Advancing the application of tools and concepts from Industrial Ecology / Sustainability Science towards Corporate Sustainability: based on a study of Spier's search for a sustainable, lower carbon future

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Abstract:

Life cycle-based analysis is widely used to calculate ecological, carbon and water footprints of entities while the industrial metabolism metaphor underpins business management approaches such as eco-efficiency, dematerialization and life cycle management. Business strategy and goals aimed at reducing the environmental impact of a business such as Spier target lower carbon emissions (carbon neutral); reduced water consumption and rain-harvesting (water sustainability); and waste minimization (zero waste). Sustainability reporting and GHG emissions calculation offer a credible means of measuring progress on a trajectory to sustainability transition. Efforts aimed at 'learning for sustainability' by training employees at all levels and building networks with learning institutions are also underway; as are climate change mitigation efforts guided by industry alliances of climatologists, agricultural economists and farm-owners in the Western Cape. However, there are inconsistencies in year-on-year reporting, delays in shifting the supply chain and gaps in implementation, particularly in the area of energy efficiency and adoption of renewable energy solutions. Organizational drivers underpinned by a sustainable micro-ecology perspective on their own are not sufficient catalysts for change. A socio-ecological systems approach holds promise as a more comprehensive framework, whereby a business is encouraged to formulate mitigation and adaptation strategies in the face of global change to ensure corporate sustainability.

Keywords: corporate sustainability, socio-ecological resilience, carbon neutral, life cycle management

1. Introduction

1.1 Background

The case study research began with the goal of assisting and guiding Spier Holdings to achieve a carbon neutral status by 2017. Exploration into the intellectual underpinnings of footprint analysis led the researcher to unravel the concepts and metaphors developed in disciplines such as Industrial Ecology and Ecological Economics, claimed as the hard sciences of sustainability by their practitioners. Lower emissions require technological innovations at various fronts and recent impetus in the application of science and technology for sustainable development (Holdren, 2008; Fiksel, 2006; Turner et al, 2003; Kates et al, 2001) has yielded an entirely new field named by its proponents as Sustainability Science. Sustainability science is dedicated to advancing a scientific understanding of human-environment systems (Clark, 2007;

Clark and Dickson, 2003). Concepts and tools from industrial ecology and sustainability science which can assist a business in strategy formation towards a sustainable trajectory are described in Section 2.

The research, grounded in a South African case study, taps into recent advances in the conceptualization and application of the sustainability sciences, taking place internationally and locally. South Africa presents a unique research opportunity whereby the conceptual divide between the global North and South (see 'Sustainability Science in a divided world' in Kates et al, 2001) is not as neat as in other nations. For example, SA businesses enjoy first world infrastructure, energy reliability and stable market structures while also facing developmental challenges of the South such as high inequality in income, welfare and education levels and high vulnerability to severe impacts of climate change. In addition to developmental demands, SA businesses thus face the challenge of coping with climate change through investments into appropriate adaptation and mitigation technologies. Businesses in the agriculture and leisure industry face greater disruption from a discontinuation of current weather patterns. Additional risks associated with climate change involve political responses in the form of nationally imposed carbon taxes or carbon capping, and in their absence, internationally imposed border tax adjustments.

Spier, a medium-sized, wine producing and leisure business in the Western Cape has established sustainability as a brand pillar over the last two decades and more recently, has defined certain macro-level organizational goals in response to threat from climate change. The performance goals require increased operational reliance on renewable sources of energy. The methodology followed in obtaining information with regards to Spier's search for renewable energy is described in Section 3 of the paper.

Three related trends in Spier's investigations towards a sustainability transition provide fertile ground for analyzing the organizational conditions and drivers that promote innovation and the adoption of renewable energy solutions by small to medium-sized businesses. These trends include the practice of sustainability reporting since 2004 and in particular, GHG emission calculation since 2008; the setting up of 'carbon neutral status' as a long-term climate change macro-goal for 2017; and the ongoing association with the Centre for Renewable and Sustainable Energy Studies (CRSES), since 2007, to evaluate and assist Spier in adoption of different renewable energy solutions. These trends and their analyses are described in Section 4 of this paper. Preliminary conclusions and recommendations are offered in Section 5.

1.2 Research objectives

The primary research objectives are to unearth:

- driving forces relevant to a sustainability transition, in particular adoption of renewable energy solutions and energy efficiency measures, through the case study of a South African medium-sized business as a complex adaptive system.
- synergies and trade-offs between improved production and resilience building, in particular making a case for business spend on renewable sources of energy (or innovations) which are expensive in the short-term but could increase long-term system resilience.

2. Conceptual underpinnings

The hard sciences of sustainable development are founded on a 'systems ecology' perspective whereby insights gained from studying the energetics of ecological systems may be applied to social issues (Ropke, 2003). Ecology which is inherently an evolutionary, holistic and philosophical endeavour provides the framework for comprehending socio-ecological systems in a way that static and reductionist conventional economic thought does not (Stanfield, 1977; Kates et al, 2001). Since the aim of the thesis is to find common ground between 'hard ecology' as represented by tools from the sustainability sciences and 'practical ecology' as exercised by decision-makers seeking corporate sustainability, a good starting point is to briefly articulate the conceptual roots which underpin the sustainability sciences and find application in related fields such as process engineering, environmental management, earth science and business studies.

