributes resources for consumption, and therefore, plays a pivotal role in increasing efficiency. In a market economy, industry is driven by economic efficiency, in which resource efficiency plays a part, but often, that part is drowned out among other economic factors (Johnson & Kaplan, 1987).

To aid corporations and other organisations in prevention of pollution including efficient use of resources, various aids have been developed, among these standardised management systems for management of environmental issues and specifically for energy management. An annual survey by ISO documented that for the environmental management system (EMS) ISO 14001 over 300,000 certificates had been issued in 2013, whereas for the much newer energy management system (EnMS) ISO 50001, slightly under 5,000 certificates had been issued ('iso_survey_executive-summary.pdf', n.d.). ISO 14001 was first adopted in 1996 (based on the earlier British Standard) and ISO 50001 is from 2011.

The effectiveness of EMSs in delivering improved environmental performance is in question as it has been throughout their existence (Annandale, Morrison-Saunders, & Bouma, 2004). Many studies found no improvement in environmental performance resulting from the adoption of EMS, as seen in a meta-study by Nawrocka and Parker (2009), although a significant number of studies did find a positive correlation between the incidence of EMS and environmental improvement. There is not yet a similar body of studies of EnMS, with its limited time track record. Organizations need to demonstrate improvement to auditors in order to receive and retain certification, but the definition of what constitutes improvement varies substantially (Nawrocka & Parker, 2009). The apparently mixed results from implementation of EMS demonstrates the need to generate better understanding of the causal relationships between environmental management initiatives and environmental performance. Such improved understanding may contribute to effective EMS implementation, improvement of standards or insights into the contextual appropriateness of adopting an EMS. To contribute to this improved understanding and to the development of a contingency theory of environmental management, this article reports on research on how EMS may be dependent upon the strategy context in which the organization operates.

In the same time period as standard EMS was first developed, corporate strategy researchers developed a new concept for strategy formation, demonstrating that strategy could be emergent, rather than deliberate (Mintzberg & Waters, 1985). An emergent strategy was a coherent pattern of action that emerged from the organization in contrast to the deliberate strategy, which was centrally planned, approved and then imposed on the organization. Deliberate strategy was dependent on the ability to plan, and strategy contexts could be unplannable, due to the degree of complexity or rate of change in strategic conditions (Mintzberg, 2000). Strategic planning became completely ineffective in such conditions (Starbuck, 1993). Leveraging control theory to analyze management systems in different strategy contexts, Stacey (1995) noted that "formal systems operate in a stable way to secure efficient day-to-day operations while the informal system operates in a destabilizing manner to promote change". A formal system was characterised by negative feedback loops, meaning that non-conformance was met by correction, whereas informal systems on the contrary were characterised by positive feedback loops which encouraged change and caused instability.

Both ISO 14001 and 50001 were explicitly based on Deming's cycle of Plan-Do-Check-Act (PDCA). This is an example of a formal, negative feedback loop, that was explicitly dependent on an ability to plan.

It follows that the methods of management would be different, dependent on whether the role of management is to implement a planned strategy in the organization, or to facilitate the emergence of a strategy from the organization. Addressing the question of how to manage, when planning is impossible, Stacey (1995) posed a challenge for further study: "How do/should managers conduct themselves in the presence of irremovable, indeed desirable, uncertainty, surprise, unknowability, and open-endedness?". Further, Stacey divided this query into two research questions:

> 1. If they cannot plan and envision the future, what do managers actually do when they innovate, when they face the unknowable?
>
> 2. Why do managers continue to prepare long-term plans and talk about shared visions in response to the need to innovate when these are not appropriate responses?

The development of the concept of emergent strategy and the development of EMS had separate trajectories, with little attention to the effects on comparative effectivity of environmental management systems based upon different strategy contexts in research, but Neugebauer, Figge and Hahn (2015) explored corporate sustainability strategy formation in the context of planned or emergent strategy. They found that "in the corporate sustainability literature it is most commonly assumed that sustainability strategies are made in a planned way" and that this, in itself is "quite remarkable". They further argued that sustainability strategy

formation is contingent upon the strategic context of a company and recommended further research to uncover the mechanisms of this contingency, because they noted that in this issue an "important gap existed in the sustainability strategy literature".

1.1 Article purpose

The purpose of this article is to contribute new knowledge that can contribute to making environmental management more effective. This author examined the discourse of standard management systems in the perspective of the described strategy context in order to better understand the varying effectiveness of management systems in relation to differing strategic environments. The starting point for the research was to begin to address Stacey's aforementioned strategy research challenge, specifically in relation to management systems based on the plan-do-check-act cycle. As adapted for the study of management systems, the research challenge was: How do/should management systems be implemented in the presence of irremovable, indeed desirable, uncertainty, surprise, unknowability, and open-endedness? The first research question, based directly on this challenge, was:

How are complexity and change handled in management systems?

1. Research questions two and three were the same as proposed by Stacey, as applied to management systems:
2. If they cannot plan and envision the future, what do management systems do to encourage necessary innovation, when they face the unknowable?
3. Do management systems continue to call for long-term plans and talk about shared visions in response to the need to innovate when these are not appropriate responses and if so, why?

1.2 Article structure

This first section of this article introduces the context of the study, its purpose and research questions that it addresses. The second section presents the theory applied and the methods employed. The section is extensive, including strategy theory, management theory, methodology, selected datasets, methods used to work with text, and the analysis framework, each presented in a separate subsection. The findings and results of the analyses are presented in the third section, which is divided into two subsections for the two investigations described in the methods section and a third subsection for the combined analyses. The fourth and final

section presents a discussion of validity, reliability, generalizability and originality as well as the conclusions in respect to the research questions and reflections upon the methods used.

2 Theory and methodology

The purpose of this article, to search for a connection between context-dependent strategy formation and environmental management requires an unusually extensive presentation on theory and methodology, because of the limited amount of previous work juxtaposing these discourses. Furthermore, an exploration of management theory was necessary to provide a theory to inform the investigations. Additionally, the breadth of theory demanded stringent methodological development. Strategy contexts were investigated as possible contingency factors for environmental management; the research was not on strategy in itself. Therefore, no methodology is presented for analysis of strategy, per se.

The three forms of strategy formation are presented in subsection 2.1. Management theory is presented in subsection 2.2. Subsection 2.3 presents the ontological and epistemological stance of the research, and compares with the management theory presented to arrive at working definitions of key concepts. Subsection 2.4 contains a presentation of datasets selected for the investigations and the motives for their selection. Subsection 2.5 describes the methods employed to extract and code the data and lastly, Subsection 2.6 presents the analysis framework created and employed.

2.1 Deliberate, evolutionary and emergent strategies

As noted in the introductory remarks, Mintzberg and Waters (1985) introduced the concept of emergent strategy, as opposed to deliberate. Stacey (1995) presented three schools of strategy denoted as “the strategic choice school”, “the ecology school” and the “complex adaptive systems” school. Whittington (2001) presented four different perspectives on strategy, which were termed “classical”, “evolutionary”, “systemic” and “processual”. Whittington’s and Stacey’s classifications were largely similar, although Whittington subdivided Stacey’s “complex adaptive systems” category into “systemic” and “processual”.

This author used three views on strategy, following Stacey, but with a simplified nomenclature. The view designated the ”strategic choice school” by Stacey (1995), “classic”, by Whittington (2001) and “deliberate” by Mintzberg and Waters (1985) was characterized by a central strategy development that is implemented in and

effectuated by the organization. This view is herein called the deliberate strategy view. The second view termed the "ecology school" by Stacey and "evolutionary" by Whittington is herein called evolutionary, to avoid confusion with issues of natural ecology in the discussion connected to environmental management systems. The third view, designated the "complex adaptive" strategy by Stacey, encompassing both the "systemic" and the "processual" view from Whittington and based on the "emergent" view of Mintzberg and Waters, is herein called emergent.

