Sustainable Innovation through Commitment and Engagement: The Example of SunFuel [1]

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Sustainable innovation is to satisfy not only customers' needs and the innovating firm's goals, it also should meet social and environmental targets. These manifold requirements lead to increased complexity and risk, often making collaboration amongst firms necessary. However, multiple targets and multiple partners may threaten enduring commitment to the innovation. Therefore, our research question is, how to manage a firm's own commitment and promote its partners' commitment to a sustainable innovation. This is particularly relevant if several technological paths exist because firms' histories and present states differ and thus companies may come to favour alternative solutions.

For a company intending to invest into a sustainable solution it is not only important to assess its own competencies and interests but also to understand the partners' positions vis-à-vis the innovation. We propose: First, at an early stage, when selecting a technological path, to screen three levels of influence on partners' strategies: firm's competencies & orientation, industry background and regulatory system and Second, to engage with partners continuously, taking changing perceptions and interests into account. SunFuel is used as an example to demonstrate the usefulness of our framework.

1. Sustainable Innovation

A number of problems arise in attempting to arrive at a working definition of sustainable innovation, not at least because the concept itself could be viewed as a slight contradiction in terms depending on the theoretical perspective taken (see e.g. Fichter 2002, p. 3). Two scientific discourses could claim a specific relevance in this regard: Within the Environmental Sciences, where much work currently goes into operationalising the path towards sustainable development, innovations are seen as both a blessing and a curse. Being held responsible for many current ecological problems, innovations are also seen as the only way forward out of these. On the other hand within the Economic Sciences, traditionally the home of research into innovation, there still remains much doubt about the exact ramifications regarding

sustainability and how this will impact on global competitiveness. Even widely received contributions such as the one by Porter/van der Linde (1995) on the first-mover competitive advantages of "greening" businesses has not convinced many sceptics who see ecological requirements as hindering conventional innovation-lead economic growth (e.g. Priewe 2002).

Notwithstanding these paradigm-induced differences there seems to be some agreement on a central issue: Sustainability can be a driver of Innovation and without Innovation there can be no Sustainability (e.g. Nill/Hübner/Rickert 2000, p. 45f or Hübner/Nill 2001, p. 19).

This has led to a slightly different accentuation regarding the current relationship between Innovation and Sustainability: Whereas the work done in environmental management focuses on innovative ways to achieve sustainability, the business administration discussion focuses on sustainable ways to achieve innovation. Exemplary positions for this are Hockerts (2003), who goes into "Sustainability Innovations"[1], whereas Kirschten (2002) rather talks about "sustainability-oriented innovations". As we also take our point of departure to be the economic sciences and more specifically innovation theory, it seems more expedient to start looking at possible reasons for the absence of definitions on "sustainable innovation" here.

What is remarkable yet maybe not surprising is that discussions into sustainability take place very much at the fringes of the innovation theory discourse. Whether it holds true that innovation theory has completely neglected sustainability (i.e. environmental) issues as some would have it (Fichter 2002, p. 3f or Nill/Hübner/Rickert 2000, p. 45f), remains to be questioned though. Certainly with the traditionally strong product-innovation and – design research traditions there is quite a body of work if not also a scientific community focusing on sustainable innovation practices (e.g. Rubik 2002; Johannson/Magnusson 1998 and Smith 2001 in "The Journal of Sustainable Product Design"[2]).

There also does not seem to be a lack of theory with regards to different types of innovations in general (i.e. product-, process-, service-, social- and institutional innovations), which could then be applied more specifically within a context of sustainable development. What remains problematic though is, that due to the inherent complexity, there are only rather vague notions about sustainability to work with on a strategic or operational level[3]. Resulting from the very holistic conceptions currently under discussion, some have resigned to the fact that further enquiry can only be undertaken after a more (business-)relevant understanding of sustainability has emerged (e.g. Kurz 2002). This seems a little dissatisfactory and therefore we feel it important to work towards an integrating perspective on sustainable innovation, even if it means looking at the sustainability concept on a very general level. Indeed this paper represents an attempt at breaking down the concept of sustainable innovation by showing some practical application possibilities within idea innovation networks of actors committed to achieving sustainable solutions.