2.1 Industrial Ecology (IE)

At a conceptual level, IE can be understood as one of four ways in which industry (or technology); environment and society may interact in order to achieve global sustainability (Graedel and Allenby, 1995): radical ecology, deep ecology, industrial ecology and continuation of the status quo. IE is offered as part of a techno-optimistic vision of a sustainable future, requiring substantial adjustments to current economic and cultural systems, with great emphasis on technological evolution or green engineering that enables pursuit of current industrial activity within environmental constraints (Graedel and Allenby, 1995).

IE supports environmental improvements at a systems level. Powerful concepts such as the biological metaphor to change currently unsustainable production systems into sustainable systems are employed. Human industrial systems are seen as embedded in the natural eco-system, requiring at a minimum, optimization of total materials and energy cycles in industrial processes and lessening impacts through waste minimization and recycling (Frosch and Gallopoulos, 1989; Graedel and Allenby, 1995; Garner and Keoleian, 1995). The biological metaphor encourages human industrial systems to change from linear material flows to cyclic or closed processes such as those found in natural systems, achieved in part by substantially decreasing resource inputs, increasing the flows within the four main nodes (the materials extractor, the materials processor or manufacturer, the user and the scavenger or recycler) and within the industrial ecological system as a whole and ultimately rejecting the idea of waste in type III ecological behaviour (Socolow et al, 1994; Graedel and Allenby, 1995).

2.1.1 IE and environmental science

The application of the above metaphors aids industrial engineers in studying the flows of selected materials within modern economic processes through supply chains and structural paths and analyse the factors which influence these flows. Such analysis involves the application of material flow accounting (MFA), firmly established as an influential region-specific framework for quantifying the use of natural resources such as wood, energy or water and man-made materials such as steel, by modern societies (Behrens et al, 2007).

A combination of MFA and geochemical techniques allows simplified quantification of global cycles of nutrients such as carbon, nitrogen, phosphorous and sulphur in their natural and perturbed forms (Socolow et al, 1994; Graedel and Allenby, 1995; Rockstrom et al, 2009). Earth system budgets or flow analyses are traditionally investigated by environmental scientists; however once the industrial component of a flow becomes substantial, the industrial engineer acquires a comparable role (Graedel and Allenby, 1995). Creation of a world systems model on climate change with global warming scenarios based on regional flow analyses of carbon dioxide is also an application of MFA. These two applications form the basis for carbon footprint calculation as a means of measuring an entity, a region or a country's contribution to global warming.

As a tool for environmental design and resource management, MFA can also be applied to a community, an industrial sector, business or household. It can be used to study the flow of a single substance or a group of substances associated with a specific environmental effect. Examples of substance flow analysis include quantitative studies of for instance lead, cadmium or mercury through the industrial and environmental systems (Graedel and Allenby, 1995).

While the dominance of natural science and engineering aspects of IE has been critiqued (Korhonen et al, 2004; Korhonen, 2008) and although huge knowledge gaps still exist within earth system science (Ayres, 1989; Rockstrom et al, 2009), efforts at quantifying human additions to the preindustrial global cycles carries important messages for political and technological responses to global change. Possible strategies that arise from an analysis of human modifications to the global carbon and nitrogen cycles include substituting plant matter or biomass for fossil fuel through a bio fuels industry based on renewable plantations and finding substitutes for fertilizer use (Socolow et al, 1994) such as regenerative organic farming (LaSalle and Happerly, 2008). Furthermore, researchers such as those at the Rodale Institute recommend low-tillage farming and organic management of soil in order to convert agricultural land into a carbon sink rather than a source of green house gases (LaSalle and Happerly, 2008).

2.1.2 IE-inspired management concepts

IE as a branch of analysis evolved into more than quantification techniques to yield concepts such as dematerialization and eco-efficiency. Based on a thorough literature review in the field, Brent et al (2008) consider dematerialization, with its suite of analytical tools and technological innovations for green engineering, as one of two key elements of IE (the other being industrial eco-systems or the establishment of islands of sustainability such as eco-industrial parks). Eco-efficiency, a management term with its roots in IE principles, was coined by the World Business Council on Sustainable Development in 1993. Increased eco-efficiency means a quantitative reduction of wastes and emissions of production per unit of output costs, including use of less raw materials and fuels through cleaner technologies and clean production systems (Korhonen, 2008). At a stretch, eco-efficiency may be understood as encompassing the goals of both dematerialization and decarbonisation or energy efficiency[1].

However, the eco-efficiency concept is critiqued for not questioning the continuation of current global production and consumption patterns; it only requires them to become more efficient

[1] Energy efficiency as a concept emerges out of energy studies with an engineering approach, and comes equipped with scientific models and equations for reducing energy consumption for every unit of utility.

through innovation in technology (Korhonen, 2008). Korhonen and Seager (2008) critique eco-efficiency from a resilience perspective and argue that indicators of eco-efficiency optimization such as a lower carbon footprint omit attributes such as spare capacity, adaptability and redundancy, which may be necessary for production system resilience.