The deliberate view is characterized by the use of "negative feedback processes of formulating plans/policies and then implementing them using monitoring forms of control" (Stacey, 1995). A fundamental characteristic of this school of thought is the assumption that management has the ability to successfully collect and analyze data about the organization's environment and based on this devise and implement appropriate plans. An influential example of this way of thinking is Porter's "five-forces" model (Porter, 1980).

In the evolutionary view, organizations are viewed as systems in an environment characterized by creative destruction and spontaneous self-organization. "Such evolving systems are so complex that agents within them cannot intend their long-term futures. Instead, those futures emerge unpredictably from the interactions between agents in conditions of non-equilibrium and disorder" (Stacey, 1995). An influential example of this school of thought is Porter (Porter, 1990) in which competition is viewed as profoundly dynamic in character, in the Schumpeterian or Austrian school: "Sustaining competitive advantage demands that a firm practice a form of what Schumpeter called 'creative destruction' on itself. It must destroy its old advantages by creating new ones. If not, some competitor will do so".

Mintzberg and Waters (1985) observed a usage of the concept of strategy not just as a decision made by top management but also as a pattern of action in the entire organization that could be observed in retrospect. Strategy could be either "deliberate" or "emergent". In the emergent strategy view behavior is "conditioned" by the organization; "behavior patterns can emerge without being intended".

2.2 Management and metaphors

Morgan (1997; 2006) presented different models or "metaphors" for organizations, categorizing the diversity within organization theory. Organizations in the respective models were denoted "Machines", "Organisms", "Brains", "Cultures", "Political Systems", "Psychic Prisons" and "Flux and Transformation". The role and methods of management depend on the view of the organization. Machine-view management is detailed control. Organism-view management is contingent upon the environment. Brain-view management must "embrace the creation of insight and

knowledge" (Morgan, 2006, p. 88), allow and even encourage challenges to accepted norms and assumptions and create systems for double-loop learning.

To the extent that the purpose of management is to implement strategy, effective management implies correspondence between the strategy view held by an organization and the management view that the organization applies. Conversely, if the strategy is emergent, the management view must support the emergence of strategy. The first three of the Morgan (2006) metaphors, "Machine", "Organism" and "Brain" correspond to the three formulae of strategy formation. In deliberate strategy formation, the organization is managed to follow the strategy derived from the strategic analysis. In the Machine view, management instructs the organization, and the organization follows. In the "evolutionary" view, flexibility and adaption are vital. The "Organism" organization is a system open to its environment, with evolutionary forces in play. Lastly, in the "emergent", the role of management is to ensure organizational learning. The "Brain" organization is learning and self-organizing. Learning itself is emergent. The "Brain" view is associated with Quinn (1992). Management is a driver of constant change. The views or metaphors on strategy and organization thus form pairs, deliberate-machine, evolution-organism and emergent-brain. Therefore, evidence of the paired organization view can be taken as evidence of the corresponding strategy view in a distinct culture.

The "Cultures", "Political Systems", "Psychic Prisons" and "Flux and Transformation" metaphors from Morgan (2006) are associated with different theories of social science. The culture view is of interest as it opens organizations to study with methods developed to study cultures, such as have emerged from interpretive sociology and social anthropology. In the culture view, the meaning attached by the organization to its environment is socially constructed. Organizations are social systems in which meaning is constructed perceptibly differently than outside the system. "Organization members actively form (enact) their environments through their social interaction" (Smircich & Stubbart, 1985). They are systems of shared meaning. The culture view is associated with the concept of Sensemaking (Weick, 1995), which is a foundation for new institutional theory (Gill, 2014). The applied theories of social science are explored further in subsection 2.3, following.

2.3 Methodology

"While there is prominent acknowledgement of a profound crisis of strategy with regards to theory, practice and education (Goshal, 2005; Mintzberg, 2004) it seems that this crisis has so far not led to a vibrant discourse about the basic concepts in this discipline from an ontological perspective" (Heil, 2008). Heil's lament is equally valid in the discourse of management systems. These discourses are instead

dominated by empiricism and pragmatism and are ontologically silent, but they are not therefore, free from ontological assumptions, because, as highlighted by Heil, "the entities being researched (in this case organisations) would necessarily have to be of a nature that makes them accessible to empirical methods (Heil, op cit).

The methodology in this research was based on phenomenological philosophy. Phenomenology in organisation research is found in sensemaking (Weick, 1995). Sensemaking is built on a foundation of phenomenology (Gill, 2014). Sensemaking represents the micro-level foundation of new institutional theory. "Phenomenological philosophy informed the development of new institutional theory (Gill, 2014, pp. 130–131). Ontologically, phenomenology implies that both the researcher's point of departure and objects of research are constructed "life-worlds". Epistemologically, the goal of the research was understanding – to convey comprehension about the object of the research to the reader. Hermeneutic phenomenology (or philosophical hermeneutics) is text analysis based on the philosophy and scientific theory of phenomenology in the tradition of Dilthey, Heidegger and Gadamer (Prasad, 2002). A phenomenological position implies an epistemological aim of understanding, verstehen, (understanding in the sense of comprehension, rather than acceptance) in the social sciences in contrast with the objective of explanation, erklaeren, in the natural sciences (Prasad, 2002). Ontologically, phenomenology rejects the subject-object dichotomy. There is simply no objective position from which to interpret an artifact such as a text. This article's author, therefore, does not claim objectivity, as that would be ontologically impossible. In contrast, this author did not take the critical position put forward by Habermas, in discourse with Gadamer. Such research has an "emancipatory" aim (Alvesson & Sköldberg, 2000), in contrast to both understanding and explanation.

The following statements from Smircich and Stubbart (1985) provided a framework consistent with the presented methodology for this author to perform research in organizations and to have developed the findings presented in this article:

- "organisations are socially constructed systems of shared meaning"
- "organization members actively form (enact) their environments through social interaction"
- "The task of strategic management in this view is organization making – to create and maintain systems of shared meaning that facilitate organized action"

Returning to Morgan's metaphors, as noted above, the "Culture" metaphor is associated with ethnomethodology, rich descriptions and an epistemological quest for understanding. It is a constructivist view, as are the remaining metaphors of "Political Systems" and "Flux and Transformation". The "Political Systems" metaphor focusses on power, enabling a Marxian analysis. This is an application of

critical theory in the tradition of Habermas, with a goal of emancipation. The emancipatory aim of research falls outside the scope of this study. The “Psychic Prisons” metaphor illustrates how “strong corporate cultures can become pathological ... the shared systems of meaning that allow them to negotiate their world in an orderly way , can become constraints that prevent them from acting in other ways” (Morgan, 2006, p. 209). It is a Freudian analysis applied to a collective. The “Flux and Transformation” metaphor is explicitly based on the works of phenomenologists Humberto Maturana and Francisco Varela (Varela & Maturana, 1972) who used biological constructivism, as a philosophical basis for ethnography (P. Parker, 1999). A critical point for this metaphor is the concept of autopoeisis, the “capacity for self-production through a closed system of relations” (Morgan, 2006, p. 243). The Flux and Transformation metaphor therefore, also rests on the epistemological basis of organisational constructed life-worlds. The philosophical distinction between the “Culture” metaphor and the “Flux and Transformation” is a fine one, and need not burden this discussion.