Two major ways in looking at sustainability have emerged after the first fairly general Brundtland-Commission report in the 1980´s: Following Paech/Pfriem (2002) we can call them the "transferability-perspective" and the "three-pillars-model". The first approach looks at sustainability in an intergenerational perspective. Production and consumption patterns are deemed sustainable if they can be practised by future generations without depleting the societal resource base. This time-related view was later extended to a geographical dimension to also include developing countries. Sustainable development thus meant they too should be able to participate in similar production and consumption practices as industrialised nations. It becomes evident though that the mere export of current consumption standards within wealthier nations might have catastrophic consequences not only for the environment but also global society as a whole. This has sparked a heavily contested public debate around different conceptions of equality/fairness albeit technology access and for our purposes thus also mandates that the "social shaping of technology" (e.g. MacKenzie/Wajcman 1999) gains in relevance within globalised innovation contexts.

Since the natural resources needed for industrial production are finite, a more thrifty utilisation seems a mandatory pre-requisite for sustainable development. Consequentially derived from this it is proposed that any assessment of innovation aimed at sustainability must include some measure of resource-effectiveness (e.g. "Ressourcenproduktivität" Nill/Hübner/Rickert 2000, p. 51).

This is further expanded on in the well-known "three-pillars-model" of sustainable development which advocates a reconciliation of the social, economic and ecological dimensions of any development towards a more sustainable future. Notwithstanding the numerous (sometimes) valid points of criticism regarding the practicalities of this "triple-bottom-line" measure of sustainability, we believe it to be a useful starting point for looking at some future requirements for more sustainable

[1] This he defines in very economic terms as „any process of social change which increases the proceeds derived from current natural, social, and economic capital, while at the same time protecting and enhancing the underlying capital stock." (Hockerts 2003, p. 45)

[2] see also www.cfsd.org.uk

[3] The process of operationalising sustainability in order to increase its practical relevance is still underway and proving to be a crucial pre-requisite for entrenching the underlying vision. For a more in-depth discussion into the problems around this within the Innovation theory discourse see e.g. Hübner/Nill (2001, p. 65f).

innovation processes.

By applying this "3D" perspective to current notions about innovation, a few things immediately become evident that are sometimes neglected in a more traditional view:

all innovation processes and the organisations initiating them are embedded within economic, social and ecological systems and thus produce

(positive and negative) external effects in all these three areas

involving actors and institutions on a global scale.

The above mentioned growing importance of increasingly globalised innovation contexts can for instance have wide-ranging consequences for existing regulatory policy-frameworks, such as national innovation systems[4]. In the development of our argumentation we will focus on the following three levels of analysis (see model) in order to operationalise the macro-level of sustainable innovation from an individual actors (here companies) level of interaction: system (state and society), industry (stakeholders and industry structure) and company (competencies and management orientation).

It would seem that highly-developed countries are more prepared, if not indeed having a greater responsibility, to transform their existing innovation policy frameworks towards meeting sustainability requirements. What this regulatory context for innovation would require therefore is a high degree of social and institutional innovation. As advocated by Hübner/Nill (2001, p. 75) "This requires a different type of approach for policy making, more participatory and more oriented towards experimentation, and the use of policies that are forward-looking, adaptive and reflexive." It is believed that a policy of incremental innovation will not lead to the required path-change towards sustainability (e.g. for Germany Bierter/Fichter 2002) and future regulatory endeavours should focus on supporting "radical brake-through innovations" (Hockerts 2003, p. 35f).

In underscoring that, the mere fact of innovating organisations themselves being embedded in varying social and environmental contexts mandates an equally high degree of product- and process innovation as well.(e.g. Paech/Pfriem 2002, p. 14)[5]. What is important in this view is to focus less on specific instruments but moreover regard the contexts of innovation, the interaction of relevant actors and the early phases of the innovation process. As Rammert (2001, p. 4) suggests in his deliberations around the politics of technodiversity "the development of technologies should better be conceived as a continuous process of creative variation, taking place in and between various technology projects, enacted by different social actors, closed and reopened in multiple arenas of conflict and selected by some institutional filters." In following this line of reasoning it seems crucial that the interventionist types of technology policy should be complemented by more interactive, and network-oriented types of innovation policies that allow for technological and institutional diversity across the entire innovation process in the long-run. (Rammert 2001, p. 5)

The fact that we are increasingly faced with very complex multiple actor networks, which are in turn embedded in wider frames of reference, highlights the need for communication and reconciliation. In order to facilitate these interpretative processes it is initially required to assess the respective parties perceptions and interests, something which we will selectively attempt for actors in the case of SunFuel.

