Drivers for sustainability-related innovation: A Qualitative analysis of renewable resources, industrial products and travel services

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INTRODUCTION

This paper analyses the role of environmentally and socially beneficial innovations and the integration of sustainability aspects with corporate strategy in private firms as antecedents and critical factors for sustainability leadership. This theme is particular relevant from a European point of view given the recent communications and initiatives by the European Commission on CSR and sustainability as well as the prominent role of the latter in the new 7th Framework Programme of the EU. Also the Lisbon agenda with its focus on the quality of life of European citizens requires that firms reconcile sustainability aspects with profitability and innovation has been identified as key to defuse sustainability demands, which immediately leads on to the question how innovation can be directed to specific forms of technological progress and when it actually should be (beyond policy makers attempting to merely influence the rate of innovation).

The theoretical approach focuses on two streams of literature to address the topic of the paper. Firstly, using concepts from the strategic management literature it is argued that special organisational capabilities or routines which improve responsiveness to sustainability challenges are needed, such as capabilities for stakeholder integration, higher-order learning and or for continuous innovation as well as higher-order dynamic capabilities related to these (Marcus & Anderson 2006; Aragon-Correa & Sharma 2003). This view is related to the evolutionary perspective of the firm (Cohendet et al. 2005) which is based, amongst other things, on a dual theory of the firm (Cohendet & Llerena 2005). Reasoning based on this stream of literature leads to the question whether leadership for sustainability is a new dynamic capability or an augmentation of established capabilities (Teece et al. 1997; e.g. Marcus & Anderson 2006) and whether stakeholder integration or innovation capabilities are novel and separate capabilities or established capabilities that are changing incrementally towards sustainability? Secondly, drawing on the literature on technology and innovation management, a focus is put on the role of individuals as promotors (e.g. Witte 1973; Hauschildt & Gemünden 1998), and on the gatekeeper concept (Allen & Nochur 1992) to illuminate, how the actual process of integrating sustainability aspects in innovation activities and corporate strategy works. Based on exploratory data collected during thirteen in-depth case studies in American, French, German and Swiss firms matched for size and industry sector, critical elements in corporate structures and processes are identified that lead to the integration of sustainability aspects into innovation processes and strategizing. The case studies are focussing on renewable resources for mobility and communication applications as well as industrial products and travel services and draw on interviews with several members in each organisation responsible at senior management level for sustainability, strategy and innovation aspects

which were carried out based on qualitative interview guidelines. To triangulate and supplement the findings from these interviews corporate reports and press releases, archival data and publicly available third-party information were additionally used. The core research questions are: “Are there specific competencies related to environmental/sustainability aspects that trigger environmentally or socially beneficial innovations?” and “Who in the company assumes leadership for including environmental or sustainability aspects into innovation processes?” The paper discusses preliminary results from analysing the thirteen firms for which case studies were carried out. The research finds that some leadership for environmentally and socially beneficial innovation is needed in terms of board responsibility and formal integration of sustainability aspects in processes and that the realization of environmentally and socially beneficial innovation and the integration of sustainability aspects with corporate strategy is often a bottom-up activity, leading to new emergent strategies in the sense of Mintzberg (1991). The analysis also shows that market demand is a pivotal factor that limits or pushes suppliers particularly in business-to-business contexts towards leadership for sustainability. As well regulation is identified as a critical enabling factor for sustainability-related innovation. Finally, the paper identifies a need for tools needed to assist in managerial or political decision-making – e.g. to integrate corporate sustainability strategies with business strategy and discuss implications of this, e.g. with regard to the activities of the European Commission or other policy-making bodies.

The remainder of the paper is structured as follows: Section 2 outlines the concept of sustainability-related innovation and the role of leadership, functional integration and regulation. Section 3 discusses how evolutionary perspectives of cooperation and here in particular open innovation processes and user innovation, especially in the context of lead markets, matter for sustainability-related innovation. Section 4 describes the empirical analysis and Section 5 presents the results in terms of empirical insights into the role that leadership, integration, regulation and cooperation, open innovation and user innovation have for sustainability-related innovation based on the case studies carried out. Section 6 discusses the findings and concludes.

CONCEPTUALISING SUSTAINABILITY-RELATED INNOVATION

Defining sustainability-related innovation

Sustainable development is defined in the Brundtland Report “Our Common Future“as follows: “*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”* (WCED 1987: 54). Already the Brundland Report, immediately after this famous definition states that in terms of needs, the focus should particularly be on those of the poor in developing countries and in doing so provides an early link to the current Bottom-of-the-Pyramid (BOP) innovation debate (Prahalad & Hammond 2002; Prahalad 2005; 2006). In this sense, one can conceptualise sustainability is a bundle of public goods (intra- and intergenerative equity, improvement or preservation of environmental quality, protection of human