2.4 Dataset selection – objects of study

Two datasets were selected to represent the discourse for examination, one based on a collection of the literature of integration of management systems and the other on a case where such integration was contemplated. The literature study captured the academic discourse (Foucault, 1993) of management systems and the case study its practical implementation. In total, 48 articles were included in the study, based on a search on December 10, 2013 for "Integrated Management Systems" in peer-reviewed literature from 1982 to 2013. Rather than being a literature review, the literature study was a descriptive discourse analysis of a subset of academic writing on formal management systems, peer-reviewed research articles on the integration of different management systems.

The choice of using a body of scientific writing as a text source for hermeneutic analysis was made because of the availability and quality of the materials as representative of the established discourse. A discourse was a reflection in language of a shared understanding (M. W. Jørgensen & Phillips, 2000). This sort of text analysis of academic literature should not be confused with a within-discipline literature review designed to contextualise a piece of work and to summarise the current state of knowledge in the discipline. In the text analysis, the body of writing was not used for its scientific results, but to demonstrate a shared meaning among a peer group. Discourse analysis within a discipline is common in medicine, (cf Haddara & Lingard, 2013) and is used by researchers both within and outside the discipline. It can be a critical approach, but is not necessarily so.

A key issue in the research questions was the handling of complexity, change and the needs they raise. Integration of management systems is not in itself an object of study in this article. The integration of different management systems is a specific moment in a management system during which complexity is increased and change is handled. Although the subject of each management system individually may be viewed as complex, derived from the complexity of ecosystems, health or customer demand for environmental, health and safety and quality respectively, the integration of these systems and others as well, must necessarily add additional dimensions such as cultural differences, different skills and different methods. The integration of systems was therefore, examined as a case of handling complexity in management systems. The integration of management systems is also a moment of change and therefore, an opportunity to study how change was conducted.

The second investigation was a case study of management system documents in an organization. The selected case is the European Spallation Source (ESS), a world-class large-scale research facility in Lund, Sweden that planned to move into construction six months from the time of the study. A spallation source is a source for neutrons that are used to explore materials on an atomic scale. Spallation is a process to harvest neutrons from atomic nuclei. It is immensely, technically complex, requiring the world's most powerful linear proton accelerator, a new type of solid, rotating target and the best scientific instruments. Significant innovation is necessary to fulfill the stated requirements. The strategic issues of complexity and innovation are therefore, present in the case.

The selection of an international research facility for the case provided an opportunity to study phenomena that might be difficult to access within industry of similar scale, due to the constraints of commercial interests. Large-scale research facilities, often called "Research Infrastructure", exist specifically to facilitate research and are by default open to study. The leaders of such institutions have actively underscored the societal usefulness of Research Infrastructure facilities as test beds for sustainability research. The European Spallation Source has been particularly extensively examined and described in terms of sustainability in peer-reviewed literature (T. Parker, 2011; T. Parker et al., 2013; T. Parker & Peck, 2014; Peck & Parker, 2016; e.g. Stadlmann et al., 2014)

Research Infrastructure facilities, including ESS, are academic environments, which use processes like peer-review in their normal planning and operational processes. The Annual Review at ESS is such a process in which peers from other similar institutions gather to assess and to advise the management. This case study was based on data collected for the 2013 Annual Review at ESS. For the review, all the relevant documents for managing the project were assembled to provide a snapshot of the state of the management of ESS. The documentation for the Annual Review formed the basis for the case study. In all, 380 pages of documents were used in this

case study. The list of documents is presented in the appended supplemental bibliography. The extensive volume of text was useful, because the method used was a form of text analysis.

Data collection and initial analysis were performed (initially for an internal report) while this researcher was an employee at the ESS. This raises potential issues of preconceptions affecting outcomes that are further explored in the discussion of reliability. Also, the period between the initial data collection and the analysis, writing and submission was protracted to allow a deepened and disengaged analysis, and adequate reflection on findings and writing after this author resigned from ESS in 2015.

2.5 Text extraction, coding and analysis

For the literature investigation, text extraction and coding was performed in the form of a matrix. The rows of the matrix were the reviewed articles, and the columns were the following codes: Advantages, Disadvantages, Success factors, Challenges/Barriers, Key proposals or conclusions, Scope of integration, Scope of systems considered and Limitations of study, such as sector or nation. The headings Advantages, Disadvantages and Key proposals were expected to yield views on complexity, and the Success factors and Challenges/Barriers headings are relevant to change, specifically the change from stand-alone systems to integrated systems. The remaining categories served as a check for variations between cultural areas or industry sectors. The body of the matrix was filled with the extracted texts. **Figure 1** shows the relationship between the structure of the Review Matrix used for the literature and the central issues in the research goals.

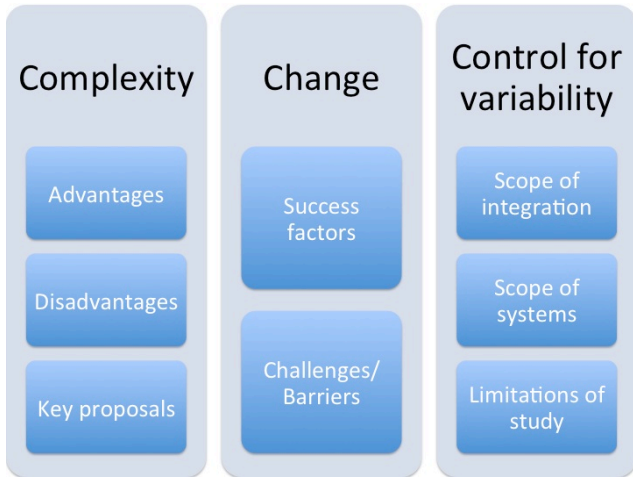

Figure 1: The relationships among the Review Matrix for the literature and the research goals.

Only articles cited in this text are included in the list of references. A full list of the articles selected to represent the discourse is included in the appended supplemental bibliography.

The text in the organization case was analyzed using a form of Attributional Coding (Silvester, 2004). This method focuses on perceived cause and effect. Every causal relationship implied in the text is marked and "extracted". The body of data thus collected was analyzed for thematic patterns. Attributions were used to investigate sensemaking in organizations. Attributional coding has been shown to be useful in studies of environmental management (T. Parker, 2013). Attributional coding was first developed as a technique for family therapy. The codes assigned for the extracted attributions were fixed and appropriate for the purpose. Because this investigation was specifically focused upon in the roles of change and complexity, complexity/simplicity and change/stability were pre-chosen as codes, and the others emerged, based on the analyzed texts and the context of this study.

For each code assigned, the passage in the document from which the attribution was extracted was categorized by the type of management system to which it belonged. The purpose of this was to enable an analysis of whether there was an observable difference between management systems based on PDCA (i.e. environment and energy), management systems based on continual improvement (also including quality) and the other management approaches. Significant differences did appear, but upon analysis and reflection the differences in this limited data set could as easily be explained by the views and styles of individual authors. These results were therefore, excluded from the findings. In addition to the attributional coding, organizational descriptions associated with specific organization metaphors were

also coded. However, the total number of this type of codes assigned was only eight, too few to constitute a useful finding.

The extensive use of coding for rigour in the analysis may be more reminiscent of a grounded theory approach than the typical rich descriptions of ethnographies of cultures. However, this research was not an application of the grounded theory approach, because it was explicitly based on meaning-based theory of behaviour and organisation. Grounded theory lacks specific ontological and epistemological foundation. "Grounded theory has been criticised for its failure to acknowledge implicit theories which guide work at an early stage" (Silverman, 2005, p. 71). In contrast with grounded theory, phenomenology explicitly presupposes that the researcher "always already" has preconceptions of phenomena. Morgan's metaphors are examples of models or theory of social science to which case data can be compared. Adequate grounding in theory is as important as rigour of analysis, for "without a theory there is nothing to research" (Silverman, 2005, p. 3).