Generation of aggregate consumption indicators such as ecological footprints of nations and companies and carbon footprints of consumers and entities are some of the latest applications of life cycle analysis (LCA), the most prominent and widely used process engineering tool to emerge out of IE practice. Over the last two decades it has generated a sizeable community of analysts and practitioners. In its early days, LCA was used as a first step to indentify problematic points in a chain, when companies or manufacturers decided to reduce their environmental impacts. Matthews and Lifset (2007) argue that the field of LCA with its focus on improving quantitative methods has much to gain from retaining synergies with IE where the emerging focus is on application of tools and concepts to real life problems. The cradle to grave approach encourages companies to look beyond their gates, upstream and downstream at their suppliers and users and their production and consumption choices, thus inspiring ‘life cycle thinking’. In this form LCA, primarily a ‘process improvement tool’ finds application as a ‘sustainable management principle’, fitting in neatly with the eco-efficiency goal.

2.2 Sustainability Science

Sustainability science, defined as use-inspired or problem-driven basic research, seeks to understand the interactions among humans (including their cultural, political, economic and demographic characteristics), their technologies and the environment (Burns and Weaver, 2008) and guide these interactions towards more sustainable trajectories (Clark and Dickson, 2003). In a seminal article just before the World Summit on Sustainable Development in Johannesburg, 2002, Kates et al (2001) highlighted three pathways for the field: wide discussion and interaction among the scientific community on research methodologies and institutional needs; keeping science connected to the political agenda and; focusing on social learning for the transition to sustainability. In the ten years since, the field has found expression in numerous research agendas within the natural and social sciences and given a home to transdisciplinary research which seeks to apply innovation in science and technology towards social well-being within planetary thresholds. Contributions to the seven core questions of sustainability science (see Kates et al, 2001) range from earth system science findings to political ecology writings, in search of sustainable solutions to meet humanity’s developmental goals (Clark, 2007).

2.2.1 Frameworks for sustainability analysis

Sustainability scientists have extended the application of MFA to unravel the notion of socio-economic metabolism and create the Material and Energy Flow Accounting (MEFA) framework. The MEFA framework is proposed to consistently integrate three parts: MFA (material flow accounting), EFA (energy flow accounting) and the HANPP (human appropriation of net primary production (Vitousek et al, 1986) through extended input output analysis. Sustainability scientists (e.g. Haberl et al, 2004; Fischer-Kowalski and Haberl, 2007; Behrens et al, 2007) believe that the calculation of societal metabolism through a MEFA framework allows a more holistic assessment of a society’s ‘progress towards sustainability’ vis a vis its ‘colonization of natural eco-systems' through land use change (agriculture and forestry) and extraction of renewable resources through fishing, hunting etc than does either ecological footprinting or the economic valuation of ecosystem services.

The MEFA framework overcomes charges levelled at techno-optimistic approaches such as eco-efficiency by looking beyond the environmental aspects of society-nature interaction to consider the cultural or symbolic system as a sphere of causation, distinct from the eco-system (Haberl et al, 2004). The view that a social-ecological system results from the overlap of natural and cultural spheres of causation allows monetary flows and lifestyle choices to be linked to bio-physical stocks and flows and these in turn to ecosystem processes (Fischer-Kowalski and Haberl, 2007). The utility and application of the MEFA framework is most appropriate at global, regional or national spatial scales due to methodological reasons (Haberl et al, 2004). Its application to very small scales of individual establishments such as Spier will therefore be methodologically challenging.

A set of sustainability analysis approaches, suitable for multi-scalar decision-making, are proposed under the banner of resilience management for socio-ecological systems (Walker et al, 2004; 2002). An array of dynamic modelling techniques such as bio complexity, system dynamics and thermodynamic analysis are being pursued by different research groups to analyse the impact of ambiguities or uncertainties resulting from key variables such as climate change, technological innovation and policy response on human-environment or socio-ecological systems (SES) (Fiksel, 2006; Walker et al, 2002). What these qualitative techniques have in common is the recognition that steady state sustainability models are simplistic, that SESs are complex and adaptive and that effective decision-making with regard to sustainability needs to increase system resilience in the face of shocks and disturbances (Holling, 2001; Gunderson & Holling 2002). The participatory approach to resilience management incorporates the cultural sphere of influence as 'unforeseeable reactions of people to unfolding change in an SES' and their visions, hopes and fears as 'drivers of change' when building scenarios (Walker et al, 2002).

Various types of resilience analysis seek to identify where resilience resides in a system and understand how and when it is lost or gained with the aim of developing strategies which increase resilience (Fiksel, 2006; Walker et al, 2002). Within resilience analysis, the process of attempting to increase resilience to unforeseen change is clearly distinguished from the process of attempting to improve system performance during times of stability and growth (Walker et al, 2002). The propositions arising from recent resilience related research suggest that a range of systems including ecosystems, institutional systems and socio-ecological systems display adaptive capacity and appear to move through the four phases of an adaptive cycle (Walker et al, 2006). An avatar of the biological metaphor, the adaptive cycle contains the four characteristic phases of growth, conservation, collapse and rebirth (Holling, 1986; Janssen, 2002), although empirical evidence suggests that in the case of social and institutional systems, human intent can suppress transition from one phase to another (Walker et al, 2006). In some instances, a rebirth phase can be organized without going through the upheaval of collapse while in other cases a system can be confined to a consolidation phase.