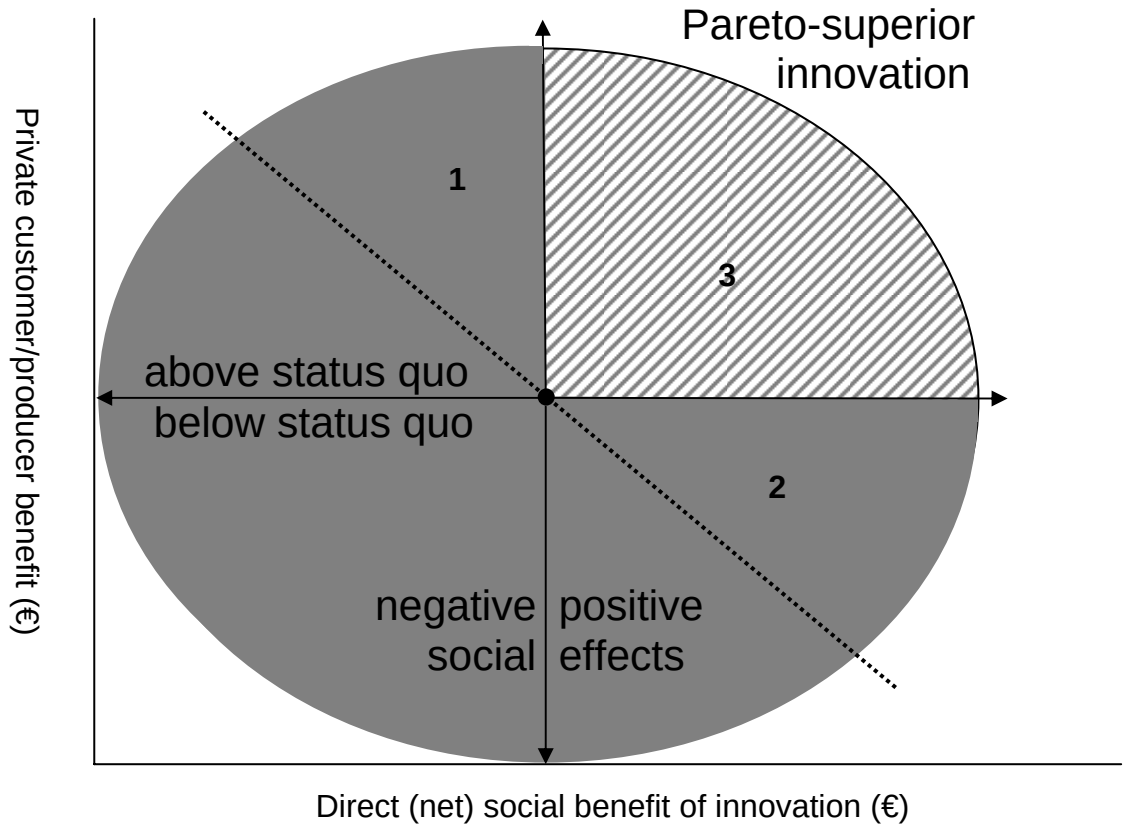
health and innovation is one key approach to preserve these public goods. For example, Fichter (2005, 84-87; 371-373) distinguishes five types of sustainability strategies and identifies amongst these the innovation-based strategy as the one which can contribute most to sustainable development. At the same time he argues that the innovation strategy enables private benefits to firms by creating new markets and market segments. Because of this conceptual prominence for sustainable development, sustainability aspects in innovation processes have received increased intention of policy makers. For example, in October 2006, Federal Secretary of State for the Environment Sigmar Gabriel proposed at the Ministry of Environment Innovation Conference that *"Germany should establish itself as a responsible energy efficiency and environmental technologist in the global division of labour between nations"* (Gabriel, 2006 translated from German by the authors). He made this statement whilst pointing out the high relevance to the ministry of the link between innovation and the environment, particularly stressing the role of of industrialised countries as lead users and lead markets in areas such as sustainable energy technologies, products based on bio-materials or nanotechnology and recycling processes. In order to enable a more specific analysis, the term sustainability-related innovation shall be defined more precisely. Hauschildt (2004) distinguishes generally three categories he proposes to measure innovation success, namely (direct or indirect) technical effects, (direct or indirect) economic effects and other effects. He explicitly refers to environmental and social effects as specific subcategories of other effects. Hauschildt and Salomo (2005) address interactions of different factors with the degree or level of innovation and based on their reasoning, one can derive, that sustainability-related innovations have a high degree or level of innovation since in their case the environmental and social effects are intended, i.e. represent additional demands. However, it is based on this reasoning a very valid question whether sustainability-related innovation is a special type of innovation in a qualitative sense, or just "better managed innovation", i.e. innovation, where more target criteria are integrated and made mutually compatible. Such innovation would in this sense only be a quantitative extension of the above performance categories of innovation success, rather than a qualitatively new form of innovation. Given that already Ogburn (1933) defines innovation as the solving of societal problems, it seems difficult to identify the added benefit of defining a "sustainability innovation" (based extending the definition of an "environmental innovation") beyond additional environmental benefits in a similar manner as for „environmental innovation". However one way of defining "sustainability innovation" (Fichter 2005) could be to divide it into "environmental innovation" (Rennings 2000) and social innovation in terms of bottom-of-the-pyramid (BOP) innovation (Prahalad 2005; 2006), since the latter seem to be an important future form of sustainability-related innovation because it addresses directly some of the foci mentioned directly after the definition of sustainable development in WCED (1987). Whereas for environmental innovation as e.g. defined by Rennings (2000: 322) reduced environmental burdens (i.e. reduced external effects) are an essential and quantifiable criterion to delineate them from other innovation activities, it seems that the benefit of a

“social” innovation is hard to discern from the generally positive social welfare effects ascribed to innovations in general. Even for environmental burdens, the actual effect can often only be established ex-post and an analogous transfer to the social effects of an innovation (such as e.g. e-learning) seems not to be trivial. These considerations raise doubts, whether a definition of “sustainability innovations” that as a consistency criterion should also include all environmental innovations as a subset is feasible. This together with the doubt of whether there are qualitative differences between innovations leads us to the use of the term sustainability-related innovation in the remainder of this paper.

In a more detailed analysis, it seems to be relevant to whom the social benefits (i.e. the positive social welfare effects/reduced negative external effect) accrue, e.g. does it run completely in parallel with private benefits? For example if Shell introduces biofuels this may significantly cannibalise existing sales (in case of a largely stagnant market or in case they can not introduce this fast enough in fast growing markets like China) and therefore their incentive to innovate is low, even though the social benefits are likely very high. The opposite example would be that of an integrated process technology to reduce the emissions of a firm, which is used by the firm in its own processes, but is not sold (e.g. to other firms in the same industry which may face similar challenges such as tightening of regulation). In this case, private benefits of the firm are not diminished by the increased social benefits. More generally, one can distinguished based on these examples, firstly, sustainability-related innovations in which (partly incremental) product or process modifications lead to reductions in energy or material consumption or emission reductions at the implementing firm or the customers of its products, who consequently should have a positive willingness to pay (at least in the order of the material or energy or waste/emission disposal cost saved by the firm or its customers). Examples of this type of innovation are cars with lower petrol consumption, more energy efficient industrial processes or water recycling and even though both the social and the private benefits stem from the same reduction of a negative external effect, they are additive (because for a firm under perfect competition a cost reduction would transfer into a price reduction that would enable customers to increase their utility by freeing part of their budget for additional consumption of goods). Secondly, there are sustainability-related innovations, where such cost savings are not the case and in this case the innovator would not be able to appropriate private benefits, but would exclusively increase social welfare by reducing negative external effects (which does not imply that this positive externality is higher than in the case of the first type of innovation, nor that the increase in social welfare is higher than for the first type of innovation, but that an innovator will not be able to gaining additional private benefit from carrying out the innovation). However, the innovators may demand a compensation from society for carrying out the innovation and may make this a precondition for actually innovating, e.g. by adding a mark-up to the price of their products which obviously partly depends on their market power and on the regulatory situation.