2.6 Framework for the analyses

In order to graphically represent, analyze and discuss the findings, a structure is used to arrange the numerous concepts emerging from the strategy and organization discourses and the literature review and case studies. The structure consists simply of two axes. The vertical axis runs from Culture at the bottom to Planning at the top and was designed to capture the difference in view of how strategy was formed and how organizations are managed, following the characterizations of Stacey and Morgan.

The Planning extreme would represent a view where all strategy is developed by specialized units, and implemented by management on the organization. The Culture extreme would be a view where all strategy emerges from the organization, and the role of management is to create an environment that supports the culture. The horizontal axis runs from Control on the left to Change on the right and is intended to capture the purpose of strategy implementation and management. The Control-Change axis can be seen as 'why'-axis (no pun intended, actually the x-axis) showing intent. The vertical axis can be seen as a 'how'-axis representing the main driving force in the organization. Neither of the axes was designed to imply that these concept pairs are dichotomies, only to propose that an attempt to map the concepts along these axes may be fruitful for discussion and analysis. **Figure 2** shows this framework in a graphical representation. **Figure 3** shows the strategy views and organization views described in the introduction mapped out in a 'how-why' graphical representation.

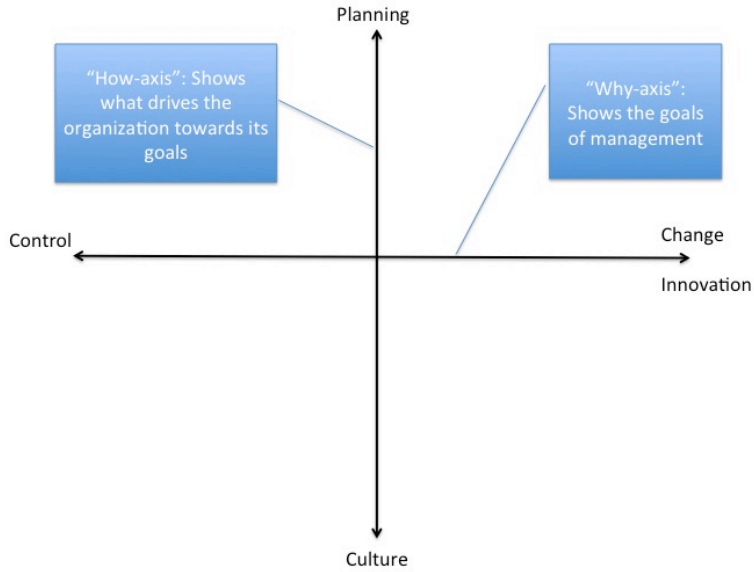

Figure 2: The graphical structure for mapping out concepts that were used in this case study

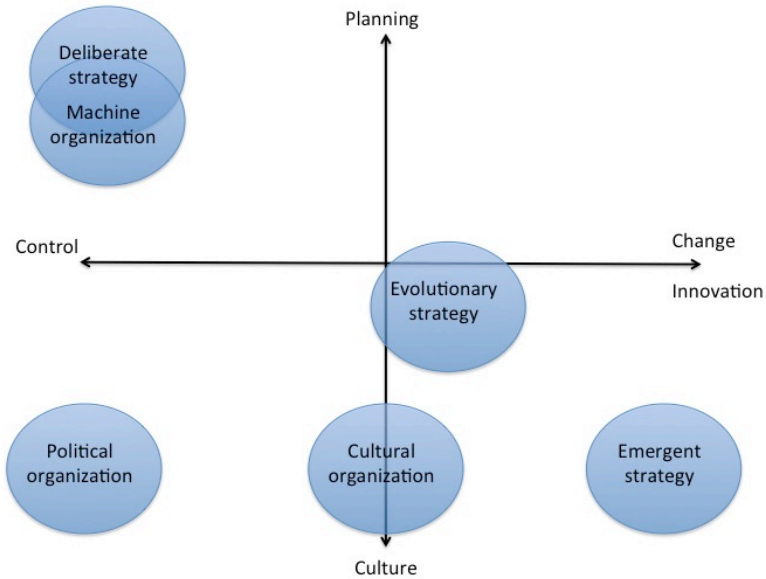

Figure 3: Strategy and organizational views mapped out in the how-why structure of this article.

A graphical depiction of meaning may be called phenomenography (Sandberg, 1994). Phenomenography is useful to discern patterns in conceptualisation (Miles & Huberman, 1994, p. 7). It harnesses the communicative and analytical effectiveness of a graphical presentation, but at the expense of the fullness of the rich descriptions that typify ethnomethodology. Since the purpose of this study required the extraction of relationships to specific concepts, the narrower analysis in phenomenography was appropriate.

3 Findings

In this section, the two datasets are first presented and analysed individually, according to the methods presented. Thereafter, in the third subsection, a combined analysis is presented, using the described framework.

3.1 Literature discourse analysis

The selected literature contained specific references to the process of integrating management systems as a way to handle complexity and also to the integration process as a process of change. This corroborates the relevance of the study to the research questions by demonstrating that the choice of literature within the subject area of integrating management systems supplied sufficient reference to the key concepts of complexity and change in relation to standardized management systems.

In the literature, the authors identified a tension between control and innovation in management systems, more of one is seen to lead to less of the other. In this view, standard MSs may hinder innovation, due to their focus on control. Management systems from ISO, in contrast with TQM for example, were described as more about control than improvement. Therefore, once again, control and improvement were described as a dichotomy, implying that control is avoidance of change and improvement is change. Only two of the articles diverged from the others by specifically discussing how to handle innovation in management systems. Tervonen, Haapasalo, and Päkkilä (2011) proposed that management systems should be constructed around systematic innovation by describing how innovation can be systematized by specifying performance to be achieved, rather than via methods of working, thus breaking the dichotomy of control versus innovation.

In relation to change, in Zutshi and Sohal (2004), successful change was described as being led by a champion. In other instances, a change culture was referred to as important. Yet another view was that change should be carefully planned to be successful. These differing points invoke different organizational metaphors. The

champion is a political figure, a leader emerging from the ranks, evidence of a metaphor of internal struggle. Change culture is a cultural view. Planning is a machine view. Similarly, to effect a culture change, in one view, strong management was seen as important, whereas in another view the authors included terms such as shared understanding, learning organization, perception and understanding.

A deliberate strategy view was evident when clear objectives were described as success factors for change and as benefits of the change to integrated management systems. There were also suggestions in the literature that competing priorities in function-specific systems could be reconciled by a computational technique, such as the proposal of Sutton (1995) to use probabilistic risk assessment of all the issues addressed by the various systems and Zivkovic et al. (2010) suggesting the use of a multi-criteria decision-making method.

Regardless of the details in the proposed technique, the proposition that the balance of priorities can be calculated, represents the antithesis to the proposition that the complexity involved could be insurmountable. Therefore, these proposals constitute an endorsement of the deliberate strategy view. A risk identified in integrating systems is that the introduction of a ranking system to prioritize issues could be miscalculated or become obsolete due to external changes, leading to erroneous choices. This is an example of complexity and change in the deliberate strategy view. The proposed response to complexity was to attempt to reduce it, by introducing a ranking system.

An evolutionary strategy view was in evidence in one of the thematic motives behind integrating management systems, improving management efficiency. Efficiency is welcome in any strategy, but is most typical of the evolutionary view, which stresses keeping costs down and options open. Flexibility is vital in the evolutionary view, meaning that the decreased flexibility that some authors described as a threat may be a result of integrating management systems, which could conflict with the strategy view. Some authors also warned against adopting unnecessary standards, as that would tend to increase costs. This can be interpreted as another example of the evolutionary view, which stipulates that the organization should travel light and be flexible.