Attention to the adaptive capacity and cyclic pattern of a resilient system is found lacking in continuous improvement management principles, newly expressed in downward trending carbon footprints of entities (Korhonen and Seager, 2008) and in decision analysis processes such as cost benefit analysis and LCA, which aim to continually maximize profits or minimize environmental impacts. The current lack of systems-oriented management and analytical tools to address corporate risk arising from global ambiguities and uncertainties is cited as a leading constraint preventing SA businesses from making meaningful contributions to sustainable development (Haywood et al, 2010).

2.2.2 An emerging research agenda in the sustainability sciences: local solutions for global problems

Korhonen (2008) noted that the full integration of natural and social science perspectives or transdisciplinarity is a difficult aim for IE. Nevertheless, such integration was kick-started with an international symposium on the theme of Business and Industrial Ecology as part of the 2003 annual Business Strategy and the Environment Conference in Leicester, UK. Application of IE to business and policy studies was foreseen in the areas of inter-organizational management for the rerouting of flows of matter, energy and information in complex production-consumption networks; establishment of islands of sustainability at industrial zone or regional level; and promoting IE as a vision and source of inspiration for management strategy beyond eco-efficiency (Korhonen et al, 2004). The contributions from new initiatives in IE towards sustainable development are widely recognised (see Brent et al, 2008; Clark and Dickson, 2003). Further collaborative research efforts from natural and social scientists are required to address the complex human-environment interactions causing global change.

In keeping with the post-Johannesburg Summit sustainability transition agenda, close co-operation with local agents involved in meeting developmental needs of communities and carbon reduction initiatives at community level are increasingly embraced from a science and technology perspective (Mulugetta et al, 2010; Clark and Dickson, 2003). While sustainable development priorities were inspired by the MDGs and set at an international level within the WEHAB (water energy health agriculture and biodiversity) framework, the role of innovative solutions at local (place-based or enterprise driven) level was recognized as pivotal towards the achievement of sustainability goals (Clark and Dickson, 2003). Local level initiatives are now hailed as low carbon exemplars in the absence of a legally binding treaty post-Copenhagen to push large, nation-wide investments in carbon reduction technologies. Community-based interventions are seen as having high innovation potential with regards to low-carbon technologies and great creativity for democratized decision-making (Mulugetta et al, 2010). Growing literature on sustainability-oriented innovation systems focuses on incentives and investments to encourage innovation, within local and urban socio-ecological systems (Swilling and Fischer-Kowalski, 2010; Stamm et al, 2009).

2.3 A socio-ecological research program for corporate sustainability in SA

Businesses in SA are reported to increasingly conduct triple-bottom line reporting, adopt a range of codes and standards for social and environmental accounting and spend on corporate social investments (Trailogue, 2009). Driven in part by legislative directives and international reporting trends, such initiatives are linked to a growing engagement with the post Johannesburg Summit corporate citizenship (CC) agenda. Authors on the subject point to the one business sector which is conspicuously missing from the emerging CC agenda: the small and medium-sized enterprises in SA (Fig, 2005; Visser, 2005; Hamann et al, 2003). Several of the catalysts for change noted in the case of large firms such as brand management linked to global markets and scrutiny from local civil society organizations, are absent in the case of SMEs unless they are part of supply chains of bigger companies (Fig, 2005). Loss of market share is not seen as a sufficient driver to bear the additional cost burden of adherence to sustainability standards required by upstream companies, even among SMEs with favourable BEE scorecards (Hamann et al, 2003).

While the questions around the definition of CC or corporate social responsibility seem to have been sufficiently addressed, there are still gaps in the analysis of drivers or catalysts for change towards responsible business behaviour in SA. Exciting research opportunities also exist in exploring the manifestation of corporate sustainability, that is, the technologies and systems change practices that can be embraced by a corporate entity aiming to contribute to sustainable development (Hamann et al, 2005; Schwarz, 2006; Draper, 2006).

An important driver for action stems from recent appreciation for the risks and uncertainties faced by the SES within which business activities take place (Haywood et al, 2010; Hamel and Valikangas, 2003). The application of an SES framework to business management allows an understanding of both large firms and small enterprises as part of a regional eco-system and their investments as contributors to building their own and the larger system's resilience. An emerging research agenda is highlighted in assisting businesses of all sizes to comprehend the causal feedbacks and loops existing between entities within an SES (Haywood et al, 2010). As captured in the vision of socio-ecological metabolism, various entities in an SES share the same natural resources, develop and deploy various technologies and solutions, for energy generation, waste recycling and wastewater treatment and must face the same societal and environmental risks and uncertainties (Haywood et al, 2010; Walker et al, 2002). Furthermore, it is possible to trace the trajectory of a business on a sustainability path as an adaptive cycle (Walker et al, 2006). Immense research opportunities thus exist in the application of sustainability science tools such as resilience / vulnerability frameworks to business analysis, incorporating the notions of system adaptability and transformability.