Distinguishing the two types of sustainability-related innovation reveals a more general issue of the crowding out of sustainability-related innovations. Assume that social benefits S1 and S2 and private benefits P1 and P2 (including the appropriable private benefit relating to the reduction of a negative external effect) exist for two innovations 1 and 2, then crowding out of the innovation with higher S (innovation 1 in this case without affecting the generality of the argument) occurs if S1 + P1 > S2 + P2 but P2 > P1 (i.e. S1 >> S2). In this case a firm would have the incentive to pursue innovation 2 despite the fact that innovation 1 would result in a bigger increase of social welfare, representing a case of market failure. Arguably, different solutions exist to rectify market failure. For example, a subsidy (P2 – P1) could be provided to the firm, compensating it for the foregone private benefit if realising the socially more desirable innovation. Of course in this case, the net social benefit of that innovation would be only (S1-S2-P2+P1) and this does not have to be positive in all situations. The above reasoning counters the argument that innovations with a private benefit will be carried out anyway by firms (and explains the anomalies observed in firm behaviour with regard to energy efficiency investments). Hence the sustainability related innovation would only be pursued autonomously by a firm if the private benefit is also higher, i.e. if P1 > P2.

FIGURE 1: Link between economic radicality and direct social benefit of an innovation[1]



[1] Direct social benefits refer essentially to the reduction of negative externalities which exist under the current regulatory regime.

Finally, Figure 1 illustrates, that the higher the economic radicality (as defined in Arrow, 1962) of an innovation (i.e. the cost reduction the innovation brings about for e.g. producing a good whilst keeping the benefit of that good constant) is relevant for sustainability related innovation, too. This is because the higher the economic radicality, the higher is the potential of an innovation to compensate for negative social effects of that innovation (e.g. because it implies a high level of resource consumption). Assume the grey and dashed-grey area in Figure 1 (i.e. the full circle) is the set of all possible innovations. If social benefits and economic radicality are monetarised in a way that both axes of Figure 1 have the same scale, then conceptually, all innovations below the dashed line running from the upper left to the bottom right are not sustainable in that either they have both, negative social effects and no economic radicality, or their compensation potential due to the (lacking) economic radicality of the innovation is so low that it cannot compensate fully for the increased resource use. This can be termed the "Playstation World" based on the notion, that such innovations neither provide positive social effects, nor do they meet consumer at a cost so much lower, that the consumer could at least in principle compensate society with his savings for the negative social effect. The areas denoted (1) and (2) in Figure 1 represent innovations that are (1) sufficiently economically radical to compensate negative social effects or (2) where the positive social effect would justify to society to accept a lower level of economic radicality (i.e. reduced consumer surplus) because the total cost/benefit (i.e. the increase of consumer surplus through price reductions plus the monetarised positive social benefit) to society would remain unchanged. Innovations in areas (1) and (2) could thus be termed compensatory sustainability-related innovations. Finally, those innovations in areas (3) of Figure 1 (represented by the dashed-grey quarter of the circle) are those that are Pareto-superior, that is if technologies or innovation opportunities exist in areas (1) and (3) with the same level of economic radicality then the latter are to be preferred from a societal point of view. Innovations in areas (2) and (3) of Figure 1 are what is traditionally understood as a sustainability-related innovation (or, more specifically, if the positive direct social effect refers to a reduced environmental externality, an environmental innovation). In an ideal world where negative externalities are fully internalised via the price mechanism society would be indifferent to any negative social effect such as a negative environmental externality and thus would have no preference towards innovations in the areas (2) and (3) of Figure 1. However in a material world where absolute physical limits exist with regard to non-renewable resources as well as concerns the stability of global ecosystems and the carrying capacity of systems such as the climate system increasing the economic radicality of an innovation without reducing negative social effects is insufficient. In other words, next to the rate of technological change (and its acceleration) the direction of such change needs to be taken into account by society to ensure that limits are reached as late as possible and this requires innovation that has positive social effects.

Defining a business case for sustainability-related innovation

Innovation that advances sustainability seems to require both, (technologically) radical system innovations that massively improve the environmental or social performance of goods or production processes whilst keeping consumer benefits and utility constant and many smaller and more incremental (product- and process-related) innovations in the existing and production and consumption systems that have a path-dependent (and hence partly irreversible) history frequently resulting in at least short- to mid-term system lock-in and inertia. Such more incremental innovation still improves the eco-efficiency of production processes and/or the environmental performance of „minor“ or “fringe” goods in use and consumption systems, such as office lighting or the energy efficiency of a printer.[2] Yet, incremental innovation often is not able to realise a globally optimal system configuration in a multi-dimensional production and consumption system space. Based on these considerations, one question that arises is what the conditions are for spontaneous emergence of activity aiming for sustainability-related innovation (be it in larger or smaller firms or for the mass market or an initial niche market)?

Based on these considerations, the question arises as to what the conditions are for spontaneous emergence of sustainable entrepreneurship or sustainability innovation (be it in larger or smaller firms or for the mass market or a niche, respectively)? A key requirement for spontaneous emergence seems to be the existence of a business case, i.e. a demand side that enables profitable sustainability innovation (see Schaltegger and Synnestvedt (2001), Schaltegger and Wagner (2006) and Wagner and Schaltegger (2003) for the fundamental logic behind a business case for sustainability). This implies amongst other things, that the willingness to pay (WTP) in the relevant market is sufficiently for the product or process innovation in question. If no business case exists, e.g. because of low WTP the state could intervene in order to regulate market failure if the sustainability innovation in question represents a high social benefit, i.e. if the level of internalisation of the external effect (e.g. through taxes or certificate systems) is low.

It could be though, that the innovation generates such an increase in private benefit, that the market (i.e. customers) are willing to pay a compensation for negative externalities from the innovation (e.g. in terms of environmental impacts) in order to make use of the innovation. An example of this could be very fast and powerful automobiles. In Germany, where taxes are usually proportional to the motor power of cars the higher tax paid by somebody owning a powerful automobile can be interpreted as a partial compensation to society for a larger negative externality (e.g. in terms of increased carbon dioxide emissions). Table 1 summarises the different possible situations with regard to the business case for sustainability-related innovation as concerns the link to market conditions.