Turning now more towards the effects on an organisational level, it is becoming increasingly clear that innovation projects under current market conditions have reached such a high-level of complexity that only a combined effort of all relevant stakeholders can be successful in the long run (e.g. Kirschten 2002). What the stakeholder-perspective thus mandates is the much more network-oriented and interactive look at the innovation process as already pointed out. Fichter (2002b, p. 19) classifies three types of innovation models: voluntaristic (looking mostly at the activity radius of the innovating system i.e. a company), contextual (looking at the innovation systems environment e.g. competitors, laws, customers) and interactive (productive interaction in the exchange processes between actors and their contexts). He specifically advocates the latter model of sustainability innovation, stressing that it needs to originate from a pro-active orientation. In this view sustainability is not merely an accidental by-product from the innovation process, but embedded on the overall strategic vision. In looking at innovation as a dynamic, non-linear and interactive process, the following four contexts seem to be of specific relevance: intrapersonal-, group-, intraorganisational- as well as the innovating systems surroundings. A central success factor is the effective networking through intensive dialogue between internal and external actors (Fichter 2002b, p. 21f). Following this line of reasoning, innovations are the result of intensive collaboration within multiple actor-networks. As many corporations are focussing only on their respective core-competencies, they develop less integrative skills to achieve the holistic approach intended under triple-bottom line sustainability. Kirschten introduces the idea of "sustainability-oriented Innovation-networks" which are characterised by amongst others: two or more partners, problem-solving orientation, functional sub-division, a time-limited project format, polycentric organisational form, less formalised, reciprocal and based on co-operation

[4] For an in depth discussion into the consequences of sustainability as a motor for innovation within the german national innovation system (NIS) see e.g. Hübner/Nill 2001.

[5] It is important to note here that although there seems to be some progress in combining the ecological and economic dimensions of sustainability the biggest challenge still lies in the integration of the social dimension, with social innovations playing an important part in this (see e.g. Nill/Hübner/Rickert 2000, p. 69). Often though the social dimension is explicitly not included (e.g. Zahn/Schmid 2002).

and trust. In Rammerts (2001, p. 15) view these should be constituted as “platforms for joint innovative action and recursive learning between the actors of the innovation network.”

As we have seen so far, a promising way forward towards achieving sustainable innovations should be initiated through intensive stakeholder integration and actor collaboration during the early phases of the innovation process. What should also be kept in mind is that there are multiple levels of analysis and activities to be taken into account; in our case state and society, stakeholders and industry structure as well as company's competencies and management orientation. It seems crucial to assess the various actors commitment in order to determine the nature of engagement that will ultimately drive the innovation process.

2. Commitment and Engagement: A Framework

2.1 Commitment: Picking a Path

According to evolutionary theory of firms' business development, firms' strategies are path-dependent: Competencies accumulate over time and the ability to exploit opportunities vary amongst firms (Nelson and Winter 1982, Helfat 1994). Leaving a particular path could be difficult if management feels constrained by sunk costs (Hannan and Freeman 1989). Thus, companies in a particular field develop firm-specific strengths and weaknesses, making them more or less attractive as a collaborative partner.

High costs, high risks and the need to accelerate entry to market often are motives for collaboration, but in a global market, when products and infrastructure are strongly complementary to each other, major technological changes *require* joint efforts across industries and nations. In the beginning these efforts may not be orchestrated and several paths may be open to consideration, leading to competing paths or even standards.

In such a phase, the appropriability of a firm's R&D investment in a technological path is crucially dependent on the commitment of partners.

However, a company's competencies and management orientation (for example search for global solutions, national or regional orientation), industry backgrounds (stakeholders such as competitors, customers, suppliers, industry structure), and ‘systems’ (regulations, law) influence and guide a firm’s R&D strategies (Fig. 1). R&D strategies are littered with uncertainty, especially when they are of cross-sectional impact and depend on many partners’ actions.