With the aim of enhancing corporate sustainability, some underlying tensions which this research aims to address are whether the concepts and tools from IE usefully guide business managers, especially from the SME sector, to make informed decisions in favour of a sustainability transition and the value of a resilience analysis framework in generating meaningful information to assist in business strategy formation in the face of global, regional and internal uncertainties.

3. Research methodology

The empirical work was undertaken over six months (February-August 2010) and included qualitative information gathering among Spier staff and intermediaries through semi-structured interviews and review of formal management documents and sustainability reports. A quantitative analysis of water and energy consumption as well as waste generation by the business was gleaned from sustainability reports from 2004-2009.

The themes and phases described in the Spier sustainability story consolidate events, trends and practices which emerged through a study of the Spier Development Framework, Spier's sustainability reports, management level documents and proposals and interviews and interactions with a range of Spier staff including creditors, book-keepers, accountants, group accountant Christie Kruger, farm manager Orlando Filander, facilities manager Cherie Immelman, cellar master Frans Smit, key senior management personnel including the CEO, the COO, Director Finance and Director Marketing and several intermediaries. The intermediaries are external to Spier but provide valuable personal insight into Spier's pursuit of a sustainable, lower carbon future. They include but are not limited to Eve Anneke and Mark Swilling: co-founders of the Sustainability Institute, Tanner Methvin: Spier's non-executive Director of Sustainable Development at board level, Gareth Haysom: ex-Director of Spier Resort Management, Riaan Meyer: research engineer at the Centre for Renewable and Sustainable Energy Studies, Rob Worthington and Denise Bester from Trialogue: the firm commissioned to write Spier's Sustainability Reports for the financial years 2008-2009 and 2009-2010 and Frank Spencer from Emergent Solutions: a service provider of renewable energy.

The full case study of Spier's search for a sustainable future will be analyzed using a socio-ecological systems (SES) framework (Walker et al, 2006; 2004; 2002), based on the notion of building resilience for sustainability, which goes beyond eco-efficiency (emissions reduction) and corporate social investments (Hamel and Valikangas, 2003).

4. Results and findings

The sustainability story of Spier can be narrated at many levels. At one level it is the story of uniquely different leadership styles which accentuated specific aspects of sustainability. Starting out as a business exploring diverse socio-economic and environmental aspirations, Spier set out on a journey of embedded sustainability, which meant moving beyond one-off external projects to transforming own business operations. This required cascading Spier shareholders' vision into top and senior management's performance measures with the hope that the vision will be embraced and realized. At another level, it is the challenge of balancing financial stability against ecological custodianship, as the Spier businesses developed and matured.

Spier's ongoing journey to sustainability is captured through various themes pertaining to different phases in time. The first of the evolving strands of the narrative captures the pioneering years of the story from when the estate was bought in 1993 to roughly 2002. This exciting phase of the business' evolution created the brand Spier as it is now recognized in South Africa and internationally. Efforts to achieve commercial success and organizational stability at the wine and leisure businesses received extra impetus near the end of the first phase but are articulated in two separate yet inter-connected stories that take us into mid-2003. The next phase described in the narrative begins when Adrian Enthoven entered the business, first as chairman of the board and later as CEO in 2004. Under his leadership, various disparate efforts under the banner of sustainable development were consolidated for the first time, as was the reporting thereof in an annual sustainability report. Alongside the organizational processes aimed at embedding sustainability into the core of the business are three key ongoing endeavours aimed at reducing Spier's ecological footprint – the search for effective renewable energy solutions for Spier's existing infrastructure; experiments with wastewater treatment and solid waste recycling. The adoption of 10-year macro-goals such as carbon neutrality and poverty alleviation in 2007 signifies the latest phase in the business' journey. The last section is a mirror of where Spier is now, as of end of financial year 2010, in terms of tracking progress on the sustainability path, devolving sustainability to individual employee level and devising an effective strategy for the future. The full narrative is available from the author upon request.

Relevant components related to renewable energy and ecological sustainability initiatives are presented in this paper in the following condensed formats:

- Table 1: Spier sustainability story: a modified adaptive cycle (growth, conservation, collapse and rebirth based on Holling, 1986)
- Table 2: Range of renewable energy and energy efficiency projects explored by Spier (2006-2010)
- Table 3: Experiments with on-site wastewater treatment by Spier (2002-2007)
- Table 4: Solid waste recycling by Spier (1999-2010)
- Table 5: Sustainability reporting, sustainability standards and footprint analyses conducted by Spier (2004-2010)