[2] For example, in one of the case firms analysed in detail later in the paper, it seems that the reliance on environmental management systems and in particular on strong and long-established industry guidelines about environmental management, which were deeply implemented in the company made a re-orientation towards more fundamental product or process innovations or a different strategic approach to sustainability management very difficult.

TABLE 1: Relationship between market conditions and types of innovation

Type of innovation	**Innovation capable for mass market**	**Innovation not capable for mass market**	**Innovation even in the niche not profitable in the mid-term**
Sustain-ability-related innovation	Example: socially transforming sustainability entrepreneurship	Sustainability-related innovation in the niche	Sustainability-related innovation that is unprofitable in the mid-term
Non-sus-tainability-related innovation	Example: commercial innovation that results in increased energy or resource consumption	Innovation in the niche without direct social benefits	Non-sustainability-related innovation that is unprofitable in the mid-term

Sustainability-related innovation that is capable for the mass market such as system- or function-oriented innovation as discussed by Fichter (2005) can originate in large or small firms (in which case small firms should be fast-growing).[3] Empirically, however many sustainability-related innovations of this type (which implicitly require some level of technological radicality) are carried out by small firms (i.e. there is a negative association between the size of firms and the level of technological radicality of an innovation). This implies a significance of entrepreneurs for sustainability-related innovation (see Schaltegger 1999; 2002). Fichter und Arnold (2003: 44) find for example that out of 14 sustainability-related innovations they researched across different industries that 10 relate to newly founded ventures and they state that "*Weiterhin ist bemerkenswert, dass in allen neuen Fällen, in denen Produkt-, Service- oder Systeminnovationen mit der Entstehung eines neuen Marktes verbunden waren, diese mit der Neugründung von Unternehmen (7 von 9 Fällen) oder strategischen Geschäftseinheiten (2 von 9 Fällen) einherging*" (Fichter & Arnold 2003: 44). Also Ripsas (2001) stresses the relevance of start-ups for the implementation of ecological products and processes, and this can be related to obstacles for incumbents when innovation is either radical in the technological or organisational (Henderson and Clark 1990) sense.

As concerns innovations that are not capable for the mass market, but can survive in a niche these frequently go along with providing supply for a peer group initially and this especially related to start-ups supply ecological food products which according to Clausen (2004) and Sigle and Clausen (2005) can frequently be traced back to founders emerging from the green movement that start out their activities with customers from a specific milieu/peer community. Also, the analysis of Petersen

[3] Kirschten (2005) separates innovations into product, process, service, organisational (e.g. environmental management systems or sustainability management approaches), institutional (for which she provides networks as an example), system-oriented (for which she provides regional cycle economies or industrial ecosystems as examples) and function-oriented (for which she provides mobility concepts as examples). The last three types of innovation listed seem to include a large component of difficult-to-appropriate benefits because they extend beyond organisational boundaries.

(2002) finds that amongst 64 sustainability-related innovations, 46 can be traced back to start-ups whose foundation was related to an ecological objective and who Petersen (2003) considers as having emerged out of the green movement. Having defined different types of sustainability-related innovation and its sources, the role of combined sources, i.e. cooperation shall be discussed in the next section. The reason for this is that whilst smaller firms have many of the characteristics that put them in a position to be very innovative, making it more likely that they carry out technologically radical sustainability-related innovation, they lack important resources and face the liabilities of newness and smallness (Gruber 2004). This means, that they may not always be able to innovate on their own, and innovation cooperation which has been a focus of recent research in the field (Boons & Roome 2005) needs to be considered as well.

THEORY DEVELOPMENT AND RESEARCH QUESTIONS

Innovation cooperation for sustainability-related innovation

The question that may arise based on the aforementioned is whether sustainability-related or environmental innovation is a specific type of innovation that lends itself to user innovation or open innovation processes (e.g. in case it requires a significant inventive step (as defined in Hauschildt & Salomo, 2005), is technologically radical and/or is complex requiring the coordination of a high number of agents or actors)? If this would be the case, then co-operation (e.g. in terms of innovation networks, open innovation or user innovation) seems to be relevant for sustainability-related innovation to the degree that such innovation is technologically radical and complex i.e. requiring the involvement of a large number of actors or capabilities and having significant technological, economical and company-specific uncertainties which require the bundling of different resources and competencies (Karl & Möller, 2004). To achieve a large improvement, sustainability-related innovation requires complementary changes to enable the most suitable uses and a large range of usage possibilities are needed (Konrad & Nill 2001: 37). The German Environmental Protection Agency e.g. states in this respect: "*Technische Effizienzverbesserungen stoßen an Grenzen, die ohne eine Veränderung der bestehenden ökonomischen, rechtlichen und gesellschaftlichen Rahmenbedingungen nicht überwunden werden können. Zusätzliche Emissionsminderungen, Ressourceneinsparungen und Naturschutzverbesserungen, die über die oben beschriebenen technischen Umweltentlastungspotentiale hinausgehen, setzen vor allem die Bereitschaft der Gesellschaft zu Veränderungen vertrauter Strukturen und Wertvorstellungen voraus* (UBA 1997: 163)*"*. This statement illustrates that technological and organisational changes often do not suffice, but that changes in market and agent relations are necessary. Some of these resources or competencies are not accessible through markets, and may therefore require cooperation or even acquisitions (Karl & Möller 2004). Also sustainability-related innovation processes tend to be socially very complex, and the knowledge to implement the innovation is widely distributed and that because of this only a very small

amount of the overall knowledge needed to carry out the innovation is available in any single firm. Boons and Roome (2005) therefore stress the role of innovation networks (see also Gemünden et al. (1996) for important variations with regard to innovation network configuration) and de Bruijn and Tukker (2002) point to the role of partnerships for sustainability-related innovation whilst Starik and Rands (1995) point to the role of inter-organisational cooperation. Another remedy to the challenge of distributed knowledge are distributed search processes based e.g. on open innovation processes und user innovation carried out by lead users as for example the case of the Novartis foundation.