Being confronted with a variety of possible technological paths, it is desirable to assess potential partners’ commitment to follow a certain technological path.

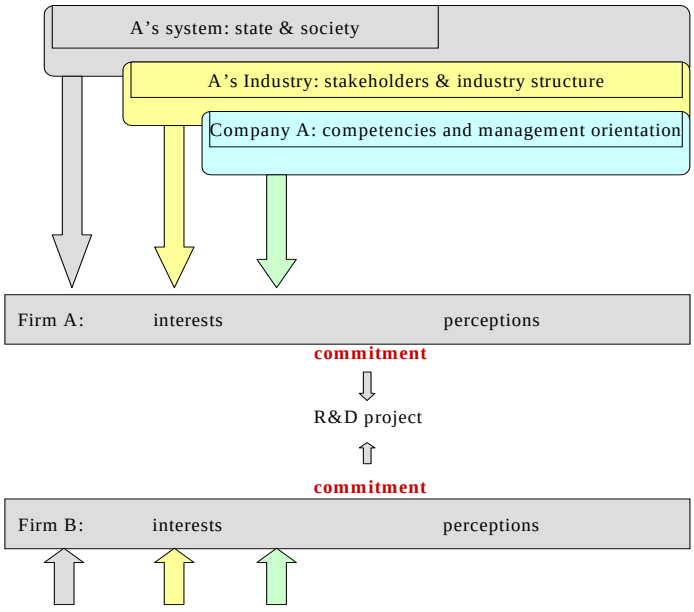

Figure 1: Factors Influencing a Firm´s R&D Strategies2.1.1 State and Society

The 'National System of Innovation' (Lundvall 1992, Nelson 1993), expressed in factors like the tradition of

scientific education, funding of basic research, technology policy, collaboration of firms with research institutions and technological accumulation in related sectors (Bartholomew 1997) has an impact on the national technological capabilities and is offered as one explanation of national patterns of innovation (e.g. Porter 1990).

Thus, firms with a different system background may favour or follow different patterns of innovation. The diffusion of these innovations in society, that is the pattern of adoption and adaptation will be influenced by norms and values.

2.1.2 Stakeholders and Industry Structure

An industry and the innovations brought forward in that industry usually concern a variety of stakeholders with different perceptions and interests.

The extent to which these stakeholders are relevant to companies depends on their power to influence the firm, the legitimacy of their relationship with the firm, and the urgency of their claim (Mitchell, Agle and Wood 1997).

Thus, firms with different industry background are exposed to and engage with different stakeholders. As far as stakeholders differ regarding their engagement with companies from different industries, this may influence an industry's innovation pattern.

Porter (1980) has described industry structure using a 'five forces' framework: rivalry among existing competitors, threat of new entrants, substitutes, and bargaining power of suppliers and of customers determine the profitability of an industry and also influence strategies of firms.

2.1.3 Company's Competencies and Management Orientation

According to the resource-based view, firm-specific capabilities or resources are the key factor influencing the performance of firms (e.g. Rumelt 1991). When rapid market or technological change is taking place, dynamic capabilities are required, that is "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (Teece, Pisano, Shuen 1997, 516). Given path dependencies and market positions, firms have to align their resources with the changing situation. However, 'picking' a path does not look the same for all firms. The number and kind of technological opportunities may well differ for different firms (Teece, Pisano, Shuen 1997): Past experiences shape the management's perception of choices and they may have different costs of shifting resource allocation.

Assessing the relevant national system of innovation, industry structure including stakeholders and the partner's competencies may help a company to understand potential influences on partner's selection of technological paths.

2.2 Engagement: Sticking to the Path

Collaboration means engagement which is an ongoing process between parties during which perceptions as well as interests may change.

2.2.1 Perceptions

When innovation is conducted as a collaboration between firms, individuals' perceptions, here defined as the process by which information is received and interpreted, may well be influenced by company, industry and national system (see above).

Managers of different companies may differ with regard to their understanding of the science and technology, as well as in their *perceptions* of risks and benefits and their priorities.

Perception is subjective: one processes information on the basis of a frame of reference. When perceptions differ, the exchange of information may be helpful to reduce differences and to achieve a common basis of view.