Table 1: Spier sustainability story A modified adaptive cycle (growth, conservation, collapse and rebirth based on Holling, 1986)			
Three definitive phases	**Growth: revolutionary beginnings (1993-2003)**	**Conservation: organizational stabilization (2004-2007)**	**Continued conservation: consolidation (2008-2010)**
Characterizing features of adaptive cycle phases	Readily available, large investments Accumulation of infrastructure and capital	Reduced capital investment Slow growth Increasingly interconnected organisation	Post-financial crash Contained spending Financial and environmental prudence
Critical events / trends	Establishment of Village Hotel Extension of wine production facilities	Third party validation GRI-based sustainability reporting Culture of goal-setting Discussion on and commitment to Spier values	Rationalization of organizational goals into 2 macro themes: • Socio-economic: poverty alleviation • Environmental: climate change (carbon neutral) Carbon footprint calculation LCA-based CF of a bottle of wine
External investments	Establishment of Lynedoch primary school Sustainability Institute (SI) Pro-poor tourism: promotion of black-owned tourism ventures	Ongoing financial commitment to Lynedoch primary school Training of employees at SI Redefinition of pro-poor projects: shift to focus on business procurement from PDIs	Ongoing financial commitment to Lynedoch primary school Training of employees at SI
Experimentation / innovation re sustainability	Vermiculture Adobe brick-making Go organic Ecological design principles Biolytix	Bio-diesel plant Unique, centralized waste water treatment plant (combining science, art and metaphysics) Investigation of bio-fuel project Green venture capital started	Investigation of greening projects Biodynamic farming Wetland conservation Investigation of CSP Procurement of recycled materials
			Biodiesel plant shut down Bio-fuel project not pursued Biolytix sold to Earth Capital Green Capital closed
Resource minimization efforts		Installation of water meters Energy saving devices: 10% reduction in electricity consumption	Installation of more water meters Timers installed on geysers Trigger matrix system installed to switch off sections of the Hotel

Table 1: Spier sustainability story (continued) A modified adaptive cycle (growth, conservation, collapse and rebirth based on Holling, 1986)			
Three definitive phases	**Growth: revolutionary beginnings (1993-2003)**	**Conservation: organizational stabilization (2004-2007)**	**Continued conservation: consolidation (2008-2010)**
Defining ideologies w.r.t. sustainability	Sustainable micro-ecology	Sustainable business management	Sustainability accounting
Dominant paradigms during different phases	Local community development and environmental custodianship alongside financial success for brand establishment	Organizational and financial stability to house innovation in renewable energy generation, green venture capital	Financial stability, integration of goals with business purpose Financial incentives for organization-wide sustainability-oriented innovation
Instruments driving sustainability	Guidance from external experts: Tom Darlington (architect) Ralph Freese (entrepreneur) Mark Swilling and Eve Annecke (community development projects, ecological design)	Informed leadership: CEO: Adrian Enthoven Director of Sustainable Development: Tanner Methvin	Employee and manager-level sustainability learning and implementation (decentralization)
Sources of information pertaining to specific periods	Semi-structured interviews: Mark Swilling and Eve Annecke Spier Development Framework, 1999 Place of Hope Gareth Haysom, Director: Spier Resort Management	Sustainability reports (2004-2007) Semi-structured interviews: Tanner Methvin, Spier board member Gareth Haysom, Director of Sustainable Agriculture Module, SI Cherie Immelman, facilities manager Frans Smit, cellar master Orlando Filander, farm manager	Sustainability report (2008) Organisation-wide and intermediary semi-structured interviews: Cherie Immelman, facilities manager Christie Kruger, group accountant Accounting staff Senior management team including CEO, COO, Director: Finance and Director: Marketing Frank Spencer, Emergent Energy Riaan Meyer, CRSES Alan Brent, CRSES Rob Worthington and Denise Bester, Trialogue

Table 2: Range of renewable energy and energy efficiency projects explored by Spier (2006-2010)	
Renewable energy generation projects	
2006	Biodiesel production plant: highly successful test batches run with on-site cooking oil with full production of 1 million litres expected in 2007
2007	Biodiesel production plant discontinued due to unexpected supply reduction
2008	Biomass generation from quick growing trees on estate for gasification or conversion to biodiesel, CRSES commissioned to conduct LCA-based feasibility study in July, 2008 with input from agricultural science, forestry and process engineering departments
2009	Biomass generation not pursued: economic reasons and scale imperative Available land reengaged for biodynamic farming and wetland conservation
2010	Concentrated Solar Plant proposed by Prof Alan Brent as an Eerste Valley solution Unlike energy-on-tap type of solutions such as biodiesel and biomass, a CSP will feed into the national grid and offset conventional energy consumption at Spier. Process heat from the CSP can be used for cooling in the wine cellar.
Energy-efficiency and energy saving projects	
2008	An electrical load survey study of hotel rooms reveals high usage through water heating and air-conditioning As a result, timers installed on geysers and trigger matrix system to switch off sections of the hotel during low season
2008	Re-commissioning of hotel's solar water heating system considered but not pursued
2009	Proposals received for solar water heating of banqueting kitchen, subsumed into greening projects
2009	Proposals received for greening of the conference and banqueting facility: • Detailed energy audit • Energy efficiency interventions • Roof-mounted PV panels CRSES involved in comparative evaluation of proposals and presentations G-Tech proposal considered the best, not pursued due to financial reasons
2010	Proposals received for energy-saving at Hotel through a centralized hot water systems using solar heat pumps CRSES involved in comparative evaluation of proposals G-Tech proposal considered better, not adopted in 2010 since funds no longer available