As concerns user innovation in this respect, sustainability-related innovation is by definition characterised by proportionally higher social benefits for users (from reduction of negative externalities) relative to private benefits that accrue to manufacturers. Also sustainability-related innovation, at least for some user groups implies considerable immaterial benefits (in terms of e.g. increased happiness of "doing the right thing", i.e. a "feel good" factor relating to moral satisfaction). This should lead to higher incentives to innovate for those users benefiting from reduction of negative externalities and immaterial aspects than for manufacturers and should result in increased user innovation activity. A specific example that illustrates such sustainability-related user innovation is that of Deutsche Bahn AG with regard to car sharing. Car sharing systems initially originated amongst users and were thus a user innovation (Hockerts, 2003). Deutsche Bahn as a manufacturer innovator and large incumbent firm started later than these users to offer car sharing and essentially took over manufacturing from some of the initial user innovators who were motivated at least partly by immaterial factors. This transition is in its general features analysed by Baldwin et al. (2006) who point out the crucial role of user communities for the transfer from user innovator to manufacturer innovator. The acquisition of user innovators by a late-entrant manufacturer is a special case of the acquisition of sustainability-related innovation for which other examples are the acquisition of Body Shop by L´Oreal or of Ben & Jerry's by Unilever. These latter two examples fit the open innovation paradigm, where the acquisition of strategic resources is one extreme on a continuum between make or buy decisions. Strategic resources are (next to product lines that allow differentiation in a new dimension or improve a manufacturers corporate image) also those that are complementary to a manufacturer's core product and where manufacturers, instead of acquiring may opt for innovation cooperation initially. An example in this respect that will be presented in more detail in the empirical analysis are second generation biofuels are also supported by truck manufacturers.

Whereas for user innovators it may be preferable to ultimately hand over production to a manufacturer innovator, the example of Hamburg Airport shows, that sustainability-related user innovation may also remain within a (commercial) user innovator as a new area of business. In this case Hamburg Airport, leveraged its knowledge in noise protection gained from application to its own operations which require high levels of noise protection as an almost inner-city airport (also involving

different user innovations such as demand side measures to reducing flight noise impacts for local residents) by selling it as a service (i.e. acting as a manufacturer innovator) to other regional airports.

The role of regulation and leadership for sustainability-related innovation

Induced innovation has been much framed by the debate of the Porter hypothesis positing private benefits of firms from stringent (but economically efficient) environmental or social regulation by means of "innovation offsets" (Porter, 1991; Porter & van der Linde, 1995). Case studies of firms are again very suitable to analyse the incidence of such innovation offsets, their determinants and their relevance relative to other factors, e.g. R&D subsidies. Regulation can created lead markets (see Beise (2001) as well as Beise and Rennings (2003) for a conceptual definition) which seem to be particularly relevant for sustainability-innovation in business-to-business (B2B) markets.

Concerning leadership in firms versus regulatory pressure (i.e. proactive versus reactive action) as drivers for firms' activities towards sustainability-related innovation important interactions exist between regulation and leadership for sustainability-related innovation, especially as concerns governance systems (Tidd et al. 2005) in that a co-evolutionary process can be proposed for the development of relevant capabilities within firms. According to Rainey (2006: 348) leadership *"… determines the plans and programs, provides the resources and capabilities, and ensures that the courses of action are appropriate and executed properly"*. In particular, such leadership can be understood as a dynamic capability (Teece et al. 1997; Marcus/Anderson 2006) that helps to develop special organisational capabilities that improve the responsiveness to sustainability challenges such as learning and stakeholder integration as well as continuous improvement and innovation capabilities (Hart 1995; Sharma & Vredenburg 1998).

The capability for stakeholder integration, as proposed by Sharma and Vredenburg (1998) and discussed with regard to the integration of potentially adverse stakeholders such as environmental non-governmental organisations (NGOs) by Hart and Sharma (2004) is also relevant in this context for innovation cooperation, since it can help to develop early-on cooperation with stakeholder groups that are crucial for the innovation process.

As concerns the capability of continuous innovation (which can be understood as a special case of a capability for continuous improvement), the role of individual employees or managers as promotors or gatekeepers (Witte,1973; Hauschildt & Kirchmann, 2001; Hauschildt & Gemünden 1998; Gemünden et al., 2006) is of particular relevance. As Hauschildt (1999: 181) states: "*The frequent observation [is] that champions or promotors occur 'spontaneously' and that their emergence is not amenable to organizational intervention*". Related to this, as concerns the gatekeeper concept (Allen and Nochur, 1992: 267) point out: "*Empirical studies … find that an effective gatekeeper role cannot be filled by simply identifying and assigning a member of staff to this*

position". Also, as in the case of stakeholder integration, it should be clarified, to which degree capabilities are truly novel or an incremental extension of existing capabilities.

Finally, establishing the firm-level implications of evolutionary concepts and models such as system failures or lock-in (David 1985), socio-technical regimes (Smith et al. 2005), strategic niche management and transition management (Kemp et al. 1998), and windows of opportunity (Zundel & Sartorius 2005) can inform questions for empirical research. How these different perspectives matter for sustainability-related innovation should be addressed in an empirical analysis based on case studies in Section 4. Based on the considerations in this section with regard to the interplay of regulation and leadership and the resulting capabilities, a number of important research questions can be asked:

- Do lead markets exist, where the company preferably introduces innovations that contribute much to sustainability, and which role has regulation for them?
- What is the role that the integration of the objectives of different corporate functions has for sustainability-related innovation?
- How does leadership assist in the process of integration and the formulation of sustainability-related innovation strategies?
- Are stakeholder integration or innovation capabilities novel and separate capabilities or are they essentially established capabilities that are incrementally incorporating sustainability aspects?
- Are there specific competencies related to environmental/sustainability aspects that trigger sustainability-related innovations?
- Who in the company is pivotal for including environmental or sustainability aspects into innovation processes?
- Is leadership for sustainability a new dynamic capability or augmentation of established capabilities?

EMPIRICAL ANALYSIS

Exploratory interview data collected was thirteen in-depth case studies in American, French, German and Swiss firms largely matched for size and industry sector. Of the firms, three each were in the, chemicals (all medium-sized) and electronics industries, two each in the automotive (of which one was a small firm) and machinery and equipment industries (of which one was medium-sized) and one in the printing industry (small firm). Two firms were in the travel services industry (of which one was a small firm). Overall, seven of the thirteen firms are SMEs in their industry, of which three are small firms. Hence across industries, countries and firm size, the sample has considerable variation which is advocated for case study research (Eisenhardt & Graebner, 2007; Ellinger et al., 2005; Ruola, 2005).