Another possible interpretation is a reflection of the observation that the implementation of a standard management system is not always cost effective, or even effective in enhancing performance. Change in stakeholder dialog was seen as the most important change resulting from management system integration. This reflects an organism/evolution strategic view, where the organization changes from interaction with its environment. Integration of management systems was theorized to lead to improved stakeholder dialog, a way of handling complexity.

An emergent strategy view was also in evidence when the literature suggested that improved communication can be both a prerequisite for successful integration of management systems and its result, leading to a shared understanding and clarity of plans. Shared understanding is typical of a meaning-based or sensemaking view of the organization, or the brain metaphor. Sensemaking that leads to clear plans is an emergent strategy.

Cultural differences between groups within the organization represented an identified barrier to integrating management systems. This demonstrated that the culture view of organizations was present, and there were also hints of a political view, which is not consistent with the strategic planning view. A political organizational view is in evidence when proposals for effective change included "rigorous training", a strong leader, strong culture, and champions. These are political metaphors, invoking revolution and even re-education camps rather than strategy. The literature also described internal efforts to resist the changes of integration that can lead groups or individuals to complicate and confuse issues. Complexity was used as a tactic to resist change. This is an example of the political organization.

3.2 The case study of the European Spallation Source

The ESS organization was governed by its seventeen partner countries, which contributed parts of the facility in-kind. This meant that partner laboratories, throughout Europe, provided labor or equipment as their government's contribution to the facility. This put a huge wealth of skills and knowledge at the disposal of the organization. However, as the in-kind process required inter-governmental bilateral and multilateral negotiations and agreements, it tended to add to complexity in governance and management. Furthermore, ESS was multicultural; in an organization at the time of this research it was comprised of 200 people, 35 nationalities. The organization was purpose-built, with no common inherited culture and mixed academics, industrialists and builders.

The documents examined contained cross-references, and were registered in the document management system, but were not organized in a common hierarchy. Documents had clear identifiers, in a common system, with version and approval control. The documents were all on a high level, not immediately actionable for management of construction activities. The systems described were general management including project planning with earned value, scheduling and budgeting, configuration management including requirements management, systems engineering, change control, procurement and in-kind management, quality management, risk management, energy management, environmental management

and health and safety management. Document types were policies, plans, process descriptions, specifications and one guideline.

All the attributions in the documents were coded according to the selected method. A total of 179 attributions were extracted and coded. The initial number of different codes used was 22, distributed as shown in **Table 1**:

Table 1: Initial codings of attributions in the case study documents

Code	No.	Code	No.	Code	No.
Analyze	7	Enable	2	Assess	10
Describe	24	Inform	4	Plan	2
Illustrate	22	Report	1	Organize	10
Control	44	Check	2	Comply	6
Change	13	Systematize	1	Protect	2
Advise	4	Assure	1	Secure	1
Complexity	18	PDCA	1	Structure	2
Value	2				

The codes were thereafter, grouped to reduce the number of different codes for the analysis. The codes Analyze, Illustrate, Assess and Advise all implied processing information for a purpose, whereas Describe, Enable and Inform all implied supplying in a more neutral way. Control, Change and Complexity remained their own categories, whereas PDCA, Plan, Check, Report and Assure were grouped together as referring to parts of the P-D-C-A cycle of management. Organize, Systematize and Structure were all related as processes of compartmentalizing. Protect and Secure seemed related, whereas Value was deemed to be an outlier.

Table 2: Attributional coding in the text in groups

Codes	No.
Analyze + Illustrate + Assess + Advise	43
Describe + Enable + Inform	30
Control	44
Change	13
Complexity	18
PDCA +Plan + Check + Report + Assure	7
Organize + Systematize + Structure	13
Protect + Secure	3
Value	2

Innovation was not present in the management systems. Rather, it was described by omission. The management systems described, in great detail, the technical requirements of the facility, but no solution was described. It is clear that the required performance had, in many respects, never been achieved before and will require innovation. The description of organizational responsibility also made it clear who was responsible for achieving the world-leading performance in various respects. Lastly, the systems management manuals described how the results should be verified.

Actions in the case study were, to a significant extent, attributed to complexity and change, showing that these were seen to be present in the case. This corroborates that the case is relevant to the research questions. Both complexity and change were always associated with a remedy. Complexity was coupled to reduction by analysis and description. Change was clearly associated with control.

Five themes in the attributions emerged from the iterative coding process described above in the findings. In the final round of analysis, these were called: Describe, Control, Organize, Assess and PDCA.

a. Describe material was presented as the helpful, objective supply of information, often but not exclusively to help handle complexity. However, each description was crafted by one author, reviewed, approved and distributed, meaning that Describe could also be understood as a political process, where each approved description was a power base for the author. What is descriptive thereby becomes prescriptive. Description can also be seen as a manifestation of culture, or as an attempt to establish or alter culture.

b. Control was the predominant driver in the study. Change provided a significant need for control, but also compliance, safety and general performance. The planned exercising of control from above reflects a machine view of the organization and a deliberate strategy view.

c. Organize reflected efforts to compartmentalize people, tasks, data and performance requirements in order to make them manageable.

d. Assess meant gathering and processing data in a predetermined way. This may be best understood as a way of establishing or altering culture. In meaning-based view of the organization, Assess would be a much more powerful tool to affect culture than Describe, as it would establish rituals in which individuals in the organization would regularly partake. (The use of the word “ritual” here is in the sense of cultural observation and does not imply anything about the value of the process.)

e. PDCA is relatively weakly present as a driver, with relatively few explicit attributions.

The apparently intentional omission of innovation processes was a manifestation of a perceived dichotomy between innovation and control. The prevalence of the control perspective represents a mechanistic view. Indeed, the control in the case was predominantly about the design of the actual machine to be built, rather than the organizational metaphor. Because control and change were closely associated, the view on change was similar.

The complexity that was explicit in the case was technical, reflecting a world-leading research machine in the making. Strategic complexity in relation to stakeholders may also have been present, as indicated by the existence of a separate system to manage in-kind contributions, but this sort of complexity was not reflected in the material.

3.3 Combined analysis

Combining the literature analysis with the case study, the study as a whole demonstrated that the management system discourse leans strongly towards control and planning, away from innovation, change and culture. Figure 4 shows the concepts in the study in a graphical analysis. The figure also shows that there are outliers in the literature diametrically opposed to the main discourse, in this representation. This was not found in the case study.

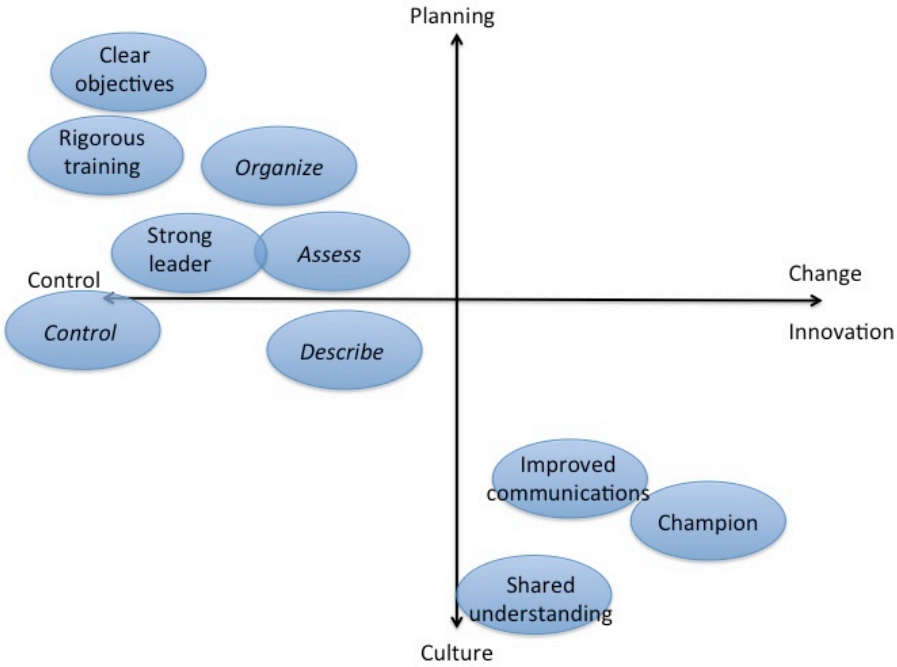

Figure 4: Concepts in the literature and in the case study mapped in the proposed structure of control-change (why) and culture-planning (how). The map shows a control/planning orientation with outliers diametrically opposed in change/culture.