Table 3: Experiments with on-site wastewater treatment by Spier (2002-2007) Underlying principle: waste recycling and reducing environmental burden	
Up-till 2003	Septic tanks and pit latrines for houses, Package plants for commercial areas requiring constant maintenance
2002	Partnership with Dowmus (Pty) Ltd, an Australian company to set up Biolytic filtration plant
2003	2 Biolytix facilities installed and functional, wastewater used for irrigation Septic tanks still in use for some buildings
2006	Discovery that Biolytix plant not functional
2007	A biological effluent treatment plant installed using a bioreactor, aeration pump, a reed bed and a ying-yang pond using a combination of scientific engineering and metaphysical cleansing techniques Monthly reports by contacted maintenance company indicate waste water meets DWAF standards for treated effluent, used for irrigation Cleansing action equated to 344 km of flow in a natural river system

Table 4: Solid waste recycling by Spier (1999-2010) Underlying principle: waste minimization and re-use	
1999	Disposal on a tip site on estate and transported by Spier to a municipal dump
2002	On-site waste removal by a local, black-owned company called Nov Waste Food-based waste given to a local pig farming co-operative
2006	80% recycling achieved of waste collected by Waste Plan Focus on separation of refuse at the point of generation
2010	89% recycling achieved: management believe a ceiling has been reached
Converse focus since 2009	Shifting procurement and consumption patterns: Products made from recycled materials, 1% achieved in 2010. Target of 50% by 2017

Table 5: Sustainability reporting, accreditations and footprint calculations by Spier (2003-2010) Underlying principle: tracking progress on the sustainability path	
2003	Fair Trade in Tourism South Africa (FTTSA) accreditation for Spier Resort Management, one of five in the country
2004	Wine Industry Ethical Trading Association (WIETA) accreditation for Spier wine
2004	158 measurable indicators drawn up based on GRI-based guidelines and South African legislative requirements
2004-2006	Sustainability reports from the office of the sustainability director capture an intense review process of the Spier businesses and maintain a consistent reporting style over the 3 year period SR for 2006 won 2 industry awards for best Sustainability Report
2007	Ten year macro-goals established including achievement of carbon neutral status, water sustainability and zero waste by 2017
2007-2008	Limited copies printed on paper, available on-line. Produced by the Directors of HR and Marketing
2008	Global Carbon Exchange (GCX) commissioned to conduct a carbon footprint analysis of Spier operations based on available information
2009-2010	Trialogue commissioned to write a belated 2009 SR and a 2010 SR Internal calculation of Spier's carbon footprint by the group accountant
2010	LCA-based carbon footprint of a bottle of wine to draw attention to emissions in the packaging and distribution stages of wine production Preliminary water footprint of estate (excluding embedded water in procured products) to aid management decision-making Ongoing processes to receive BEE accreditation for all business units

4.1 Observations and discussion

Based on a preliminary systems analysis of the information presented above, the following observations are made:

4.1.1 The Spier sustainability story follows a modified adaptive cycle:

In addition to what is captured in Table 1 above, it is not exactly clear if Spier actually went through a short collapse phase post-2008 financial crash after which a new management team was put in place underpinned by financial prudence. Thus the seemingly continuous trend of consolidation may have had a short chapter of upheaval in between. However, the phase of rebirth and rejuvenation generally witnessed after a collapse, whereby bound up resources are released, has not emerged. What is definite is that the current business strategy is to drive organisation-wide sustainability through measurement tools and performance indicators, recently integrated with footprint analyses. While the post of sustainability director was never filled again since 2007 with the intention of decentralizing sustainability-oriented innovation, the task of reporting on sustainability lays with the finance director.

4.1.2 Multi-scalar shifts, events and trends impact the Spier adaptive cycle:

Following Walker et al, 2002, 2006, the observed shifts, crises or non-linearities in the Spier business system result from processes and structures interacting across scales. The macro scale comprises of socio-economic forces such as union membership, urban transport unreliability, coal-based conventional electricity and global financial cycles, specifically the financial crash of 2008, over which Spier has little control. The micro scale compromises of process and structures within the business such as the separate procurement drives within the wine and leisure businesses to address environmental and social concerns, the greening projects, and various environmental initiatives driven by shareholder interest (biodynamic farming, wetland conservation, composting site using waste from packing-shed and Eerste river management). The micro processes are currently the focus of integration efforts by management. At the same level as Spier are organizations such as the SI and the CRSES, containing experts with distinct mental models and knowledge areas and providing a platform for social learning to take place within Spier, necessary to navigate the transition to sustainability. At this level are also affiliations of agricultural economists and other farm-owners such as the SAFWI (South African Fruit and Wine Initiative) set up to ‘confront climate change’ within the Western Cape fruit and wine industry through carbon emission calculation and reduction strategies.

4.1.3 Eco-efficiency optimization targets for lower emissions, waste minimization and recycling require sustainability-oriented innovation to be fully achieved

Up to a point, goals for solid waste recycling, energy efficiency and procurement from recycled and less-resource intensive materials can increasingly be met by following continuous improvement principles. For instance, the climate change macro-goal is addressed through operational decisions such as – lighter weight bottles, recyclable wine cases, humidifiers and solar bulbs in the cellar, harvesting of rain water from the cellar buildings, installation of water meters and water saving devices and solar water pumps. However, beyond a point, as noted by the facilities manager in the case of Spier’s waste recycling, a ceiling is reached. Furthermore, beyond energy efficiency measures, the goal of carbon neutral may only be achieved in a sustainable manner by off-setting conventional energy use on-site with renewable energy generation. Off-setting emissions by investing in an off-site clean development mechanism has been shown to be unreliable for a variety of reasons including non-standardisation of carbon calculations, gaps in local expertise where CDM projects are implemented and uncertainty around the real value of a CDM project in reducing emissions (Murray and Dey, 2008). Thus, the path from current practices to sustainable goals is not one of continuous process optimisation, as portrayed by eco-efficiency thinking, but rather a leap as signified by systems change and achieved through sustainability-oriented innovation. A successful innovation is the wastewater treatment on the Spier estate, which uses a highly ingenious method combining engineering techniques with metaphysics and art.