The case studies focus on renewable resources for mobility and communication applications as well as industrial (i.e. mechanical, chemical and electronics) products and travel services and draw on interviews with one or several members in each organisation at senior management level with

responsibility for sustainability, strategy or innovation aspects. The interviews were based on a standardized qualitative guideline and the responses were triangulated with third party sources such as content analysis of electronic and printed documents to support the interview information in order to increase the reliability of the analysis. The guideline was adapted to account for additional themes that emerged as the interviews progressed.

The data collection process was halted when new perspectives on the issues under study were not recorded any more, indicating that theoretical saturation was reached (Miles & Huberman, 1994; Glaser & Strauss, 1967; Lamnek, 2005). Whilst inclusion of additional cases in the analysis may have resulted in some additional insights, Glaser and Strauss (1967) argue that when theoretical saturation is reached, data collection should stop in favour of a comparative cross-case analysis.

Data collection was carried out in the second half of 2006 and all through 2007 yielding over 30 hours of structured interviews with 23 senior and middle managers (e.g. Managing Directors, Vice Presidents, Senior Managers, Senior Principal Engineers, Managers, Directors, Research Scientists) in the thirteen case firms. Interviews were recorded and subsequently transcribed in the majority of cases. If recording was not possible, detailed handwritten notes were taken. It was attempted to interview in each firm a senior environmental representative and a senior innovation manager to avoid common source bias. To triangulate perceptions within the company, it was also attempted to interview more than one person in an environmental and/or innovation function within the company, to reduce hindsight and related perception biases.

In smaller firms, where the environment and innovation functions were sometimes combined into one position fewer interviews were carried out. Table 2 summarises the key parameters of the case firms. Firms are reported anonymously for reasons of confidentiality. The results from the case studies relate mainly to the research questions above which can be grouped in the three overarching themes markets/regulation, leadership/integration and capabilities/promoters. These are discussed one by one in the following.

TABLE 2: Key parameters and company characteristics (names disguised for confidentiality)

	Size (number of interviews)	**Industry**	**Board level sustainability responsibility**	**Main sustaina-bility-related innovation**	**Country**
D1	S (1, common[1])	Printing	Yes	Printing process	Switzer-land
M1	M (1, common)	Machinery	?	?	Switzer-land
M2	L (3)	Machinery	No	Engines	Germany
A1	L (1)	Automotive		Various	France

A2	S (1, common)	Automotive	No	Electric vehicles	Canada
C1	M (2)	Chemicals	No[2]	Process efficiency	France
C2	M (2)	Chemicals	No[3]	New chemicals	Germany
C3	M (1)	Chemicals	No, but council	New chemicals	United States
E1	L (3)	Electronics	No, but council[4]	Energy efficient products	France
E2	L (1)	Electronics	No, but council	Remanufacturing process	United States
E3	L (5)	Electronics	No[5]	Energy efficient products	Germany
T1	S (1, common)	Travel Services	Yes	Sustainable/carbon-low/-free tourism	Switzer-land
T2	L (1)	Travel Services	?	?	Switzer-land

[1]denotes that the person interviewed has sustainability and innovation responsibilities

[2] At group vice president level one person is tasked solely with sustainable development

[3] Sustainability aspects are discussed in the firm's technology council, a public relations function at manager level in the corporate communications department and a vice president for chemical services exists.

[4] Ethics committee; the company also has a corporate responsibility officer one level below the board level

[5] A function for corporate responsibility exists at manager/vice president level; the firm's corporate technology council discusses and decides strategic aspects of sustainability as far as they relate to innovation and technology aspects

RESULTS

Markets and regulation

Market demand is identified in the case studies as a pivotal factor in B2B contexts that justifies sustainability as a strategic topic. This has been mentioned more than once in the case studies, and was put by one interviewee as follows: *"If the customer does not want this, then you can develop as much as you want"* (C2; translated from German). Related to this, as a risk of leadership in B2B context was pointed out in that customers do not immediately introduce improvement on large scale, even though they may be very vocal in demanding the improvement in the first place. Often the need is for an external event to push adoption by customers and the interviews revealed that frequently this can be novel regulation. Regulation has also been identified in the interviews as a driver for public-private alliances that can ultimately result in the emergence of lead markets fostered by regulation (E3). Finally, cost issues have been identified as obstacle to leadership for sustainability-related innovation and it was pointed out that for example in the chemical industry there is usually no payback for an

early change to a cleaner process technology since customers would accept higher prices for a product produced with a cleaner technology (C1).

Leadership and integration

From the case study interviews it emerges, that leadership for sustainability-related innovation exists in terms of organisational structure as well as the integration of sustainability considerations in processes. In terms of organisational structure, two aspects stand out. Firstly this is that a board member with responsibility for sustainability can act as power promoters for sustainability-related innovation. This view is reflected by the following statement: *"In large, hierarchical organisations clear leadership from the board is critical. The role of middle management is less important"* (E3; translated from German).

The role of middle or senior management under the board level seems to be assessed differently by the interviewees in different companies (e.g. one interviewee in A1 subscribes to the view above, whereas one in M2 pointed out that middle management often initiates innovation activities) and it was pointed out, that regardless of the management hierarchy, the personality of leader has to reveal competence as well to provide credibility to any statements with regard to sustainability or sustainability-related innovation. However, whilst board leadership provides a context for sustainability related innovation, it was also pointed out in the interviews that this has only limited influence, if board as a whole does not embrace a holistic approach to sustainability and that this also limits the possibilities for middle managers.

As an alternative to assigning board level responsibility for sustainability, most of the larger companies interviewed usually have technology or sustainability councils at the corporate level (e.g. A1 or C2) which discuss and decide on sustainability topics and as part of this on sustainability-related innovation. Related to this, interviewees in one company felt that leadership for sustainability-related innovation and resulting integration of sustainability into innovation processes was also brought about through a corporate longer-term focus on mega-trends who themselves relate to sustainability issues, such as mobile communication, energy or water supply, or health care (E3; E1).