2.2.2 Interests

Different companies will have a number of interests in the technology and its innovations. The *novelty* of a technology makes it particularly difficult to foresee which interests may arise. Displaying interests is necessary to be able to negotiate them.

A company could assess whether perceptions and/or interests of the partner are different from the firm's.

When perceptions are dissimilar, the partners need to exchange information to learn about the technology's chances and risks for a particular environment. Exchanging information can lead to an approximation of views.

When perceptions of the firms are similar to each other, but interests are conflicting, the partners need to negotiate the features and goals of the technology and respective innovations: They need to compromise. This may lead to a revision of the decision for a technological path.

Even if perceptions and interests are similar, it is important to question decisions and strategies.

We can look at engagement as a process during which information changes perceptions and negotiation aligns interests (Fig. 2). Nurturing commitment requires taking account of changing perceptions and interests. Depending on whether mainly perceptions or mainly interests are different, engagement needs to focus on providing information or on compromising. Information does not change interests directly but may do so through changing perceptions.

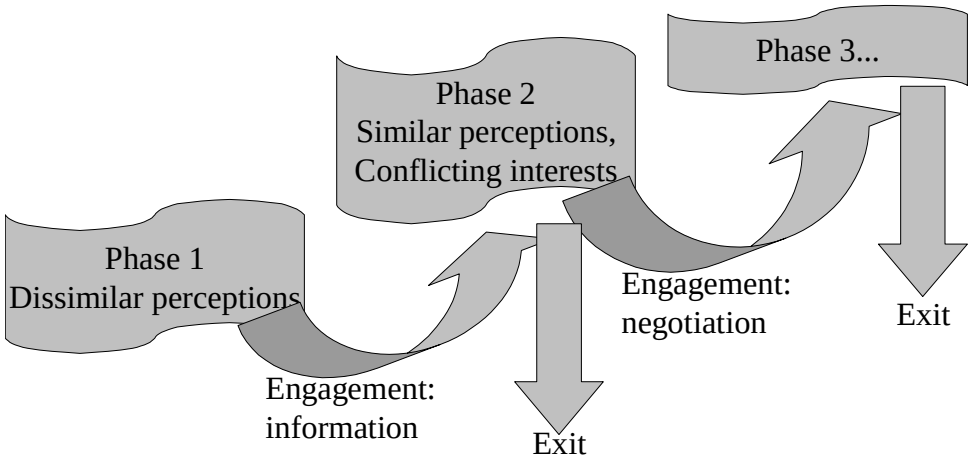

Figure 2: Phases of Engagement (Weisenfeld 2003)

3. Application to SunFuel

3.1 Request for Sustainability

The 'value chain' for providing mobility to people encompasses several companies with various industry backgrounds. If this value chain is to undergo major changes – as the request for environmentally more suitable solutions indicates – it requires major investments and entails enormous risks. Thus, concerted efforts seem to be appropriate if not necessary.

The transport sector, based almost 100% on oil, faces the challenge of coping with environmental pollution, climate change and limited oil reserves. New sources of energy and/or new ways of transport are

needed. The fuels of the future have to meet the criteria of *sustainability*: the ecological and the economical aspects and the social acceptance are key factors for the success. The alternatives that are taken into account are hydrogen, natural gas, biodiesel, SynFuel (Gas to Liquid, GTL), SunFuel (Biomass To Liquid, BTL) and bioethanol. Whereas hydrogen is seen as a long term solution, synthetic fuels (designer fuels) are possible mid-term solutions. Various companies perform R&D and pursue several possibilities to develop new fuels and adapt engines. Thus, there is a *variety of technological paths* to choose from.

3.2 SunFuel

The designer fuel SunFuel is based on renewable sources of energy processed of biomass. Volkswagen presented its new fuel and transmission strategy at the Vienna motor symposium in April 2001 (Automotive Intelligence News 2001). "SunFuel® represents a major step in Volkswagen's fuel strategy. It is completely free of sulphur and aromatic compounds and is CO2-neutral, as its combustion in the engine only releases the CO2 back into the atmosphere that the plant absorbed while it grew." explained Dr Wolfgang Steiger, Head of Engine Research at Volkswagen (Volkswagen 2003) While hydrogen may become a primary energy resource for the car in 20 years' time, Volkswagen sees synthetic fuels derived from gas and subsequently from biomass as complementing petrol and diesel in the meantime (Volkswagen 2004). DaimlerChrysler took up research in this area as well and stated its commitment to renewable fuels. "Together with DaimlerChrysler, Volkswagen will be involved in a research project with the Freiberg, Germany, company Choren Industrie GmbH for the manufacture of high-quality fuels from biomass. In this project in the pre-competitive environment, the two automakers intend to make more rapid progress in gaining well-founded experience with renewable fuels" (DaimlerChrysler 2002).