The framework analysis showed that the 'how' of planning is strongly associated to the 'why' of control. There is a weaker association between the 'how' of culture to the 'why' of change and innovation. It was clearer that the need for innovation was associated with absence of detailed planning. Generally, this could be interpreted as an expression of the thought that detailed planning might deter innovation, but it could also simply express that when innovation was required, then detailed planning was not possible, precisely because it was unknown territory. In the particular instance of the case study, there seemed to exist a two-part method to allow for innovation: Refrain from detailed planning and control and set targets requiring innovation. In the data, most clearly in the case study, the existence of change (which differs from the goal of change in the framework) was a strong driver for exercising more control.

The pronounced planning-control focus of the management systems was typical of a deliberate strategy view, and a machine organization view. This diverges from the

evolutionary strategy view associated with Deming. Based on the data in this study, the implementation of management systems differs from their pronounced philosophical basis. The deliberate strategy view and the machine organization view are older, 'classic' models. The tendency for management systems in literature and practice to migrate towards those views may reflect a lack of strategy and management sophistication among management system academics and practitioners, reflecting perhaps other skill sets. This would also explain the comparative underdevelopment of culture-creation mechanisms, such as education, conversation, rituals and measurement, in management systems, despite, in some cases, explicit inclusion in standards.

Both in the case study and in the literature, the management systems exhibited strong political elements. The political organization metaphor was not definitively associated with any particular external strategy; instead it represented an internal strategy or power struggle. The management systems in this perspective functioned chiefly as power bases for various staff functions desiring influence. Such internal competition need neither inhibit performance, nor arise as an unintended effect. The competing systems and staffs vie to affect norms and cultures, together with outside influences and the results emerge from the organizations. This leads to a paradox. A group of systems, each individually strongly oriented towards a deliberate strategy, can compete internally to support a wholly emergent strategy.

For environmental management applications, it was interesting to reflect on the management role in the political organization view. Management may allow, or even tacitly encourage internal political competition to allow winning strategies to emerge. In this effort, the divergence of priorities in different implemented management systems is not a problem, but an asset, challenging the organization to process the conflicts. In comparison, in the implementation strategies in the reviewed literature, almost all problematize the loss of efficiency in duplication of staff effort, and unclear priorities. The exception was Jørgensen et al. (2006) who instead problematized creating a ranking system as a disadvantage of integration. The difference can be one of understanding of the strategic implications of the management systems, to implement a deliberate strategy or to provide inputs to sensemaking so that strategy can emerge.

In the relationship between environmental management and general management strategy, two issues appeared that might be a potential cause of ineffectiveness. The first was a risk of divergence of goals between general business strategy and environmental management. Especially for organizations implementing several different management systems (i.e. also quality, health and safety etc.), the case study demonstrated a risk of misalignment among systems, and between standard management systems and general management (Wilkinson & Dale, 1999).

Returning to EMS, EnMS and PDCA, the Plan activity typifies the strategic choice school, but the focus on continual improvement that the PDCA cycle promotes is typical of the evolutionary school of strategy and it is to this group that the strategy theorists put the efforts of its author, Deming. However, the standards also place considerable emphasis on education and training. Raising employee awareness and sensitivity to outside influence can be seen as an effort within an emergent strategy. Alternatively, it can be viewed as an effort to affect organizational culture and understanding (Burström von Malmborg, 2002).

Management system effectiveness may be connected to the system's strategy relevance. As one early study, showed: "EMSs in many cases suffer a weak strategic orientation, a low degree of integration into the central value chains and a low integration into other management systems" (Schylander & Martinuzzi, 2007).

4 Discussion and Conclusions

Before drawing conclusions from the analyses, it is necessary to reflect on the validity and reliability of the observations and on the generalisability of the conclusions, given the applied methods and the relevance of the data. Validity can be described as another word for truthfulness, in contrast to anecdotalism (Silverman, 2005, p. 34). In an interpretive view, validity may encompass both the degree of access that the researcher has had to the meanings of the informants and her/his ability to extract and convey truthful meaning in the methodology. In the dual studies presented, validity profits from the voluminous amount of accessed text, which supplied a richness of data from which to extract meaning. The two investigations were selected for abundance of publicly accessible text, thereby significantly contributing to the validity of both studies. The use of both coding and a graphical analysis method helped to ensure against anecdotalism.

The literature selected to represent the academic discourse on management systems in relation to change and complexity was based on a search for peer-reviewed materials on integration of management systems, because the act of integration represented a moment of change and increased complexity. In terms of validity, the question was if this selection validly represented the meanings of the authors in relation to the concepts of change and complexity. The result that there was sufficient reference to the key concepts that could be extracted from texts, corroborated the hypothesis that this integration literature constituted a valid extraction.

Reliability may be described as consistency over time or among researchers (Silverman, 2005, p. 33). In an interpretive view, this could be the extent to which

a different researcher would extract similar meaning from the data or if the results would be different at a different time. The literature investigation encompassed material from a protracted period. No significant trends over time were readily apparent. The coding and graphical analyses also added to reliability, by adding a structure that permitted the analyses to be repeated by other researchers and lessened the impact of preconceptions. This reliability, however, comes at the expense of the richness of description in an ethnography. The choice of the more reductionist path of phenomenography was an effect of the purpose of the study, to seek understanding in such a way as to improve management, rather than as an ends in itself.

The rigor employed for reliability carried special importance, because the researcher was an employee at the case study organisation at the time of data collection, which inevitably led to preconceptions that could potentially affect the analysis. The analysis, conclusions and writing were performed after the author's resignation from the case study organisation.

The question of the generalisability of the results was especially relevant due to the unusual type of organisation in the case study. This case study was selected for its accessibility, thus delivering validity, but bringing generalisability into question. To an extent, all case studies suffer this allegation, as no single case study can be typical of all. The strength of the case study is that the richness of data can provide the basis for formation of hypotheses of recurring phenomena or relationships that can be tested in further studies, with different methodologies. In this article, the selected case study was juxtaposed upon an analysis of a relevant academic discourse, which provided an opportunity to compare observations in the specific case, with meaning-relationships in an established discourse. The combined analyses demonstrated a strong coherence between relationships observed in the case study and in the literature discourse. This coherence implied that the relationships in the case study may be more general than the uniqueness of the organisation implies.

The originality of the research presented in this article was demonstrated by comparison with Neugebauer, Figge and Hahn (2015), a theoretical discussion illustrating that environmental management systems predominantly assume a planned strategy formation, whereas the literature of business strategy increasingly recognises other types of strategy formation. Compared with Neugebauer et al., this research adds empirical evidence and in-depth analyses that elucidates the internal processes of strategy formation, in the different strategy contexts, which is considered to be a significant contribution to the literature in this field.