Secondly, integration is achieved through formal consideration of sustainability topics with regard to innovation in pre-development and stage-gate processes and related guidelines. This approach to achieving integration has become increasingly relevant as is witnessed by the following quote: "*They [environmental criteria] are covered in a systematic way … I would say: 5 years ago this was only piecemeal … it is now structured in a way that we [environmental department] do not have to do much any more"* (M2; translated from German). Next to such formal integration, informal integration into processes and guidelines is additionally achieved by means of clear statements of direction by senior managers, voluntary support offers to business units by central environmental units and by means of bottom-up activities of individual employees. From the interviews it emerged, that if

strong leadership exists in terms of e.g. board responsibility or clear statements of direction, then systematic integration of e.g. environmental aspects in innovation processes is often substituted by more informal mechanisms such as voluntary support offers to business units or bottom-up activity with regard to sustainability-related innovation. The insights born out by interviews are also consistent with findings in the literature that a charismatic leader is important but needs to be supported by processes and structures (e.g. in terms of guidelines, operating procedures or routines) which can be linked to the evolutionary view in terms of learning and improving routines (Nadler & Tushman, 1990).

Capabilities and Promotors

The finding of the previous section that sustainability-related innovation is often a bottom-up activity links to the questions about capabilities and promoters in that it indicates an emergent strategy (Mintzberg, 1991). One important aspect of this is that sustainability issues according as was mentioned by several interviewees (e.g. in A1) are more accepted amongst middle management and researchers now than they were in the past (though it was pointed out that depends on department and corporate function considered). One interviewee stated: *"In the 70ies, 80ies maybe also there was a generation … for which environmental protection was only cost … But today we pursue integrated environmental protection … That is a completely different type of environmental protection … This generation conflict does not exist any more in the company today"* (C2; translated from German). Concerned and aware employees often act as technological promotors for sustainability-related innovation activities, as was pointed out in the interviews. However, such bottom-up activity where individual employees that are very concerned about sustainability act as promoters needs subsequent board-level support, as is illustrated by the following statement: *"The pattern is more that there are people. There were people then who said: let's pursue this. … Let's push this. We cannot enforce it, but we have to see if this is relevant. … And then the board discovered it and said: Wow, this could be very important"* (M2; translated from German). This finding shows that senior management essentially functions as a gatekeeper for the bottom-up activity of individual employees that work on sustainability-related innovation, i.e. senior managers were identified as power promotors who help to increase the acceptance of a sustainability-related innovation and who break organisational resistance resulting from the firm being a only partly rational social systems.

Concerning the question whether sustainability-related innovation capabilities are novel or established capabilities incrementally incorporating sustainability aspects, the interviews provide evidence for both interpretations. One interviewee stated that that a chain starting from the attempt to improve the corporate image via the corporate culture/climate and individual employee motivation results in a process of continuous improvement (D1). It was also pointed out however, that the continuous improvement process that resulted in innovation was fuelled out of the company's

environmental management system and that next to this, another key driver for innovation was a corporate culture in the company that was allowing mistakes and hence experimentation and that this culture was largely promoted by management, but was not related to environmental or sustainability issues.

On the other hand, some interviewees identify specific competencies related to sustainability aspects that support sustainability-related innovations. This is illustrated in the following quotes relating to life cycle analysis which has been identified in more than one interview as an important sustainability-related capability: "*… e.g. what we call the life-cycle analysis: This is clearly an input or decision that I support, that I've launched because I felt that we need to. But from another side, we have somebody who is a responsible care director. So, to define who is at the origin is very difficult, it's mixed, I would say"* (C1). However, also concerns were voiced in the interviews as in the following statement: *"All of this has exploded in the market place … I am right now going out and making presentations getting people to think about life cycle perspectives … I am a little weary about that. We are using life cycle analysis and higher level life cycle type tools … I think I get very nervous about the trade-off … I'd rather have them thinking about things that are pretty simple …I don't want to get them tied up in complex analysis … that they get paralyzed … I try to get them to understand that life cycle analysis is just one element in the toolbox"* (E2).

As concerns stakeholder integration and the question whether it is a novel and separate capability or an established capability that is incrementally incorporating sustainability aspects there is evidence for both interpretations. In one of the large electronics companies interviewed, it was pointed out that a significant amount of stakeholder integration is achieved through the function of a corporate responsibility officer. However, it was also noted that this function was more oriented towards public relations and that it only existed since less than two years, hence making an assessment of its effect difficult. Many of the interviewed firms stated that they cooperate in product development when environmental aspects are concerned. Often this is with customers, and often on a single case basis or in project working groups. Table 3 provides a summary of the cooperation partners for the years 2003 to 2005 of those firms, who provided a complete overview.

TABLE 3: Cooperation activities of firms (as far as comprehensive statements were made)*

Company	C2	E3	T1	T2	M2	M1	D1	A2
Cooperation activity	8 (M)	12 (L)	5 (S)	6 (L)	4 (L)	1 (M)	10 (S)	1 (S)

* based on the following possible cooperation partners: scientific institutions; users of the product; recycling firms; consumer associations; trade unions; competitors; suppliers of raw materials; intermediate product suppliers; external consultants; government or enforcement agencies; owners; commercial or industrial customers; environmental NGOs; trade associations; waste disposal firms; retail customers (maximum score firms could achieve: 16)

As can be seen from Table 4 which analyses in more detail the cooperation of the German and Swiss firms interviewed (since for these more disaggregated information was available) in combination with Table 2, it is not only large firms who have high levels of cooperation with regard to sustainability-related innovation though the tendency is, that the level of cooperation activity associates with size. The impression is, that it also matters whether firms have a cooperation culture or a degree of openness (in which case they tend to cooperate much) or not (in which they cooperate to a lesser degree). Also, for very small firms few products are more likely to be developed together with a cooperation partner (as for example hospitals in the case of A2).

TABLE 4: Cooperation activities of German and Swiss firms**

Cooperation partner / Firm size	M	L	L	S	L	S
Scientific institutions	+	+	+		-	
Users of the product		N/A		+	+	+
Recycling firms	++	++	+		+	++
Consumer (protection) associations		++			N/A	
Trade unions		+			N/A	+
Competitors			+	+	?	
Suppliers of raw materials	++	+		+		++
Intermediate product suppliers	++	+			+	++
External consultants		+	+		?	+
Government or enforcement agencies	+	++	+			+
Owners					?	
Commercial or industrial customers	+	++			N/A	++
Environmental NGOs		+		+	N/A	
Trade associations	+	+			?	+
Waste disposal firms	++	++	+	+	+	++
Retail customers		N/A			N/A	

**: M: medium-sized firms; L: large firms; S: small firms; N/A: data not available

By the interviewees, cooperation with competitors was considered very difficult (e.g. D1 pointed out, that own suggestions for cooperation were not taken up), as was cooperation with environmental NGOs, representing some evidence against fringe stakeholder hypothesis. One case firm pointed out that cooperation with fringe stakeholders can have both outcomes and states: *"I think … it is the perspective that the particular NGO takes with regard to what it is they are trying to achieve and what they think that ill in society is … the closer you get to an NGO that believes …*

industry is inherently wasting the planet … then the less likely you are, in my experience, to get a reasonable interchange to something that is helpful. The closer you get to someone who says look, life is certainly better now than it was 200 years ago, so lets see how we keep it moving in the right direction then I think you get that more positive interaction" (C3).