With regard to the current diesel-/petrol-powered engine, car manufacturers have performed R&D to improve the internal combustion engine, to improve fuel efficiency and to complement diesel and petrol with designer fuels.

The industry structure of the automobile manufacturers can be described as follows (Brunner 2003):

The automobile market is an oligopoly: six car manufacturers have a market share of approximately 80%. There is intense rivalry among the firms. Threat of new entrants as well as substitutes are lacking and suppliers have low (but potentially rising) bargaining power. Thus, the overall competitive environment is rather stable. Overcapacities coupled with decreasing demand in developed countries make emerging markets attractive targets.

Stakeholders exercise pressure on the automotive industry especially regarding the issues of climate change and local pollution. Companies' approach in general is reactive rather than proactive (Brunner 2003, 21).

Shell has 20 years of experience in the process of GTL and has developed the SMDP to transform gas into fuel. In co-operation with the Energy Research Centre of the Netherlands Shell is exploring the biomass integrated gasification Fischer-Tropsch (Bio-FT) process, which produces a synthetic diesel (Shell 2002)

"Shell is a global group of energy and petrochemical companies. The aim of the Royal Dutch/Shell Group is to meet the energy needs of society, in ways that are economically, socially and environmentally viable, now and in the future"[6]. As a global group, several national systems of innovation are relevant, but in different ways for different businesses. With regard to sustainability issues, European managers are exposed to higher regulatory standards whereas the managers in developing countries face more severe social problems (Salzmann 2003, 7).

As a global player with impact on the world economy, Shell attracts the attention of many stakeholders not only on a national but also on a global scale. The 'Brent Spar' case is often cited as an example of stakeholder impact on a big firm. Non-governmental organisations (NGO) take on climate change or local environmental or social aspects as issues to put pressure on firms (Salzmann 2003).

The industry structure for Shell's energy business can be described as follows (Salzmann 2003):

The energy market is an oligopoly: a few large integrated oil companies dominate the market and there is a significant level of competition. The bargaining power of suppliers is high: the OPEC controls most of the production of oil. The industry has high capital intensity and scale economies, thus, barriers to entry (and exit) are high.

Both car manufacturers and firms of the oil & gas sector invest in promoting sustainability issues in the 'mobility sector'. While the sector is based on petrol-/diesel-powered engines, the companies acknowledge the request for more sustainable solutions and invest in R&D accordingly. The complex nature of the mobility sector coupled with different industry backgrounds and core competencies of companies however make an orchestrated effort difficult. There are a number of co-operations within and between the sectors, and stakeholders address both sectors on the grounds of climate change and pollution.

For the mineral oil industry, the dependence on suppliers is significant, and stakeholders scrutinise environmental and social issues heavily. It could be assumed that pressure for change is high. The research portfolio encompasses designer fuels, especially GTL,

[6] see www.shell.com

fuel cells and hydrogen technology.

The automotive industry also performs R&D in these areas. Volkswagen explicitly emphasises BTL as a mid-term solution. Currently, suppliers' and customers' power is low. Brunner (2003, 17) concludes that overall the automotive industry defends the existing system because it considers the associated risks of a radical change as being too high. Implementing a radically new technological system world-wide would be very complex and uncertain.

To commit to a certain technology such as SunFuel, a joint effort is required not just with regard to a company's R&D but also with regard to regulatory institutions (national system) and stakeholders. Respective activities are for example the request for an extension of the German tax exemption beyond 2008 and the co-operation of Volkswagen with governments of Brandenburg and Lower Saxony to promote the development of SunFuel (Ministerium für Wirtschaft, Brandenburg2003).

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[1] SunFuel is registered trademark of Volkswagen AG (Wolfsburg)