The finding that different strategy contexts can simultaneously exist for different functions, for example plannable environmental management in an otherwise dynamic and or complex strategy environment, was not known from the previous

management system literature and is therefore, a significant contribution of this research.

The description of how management systems can function in evolutionary and emergent strategy environments was also new to the management system literature and is an important contribution to the further development of management systems and techniques for their implementation.

Many scholars have argued that qualitative research is most fruitful to generate hypotheses, as in "qualitative data … often have been advocated as the best strategy for discovery, exploring a new area, developing hypotheses" (Miles & Huberman, 1994, p. 10 emphasis in original). Additionally, qualitative research can be used to test hypotheses, to investigate meaning and to assess causality (Miles & Huberman, 1994). This paper reports a qualitative investigation of meaning to generate a description of causality valid for the examined evidence. Future research may use similar methods to corroborate or refute the generality of this research by application to other data sets. The results presented in this paper may also be used to generate hypotheses for quantitative research of wide data ranges.

4.1 Conclusions

The first research question posed was: "How is complexity and change handled in management systems?" In general, the research showed that the management systems seek to reduce perceived complexity and to control change. There is strong evidence in the literature and in the case study that established management systems in organizations are used as political instruments, to establish control and to hinder unwanted changes. However, there was also conflicting evidence and interpretation. Management systems were also seen to spread information, which could help enable emergent responses. This was an indication that management system functionality is contingent upon the strategy context.

The second research question was: "If they cannot plan and envision the future, what do management systems do to encourage necessary innovation, when they face the unknowable?" The evidence pointed to three ways for management systems to facilitate innovation.

a. The first is to inform of what is known, educate and train, and cause dialogue. This gives input to the process of innovation.

b. Secondly, the systems may be used to set goals that require innovation to achieve.

c. Thirdly, the systems may be used to facilitate by omission, tacitly refraining from regulating the activities necessary to innovate and achieve goals.

The third research question was: “Do management systems continue to call for long-term plans and talk about shared visions in response to the need to innovate when these are not appropriate responses and if so, why?” The plans were not necessarily a reflection of the planning view of strategy. Instead, the plans in management systems should be seen as artifacts of the evolutionary strategy view, where supporters of somewhat competing plans struggle within the organization in an evolutionary process of change.

The purpose of the plans can be seen as instruments (or rituals) to cause planning. The planning leads to emergence of shared meaning within the organization, to emergent strategy. Counter-intuitively, the plans therefore, can lead to the emergence of strategy that supersedes the plans.

Morgan (1997) used the concept of a metaphor for the organizational models presented. This underlined the point that these views are not mutually exclusive. Any organization can be viewed in any metaphor at any time, but the explanatory value of the applied model will vary. Mintzberg and Waters (1985) showed that companies had intended and emergent strategies simultaneously. Simultaneous competing strategic views might imply that the corresponding management forms can be expected to co-exist.

Management systems were conceived in the evolutionary strategy view, but in the discourse and implementation, there is a stronger emphasis on the deliberate strategy view. This need not be so, as demonstrated both in the literature and in the case study by opposing examples.

A management system at odds with the general strategic focus of the organization would seem likely to be ineffectual, and could cause tension and political competition within the organization. As this research was based only on a body of literature and one case study, more research is needed to ascertain if this is indeed true. The case study gave evidence that multiple strategy contexts can be simultaneously present in the same organization, meaning that an environmental strategy, for example, might be formed in a planned way, even if other functions of the organization exist in an unplannable environment. The simultaneous existence of different strategy formation mechanisms corroborates the statement that most strategy is formed in “a mixed way” (Neugebauer et al., 2015).

The investigations reported upon in this paper provide strong support for the conclusion that organizations seeking to create a dynamic, innovative culture and desirous of implementing a standardized management system, would do well to carefully consider management system design to support such a culture, while avoiding over-emphasis on planning and control.

The methods used in this research was based on text analysis of a review matrix and attributional coding of case material produced ample data to be able to answer the

research questions. The case study investigation was limited to a single organization, which, in all likelihood, is neither completely unique nor entirely typical. This research would therefore, greatly benefit from additional similar studies in other settings.

5 References

Alvesson, M., & Sköldberg, K. (2000). Reflexive methodology : new vistas for qualitative research. London ;;Thousand Oaks Calif.: SAGE.

Annandale, D., Morrison-Saunders, A., & Bouma, G. (2004). The impact of voluntary environmental protection instruments on company environmental performance. Business Strategy and the Environment, 13(1), 1–12.

Burström von Malmborg, F. (2002). Environmental management systems, communicative action and organizational learning. Business Strategy and the Environment, 11(5), 312–323. http://doi.org/10.1002/bse.337

Foucault, M. (1993). Diskursens ordning (Orig. L'ordre du discours). Stockholm: Brutus Östlings Bokförlag.

Gerland, P., Raftery, A. E., Ševčíková, H., Li, N., Gu, D., Spoorenberg, T., … Wilmoth, J. (2014). World population stabilization unlikely this century. Science. http://doi.org/10.1126/science.1257469

Gill, M. (2014). The Possibilities of Phenomenology for Organizational Research. ORGANIZATIONAL RESEARCH METHODS, 17(2), 118–137.

Haddara, W., & Lingard, L. (2013). Are We All on the Same Page? A Discourse Analysis of Interprofessional Collaboration. Academic Medicine, 88(10). Retrieved from http://journals.lww.com/academicmedicine/Fulltext/2013/10000/Are_We_All_on_the_Same_Page__A_Discourse_Analysis.30.aspx

Heil, D. (2008). Strategic innovation and organisational identity: A hermeneutic phenomenological investigation. Journal of General Management, 33(4), 1–12.

IPCC. (2014). Summary for Policymakers. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, … L. L. White (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 1–32). Cambridge, United Kingdom, and New York, NY, USA: Cambridge University Press.

iso_survey_executive-summary.pdf. (n.d.). Retrieved from http://www.iso.org/iso/iso_survey_executive-summary.pdf?v2013

Johnson, T. H., & Kaplan, R. S. (1987). Relevance Lost the rise and fall of management accounting. Boston MA: Harvard Business School Press.

Jørgensen, M. W., & Phillips, L. (2000). Diskursanalys som teori och metod. Lund: Studentliteratur.

Jørgensen, T. H., Remmen, A., & Mellado, M. D. (2006). Integrated management systems – three different levels of integration. Journal of Cleaner Production, 14(8), 713–722.

Miles, M., & Huberman, M. E. (1994). Qualitative data analysis an expanded sourcebook (2nd ed.). Thousand Oaks CA.: Sage.

Mintzberg, H. (2000). The Rise and Fall of Strategic Planning. London: Pearson Education Ltd.

Mintzberg, H., & Waters, J. A. (1985). Of Strategies, Deliberate and Emergent. Strategic Management Journal, 6(3), 257–273.

Morgan, G. (2006). Images of Organization (Updated ed.). Thousand Oaks: SAGE Publications.

Nawrocka, D., & Parker, T. (2009). Finding the connection: environmental management systems and environmental performance. Journal of Cleaner Production, 17(6), 601–607.

Neugebauer, F., Figge, F., & Hahn, T. (2015). Planned or Emergent Strategy Making? Exploring the Formation of Corporate Sustainability Strategies. Business Strategy and the Environment, n/a-n/a. http://doi.org/10.1002/bse.1875

Parker, P. (1999). Cognition and social organisation : a framework. Lund, 1999. Retrieved from http://ludwig.lub.lu.se/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat01310a&AN=lovisa.001158140&site=eds-live&scope=site

Parker, T. (2011). Cutting Science's electricity bill. Nature, 480, 315–316.

Parker, T. (2013). The view from below – a management system case study from a meaning-based view of organization. Journal of Cleaner Production, 53(6), 81–90.