4.1.4 Renewable energy innovation and experimentation is a separate structure following its own adaptive cycle within the larger business cycle:

Innovation in renewable energy at Spier was begun in 2003 with investigation of biomass and biodiesel production facilities. The larger business at his time was in a conservation phase. Due to various economic reasons, the projects were not pursued. Empirical evidence suggests that while Spier continues to explore energy efficiency measures and further renewable energy options, implementation in this cycle has not occurred since 2008 for a variety of reasons. The last investment made in this area was the installation of timers on geysers and a trigger matrix system for the hotel. The cycle is locked into exploring emergent solutions as opposed to trying and testing. Thus, although Spier's strategy is to devolve sustainability-oriented innovation to individual operational manager level, there is not much evidence to prove that this approach to corporate sustainability is translating into actual achievement of emission reduction. The macro goal of reaching carbon neutral status by 2017 would require much more activity in this cycle.

4.1.5 Management decisions pertaining to (non) adoption of renewable energy solutions are linked to the type of analytical tools used:

Lack of investment into the greening project and more recently, the solar heat pumps, is linked to the analytical tools used by the technical reviewers from CRSES and the presentation techniques used by the renewable energy service providers. These tools and techniques have been reductionist in their approach, evaluating the financial benefits from investment in solar panels or heat pumps over the short term, with no reference to the kinds of investments required to build the long-term resilience of a business in the face of future risks and uncertainties, or the impact of such investments on the resilience of the larger socio-ecological system of which Spier is a part. These tools continue to be utilised as the basis for decision-making since they are compatible with the current dominant paradigm within the organisation of financial prudence, over and above social and environmental innovation. The current phase of continued conservation at Spier aims to drive corporate sustainability through eco-efficiency measures based on footprint analyses.

5. Conclusions and recommendations

5.1 Conclusions

The combination of a business cycle which is in consolidation mode, a management ethos centred on financial prudence, an operational paradigm of continuous improvement principles, and the use of reductionist analytical tools contribute to minimal investment in innovation, in particular, adoption of renewable energy solution. All of these forces do not bode well for encouraging organisation-wide sustainability-oriented innovation, necessary for building resilience in the system. The systemic characteristics at Spier also signal difficulties in achieving a carbon-neutral status by 2017 and in retaining the role of industry leader with regards to sustainability.

Based on the Spier case comparison and resilience-based analysis above, the following conclusions are put forward:

5.1.1 The search for driving forces relevant to a sustainability transition within corporate sustainability, in particular adoption of renewable energy solutions and energy efficiency measures, needs to be informed by a resilience management framework. Drivers may occur in the form of informed leaders, experts external to the system or systematic sustainability learning within an organization over a period of time, depending upon the particular phase of an adaptive cycle which the business is in. Drivers which work in one phase may be ineffective in other phases. Furthermore, innovation is difficult if a business cycle is locked into a drawn out conservation phase and is not allowed to reconfigure.

5.1.2 Synergies exist between production improvement and resilience building when sustainability-oriented innovation allows eco-efficiency targets to be fulfilled, while increasing system resilience. Trade-offs exist when innovations such as renewable energy solutions are adopted based on their ability to increase business and SES resilience in the long-term even when eco-efficiency based measures such as life-cycle and cost-benefit analysis indicate financial loss in the short-term.

5.2 Recommendations for managers and renewable energy practitioners

- *Recommendation for managers of businesses:*

Adaptability is hailed as the capacity of human actions in an SES to manage resilience through the unique human capacity for foresight and deliberate action (Walker et al, 2006). Managers are thus in a position to adopt strategies which increase system resilience and allow a business to transform, that is, change or reform without going through the trauma of system collapse. Managers must keep in mind the shifts and trends taking place at scales above and below the business system and become aware of the particular phase that the organisation is in. Using Spier as a case comparison, managers are encouraged to create an impetus for organization-wide sustainability-oriented innovations, through various means including dedicated innovation funds and investments in sustainability learning.

- *Recommendation for renewable energy practitioners:*

It is important for technical consultants and engineers to be cognizant of the phase of adaptive cycle which their business clients are in, in order to ensure actual implementation of renewable energy solutions by the clients. Risk is a critical component of business decision-making and pro-renewable energy decisions need to be presented as increasing the adaptability, transformability and resilience of a system. Life-cycle based cost benefit analyses may not capture a 20-year strategic reference cycle of a business and may direct investments away from renewable energy innovations in the short term.

Renewable energy practitioners and managers are thus advised to use the recent developments in resilience management theory and practice as a reference framework when promoting or considering the adoption of renewable energy solutions.

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