CONCLUSIONS

The analysis reported here was aimed at developing a better understanding of the way environmental and social considerations are integrated into business strategy and how this influences sustainability-related innovation aspects. The case studies in this respect should help to develop a more detailed picture of exactly how sustainability is integrated in corporate and business strategy in a way that fosters innovation. The aim was to derive from the case studies a better understanding of the joint role of institutional factors (such as regulation and markets) and firm-internal factors for the pursuance of sustainability-related innovation in firms.

The analysis in this respect finds that market demand is a pivotal factor that limits or pushes suppliers in B2B contexts towards leadership for sustainability and that regulation is frequently an enabler of increased diffusion and adoption. Also it reveals that sustainability-related innovation is fostered by board responsibility and formal as well as informal integration of sustainability aspects in processes and that sustainability-related innovation often is a bottom-up activity. These insights improve the knowledge base for EU policy making with regard to sustainability and industrial innovation. In particular, they reveal that capabilities are path dependent and depend on historic irreversibility. For example, in the case of one of the American firms, the most important sustainability-related innovation in their judgement of the last years related to a new approach to micro-biocides for wood preservation that allows for controlled release maintaining the intended effect without being based on metals such as chromate copper arsenate whilst minimizes the potential from skin irritation for users. It is based on a predecessor technology for marine use biocides that reduces the impact on marine life and that is designed for degradation. That technology again was initially developed for agricultural applications many years ago where it was long in use. This provides an interesting perspective on how firms can innovate strategically for sustainability, as it is often proposed or at least desired by policy makers. As the example and similar ones in other firms show, a more sustainable product is oftentimes based on long-existing competences of the company that are transferred from one application field to another rather than a firm developing a technologically radical new product or process design. The development of the underlying knowledge base in the company is a historic and evolutionary process which may involve irreversible decisions about technologies, market foci or other parameters and in this sense is path-dependent.[4] Frequently it seems, these

[4] An important example of a historic market focus that has become an issue is the current debate of the European Commission with European car manufacturers over fleet emission targets for carbon dioxide, where Italian and French car

decisions are taken when there is large uncertainty about future sustainability challenges and therefore whether firms are today in a position to address commercially successfully novel or tightened environmental or socially-related regulation seems to depend on a in this respect rather haphazard historic process that may or may not have equipped them with suitable capabilities, routines or competences to address that regulation. An important implication of this for policy making seems to be, that innovating for sustainability is maybe not as strategically feasible as this is demanded by policy makers, meaning that the timelines required for addressing current sustainability challenges are even more demanding given that firms need possibly considerable time to develop relevant knowledge if this is not by (historic) chance already well developed in their organisation. This of course makes strong incentives to do so even more crucial, but also means that policy makers cannot simply assume that the relevant knowledge is available but should ideally take an active role in the creation and quick diffusion of such knowledge to firms.[5] The situation can also be understood as a co-evolving system of regulatory demands and knowledge needed to meet these demands in which both aspects need to be in a balance for the system to function. As concerns the question whether leadership for sustainability is a new dynamic capability or merely the augmentation of established dynamic capabilities (or in the terminology of evolutionary theorizing higher-order routines, see Nelson & Winter, 2002) the fact that regulatory demands and knowledge are co-evolving indicates that a combination of new and existing dynamic capabilities applies, which is in line of the finding of Marcus and Anderson (2006) that it is not one general dynamic capability, but different ones for business and social responsibility objectives that are at work in the U.S. food industry.[6]

In this respect, whilst an empirical analysis of the interaction of corporate and business strategies with innovation activities should be able to inform about resulting changes in firms' economic, social and environmental performance, the results from the case studies show however, that often it is actually the expectation of improved economic performance that leads firms to ultimately pursue sustainability-related innovation. This is particularly the case in larger firms analysed implying that established dynamic capabilities matter more here for changes in organisational routines. Here, improved environmental performance is frequently a prerequisite to pursue sustainability-related innovation. An environmental management system which has been described in some of the case firms as one source for sustainability-related innovation can be interpreted in this regard as a dynamic capability (Avadikyan et al., 2001) that however mainly relates to social responsibility objectives.[7] It

manufacturers are because of their historically evolved market focus on smaller cars in a less entrenched position than some German car manufacturers (Anon, 2007).

[5] Grubb (1997) points to the relevance of this time lag e.g. in the context of climate change.

[6] Whist the empirical evidence for one generic dynamic capability affecting both, business, and social responsibility objectives seems limited such a capability has been proposed frequently in the conceptual literature, e.g. by Hart (1995) who suggested that the capability of establishing a shared vision could be one such generic dynamic capability.

[7] Avadikyan et al. (2001) argue that environmental management capacities result from the adaptation of three types of mechanisms within companies, namely incentive, coordination and cognitive mechanisms. The environmental management process means according to them a process through which organizations change structures and corporate cultures resulting from a combined effect of individual learning and organizational transformation.

can be interpreted as a novel dynamic capability, whilst the dynamic capabilities that react to regulation and market forces in terms of incorporating sustainability-related demands e.g. in innovation processes or strategy making seem to be mainly existing dynamic capabilities. In the case of the smaller firms analysed, sustainability entrepreneurship as it was discussed in Section 2 and especially Table 1 seems to be at least partly based on new dynamic capabilities relating to leadership for sustainability. In small firms this seems to lead to more comprehensive sustainability-related innovation which may ultimately result in technologically more radical innovation or a more comprehensive incorporation of sustainability aspects into operations. For example, in one case firm, even the service truck was converted to run on biofuel (which in a large firm would correspond to essentially their full fleet being converted). To some degree this seems to indicate that the co-evolution of industry structure and technology; artefacts, understanding and practice (Nelson & Winter, 2002) seems to be faster and more comprehensive in smaller firms and the consequences of this for institutions and innovation systems should be analysed further.

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