Parker, T., Andersson-Ek, P., Bengtssson, R., Blücher, A., Didriksson, M., Eriksson, R., … Österback, R. (2013). ESS Energy Design Report. European Spallation Source ESS AB. Retrieved from http://europeanspallationsource.se/sites/default/files/20130131_ess_edr.pdf

Parker, T., & Peck, P. (2014). Greening for Bosons. Presented at the 55th ICFA Advanced Beam Dynamics Workshop on High Luminosity Circular e+e- Colliders – Higgs Factory (HF2014), Beijing. Retrieved from http://indico.ihep.ac.cn/event/4221/other-view?view=standard

Peck, P., & Parker, T. (2016). The 'Sustainable Energy Concept' – making sense of norms and co-evolution within a large research facility's energy strategy. Journal of Cleaner Production, 123, 137–154.

Porter, M. E. (1980). Competitive Strategy. New York: Free Press.

Porter, M. E. (1990). The Competitive Advantage of Nations. New York: The Free Press.

Prasad, A. (2002). The contest over meaning: Hermeneutics as an interpretive methodology for understanding texts. Organizational Research Methods, 5(1), 12–33.

Quinn, J. B. (1992). Intelligent Enterprise. New York: Macmillan.

Sandberg, J. (1994). Human competence at work: an interpretive approach. Gothenburg: BAS ek för.

Schylander, E., & Martinuzzi, A. (2007). ISO 14001 - experiences, effects and future challenges: a national study in Austria. Business Strategy and the Environment, 16(2), 133–147.

Silverman, D. (2005). Interpreting Qualitative Data : Methods for Analysing Talk, Text, and Interaction. London; Thousand Oaks, Calif.: Sage Publications.

Silvester, J. (2004). Attributional Coding. In Essential Guide to Qualitative Methods in Organizational Research (pp. 228–241). Sage.

Smircich, L., & Stubbart, C. (1985). Strategic Management in an Enacted World. Academy of Management. The Academy of Management Review, 10(4), 724–737.

Stacey, R. D. (1995). The Science of Complexity: An Alternative Perspective for Strategic Change Processes. Strategic Management Journal, 16(6), 477–495.

Stadlmann, J., Gehring, R., Jensen, E., Parker, T., Seidel, M., & Spiller, P. (2014). Energy Effciency of Particle Accelerators: A Networking Effort within the EuCard2 Program. In Proceedings of IPAC2014, Dresden, Germany (p. Dresden, Germany). Dresden, Germany. Retrieved from http://accelconf.web.cern.ch/AccelConf/IPAC2014/papers/thpri102.pdf

Starbuck, W. H. (1993). Strategizing in the real world. International Journal of Technology Management, 8(1–2), 77–86.

Sutton, I. S. (1995). Integrated management systems improve plant reliability. Hydrocarbon Processing, 74(1), 63.

Tervonen, P., Haapasalo, H., & Päkkilä, J. (2011). Contribution of integrated environment, safety, security and quality management to business excellence. Integruotos Aplinkos Apsaugos, Saugos, Saugumo Irkokybės Vadybos Sistemų Poveikis Verslo Tobulumui., 6(1), 53–68.

Varela, F., & Maturana, H. (1972). Mechanism and Biological Explanation. Philosophy of Science, (3), 378.

Weick, K. E. (1995). Sensemaking in organizations. Thousand Oaks: Sage Publications.

Whittington, R. (2001). What is Strategy and Does it Matter? London: Thomson Learning.

Wilkinson, G., & Dale, B. G. (1999). Integrated management systems: an examination of the concept and theory. TQM Magazine, 11(2), 95.

Zivkovic, N., Mijatovic, I., Janicijevic, I., & Kudumovic, M. (2010). The Role of Design and Development Process in Integration of Management Systems (Uloga procesa projektovanja i razvoja u integraciji menadžment sistema). Technics Technologies Education Management, 5(1), 88–99.

Zutshi, A., & Sohal, A. (2004). Environmental management system adoption by Australasian organisations: part 1: reasons, benefits and impediments. Technovation, 24(4), 335–357.

Other publications by this author

Parker, T. (2011). Cutting Science's electricity bill. Nature, 480 315-316.

Parker, T. (2013). Sustainable Accelerators. In: EuCARD'13, CERN, Geneva, 2013-06-12.

Parker, T. (ed), Andersson-Ek, P., Bengtssson, R., Blücher, A., Didriksson, M., Eriksson, R., Fröjd, C., Gesterling, M., Gierow, M., Indebetou, F., Jensen, F., Jurns, J., Lindström, E., Lundgren, D., Nilsson, M., Persson, J., Persson, T., Renntun, M., Stenlund, J., Strömberg, S., Strandberg, G., Stråth, N., Swartling-Jung, M., Wiegert, M. & Österback, R. (2013). ESS Energy Design Report. ESS reports, ESS-0001761. European Spallation Source ESS AB.

Parker, T. & Peck, P. (2014). Greening for Bosons. In: 55th ICFA Advanced Beam Dynamics Workshop on High Luminosity Circular e+e- Colliders – Higgs Factory (HF2014), Beijing, 2014-10-09.

Parker, Thomas and Kiessling, Anders (2016) Low-grade heat recycling for system synergies between waste heat and food production, a case study at the European Spallation Source, Energy Science & Engineering, 10.1002/ese3.113, http://dx.doi.org/10.1002/ese3.113

Seidel, M., E., J., R., G., J., S., P., S. & Parker, T. (2015). Improving the energy efficiency of accelerator facilities. In: 6th International Particle Accelerator Conference, Richmond, VA, USA, 2015-05-03.

Stadlmann, J., Gehring, R., Jensen, E., Parker, T., Seidel, M. & Spiller, P. (2014). Energy Effciency of Particle Accelerators: A Networking Effort within the EuCard2 Program. In: 5th International Particle Accelerator Conference, Dresden, Germany, 2014-06-15.

Weisend, J., Darve, C., Gallimore, S., Hees, W., Jurns, J., Köttig, T., Ladd, P., Molloy, S., Parker, T. & Wang, X. (2014). Status of the ESS Cryogenic System. In: Joint Conference of the Transactions of the Cryogenic Engineering Conference (CEC) / Transactions of the International Cryogenic Materials Conference, Anchorage, AK, June 17-21, 2013. American Institute of Physics. 633-638. http://dx.doi.org/10.1063/1.4860761.

About the author

I completed my masters in Engineering Physics at Lund University in 1994 and joined the Department for Industrial Environmental Economics, thereby having the great privilege of being part of the founding group of the International Institute for Industrial Environmental Economics (IIIEE). I left the IIIEE in 1998 after completing my Engineering Licentiate and joined the energy utility, 'Lunds Energi,' as the Environmental Manager, at a time when the electricity market was being deregulated. I worked there for eight years, shifting positions often, primarily within business development and also including two years as the managing director of the energy retail business and a year as the head of energy trading. After this period, I was recruited to be CEO of NEMS AB, a nanotechnology start-up, where for two years, I led the company to a proof-of-concept of the technology phase, before joining the European Spallation Source as Head of Energy Division for six years. The ideas and business concepts developed for ESS formed the bases for the foundation of the energy-recycling start-up WA3RM AB, where I have worked since the summer of 2015. This chronology demonstrates that I have many years of management experience, with a strong emphasis on business development, innovation and change. My political views are strongly held and fiercely liberal. I have a strong attachment to science, both natural and social.

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This dissertation demonstrates that Environmental Management Systems function differently, depending on the strategy context the organization operates in. To be effective, environmental management needs to employ management practices appropriate to the strategic setting, as suggested in this dissertation.

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