Planning for System Innovation in Product Development Teams of Manufacturing Companies: Criteria Development for a Scenario Method

A. Idil Gaziulusoy
University of Auckland
Department of Civil and Environmental Engineering
Sustainability Engineering Programme
agaz002@ec.auckland.ac.nz

Carol Boyle
University of Auckland
Department of Civil and Environmental Engineering
Sustainability Engineering Programme
c.boyle@auckland.ac.nz

Ron McDowall
University of Auckland
Department of Management and International Business
Sustainability, Complexity and Decision
r.mcdowall@auckland.ac.nz

Abstract
Due to the complexity embedded in the socio-technical system and associated long planning periods, system innovation has become a research topic to remain mainly in the science and technology policies area and not much effort has been put into investigating the means of involving companies and product development teams in planning for system innovation. This paper presents results of ongoing research which proposes to develop a scenario method to help companies and product development teams in planning for system innovation. This paper presents the criteria which need to be met by the scenario method. Firstly, a brief overview of the theory around system innovation is given. This is followed by a critical analysis of dynamics and levels of innovation to set a background for criteria development. Then, a discussion clarifying the relevance of companies and product development teams to system innovation is provided prior to criteria development. Following this discussion, five criteria which must be met by the scenario method being developed are identified.

Keywords
socio-technical system, system innovation, sustainable design, business sustainability, sustainable technology development

1. Introduction

Sustainability is increasingly becoming the new business paradigm, especially in manufacturing companies, due to increasing legislative requirements, societal demand and changing organisational ethics and culture. In the last twenty years, a substantial amount of research effort has been directed towards improving business sustainability. The developed theories and related methods/metrics/tools covered both organisational and technical/technological areas such as management approaches, voluntary uptakes, clean production, industrial ecology, life-cycle assessment, eco-design and sustainable design.

The theories developed and practices undertaken in all of these areas are valuable and have aided the industry and companies to take initial steps towards sustainability. Nevertheless, within the sustainability context, the requirement for dematerialization of production and consumption (Schmidt-Bleek, 1994) and the needed decreases in greenhouse gas emissions (Rennings, 2000) are not likely to happen through the current technological path. Therefore, "Solutions are needed that break existing trends in current development processes." (Weaver et al., 2000, p.44). In summary, what we should aim for is path-breaking in current technologies, that is, as defined by Dosi (1982), a breakthrough shift from the current 'technological paradigm' towards a new one. As a result, companies and product development teams face a challenge which is not comparable in scale to any previous challenges the manufacturing industry has faced. On the one hand and in the short-term, the companies have to design/redesign products to meet immediate business priorities like decreasing the cost and time-to-market while assuring quality, market appeal, competitiveness, and compliance to ever-toughening legislation and standards. On the other hand, in addition to these generic and short-term business goals, they should develop new technologies in the medium and long-term which will overcome the burden put by the prevailing production-consumption patterns on the environment and society.

This paper presents results of ongoing research which proposes to develop a scenario method for the use of companies and product development teams in planning for system innovation. These results focus on the criteria need to be met by the scenario method. The next section provides a brief overview of the theory around system innovation followed by an analysis of the levels and dynamics of innovation. The third section starts with a discussion regarding the relevance of companies to system innovation and then the developed criteria are presented prior to the conclusions.

2. System Innovation for Sustainability

2.1. A Brief Overview of Theory

The type of radicalism which requires a shift in the technological paradigm is far more challenging than radical innovation at company/product level, since radicalism at the product level can be achieved in the existing technological paradigm without major change at market and/or user level. A shift in the technological paradigm requires changes at system level as a prerequisite. Innovation at system level covers not only product and process innovations but also changes in user practices, markets, policy, regulations, culture, infrastructure, lifestyle, and management of firms (see, for example, Berkhout, 2002; Kemp & Rotmans, 2005; Sartorius, 2006; Geels, 2006) to give way to and support diffusion of those new technologies. Similarly, Freeman (1992) states:

> Successful action depends on a combination of advances in scientific understanding, appropriate political programmes, social reforms and other institutional changes, as well as on the scale and direction of new investment. Organisational and social innovations would always have to accompany any technical innovations and some would have to come first (p. 124).

Therefore, the co-evolutionary nature of innovation and the need for a systemic perspective, which covers not only the industrial system (market-user-company) but also the social and technological systems, is even more significant in the case of developing sustainable technologies.

In order to emphasise the complex nature of system innovation, which covers not only technological but also institutional, social/cultural and organisational changes associated with it, Geels (2004) uses the term socio-technical system. Multi-level model of socio-technical change (Geels, 2005a, 2005b; Geels & Schot, 2007), which is based on transition management theory (e.g. Kemp, 1994; van den Ende & Kemp, 1999; Kemp, Rip & Schot, 2001) and several theories of co-evolutionary innovation, helps us to understand the dynamic relationships behind system innovation which take place at three different levels being macro (socio-technical landscape), meso (socio-technical regime) and micro (niche innovations).

According to the multi-level system innovation model, the stability increases and rate of change decreases towards the upper levels (macro) of the socio-technical system, while the depth and influence of change increases towards the lower levels. Nevertheless the change does not happen in a linear fashion and, as Geels (2005a) states, the relationship between the three levels is similar to a nested hierarchy. The layers have internal dynamics as well as influencing changes at other levels and the central focus is at the middle where the socio-technical regime resides.

The theory around system innovation is now very elaborate; however not much effort has been put into how companies in practice can and will fit into the picture. Companies are essentially the most important actors within the system innovation since they are indeed going to develop the new technologies. In addition, technology is not an abstract concept. It manifests itself through artefacts; i.e. infrastructure, products, and services, which are usually closely linked in a systemic structure. Products of a different technological paradigm will be essentially different from the products of current technological paradigm in terms of both technical characteristics and social meaning. One of the untouched areas is, thus, how manufacturing companies and product development teams can develop strategies towards system innovation. Consequently, there is an emerging need for tools and methods that would enable companies to include system innovation on their agenda and start planning for it.

2.2. Levels and Dynamics of Innovation within the Socio-technical System

Figure 1 is based on eco-design and eco-innovation typologies of Brezet (1997) and Halila and Hörte (2006). Brezet (1997) defines four levels of innovation. The first level is product improvement. Product improvements are focused on reducing environmental impacts for existing products. The second level is product redesign. In product redesign, product concept remains almost intact but either the product or its components are further developed or replaced. The third level is function innovation. At this level, the innovation is not limited to existing product concepts but related to how the function is achieved. The fourth and final level of innovation defined by Brezet (1997) is system innovation. At this level the whole technology system is replaced by a new system.

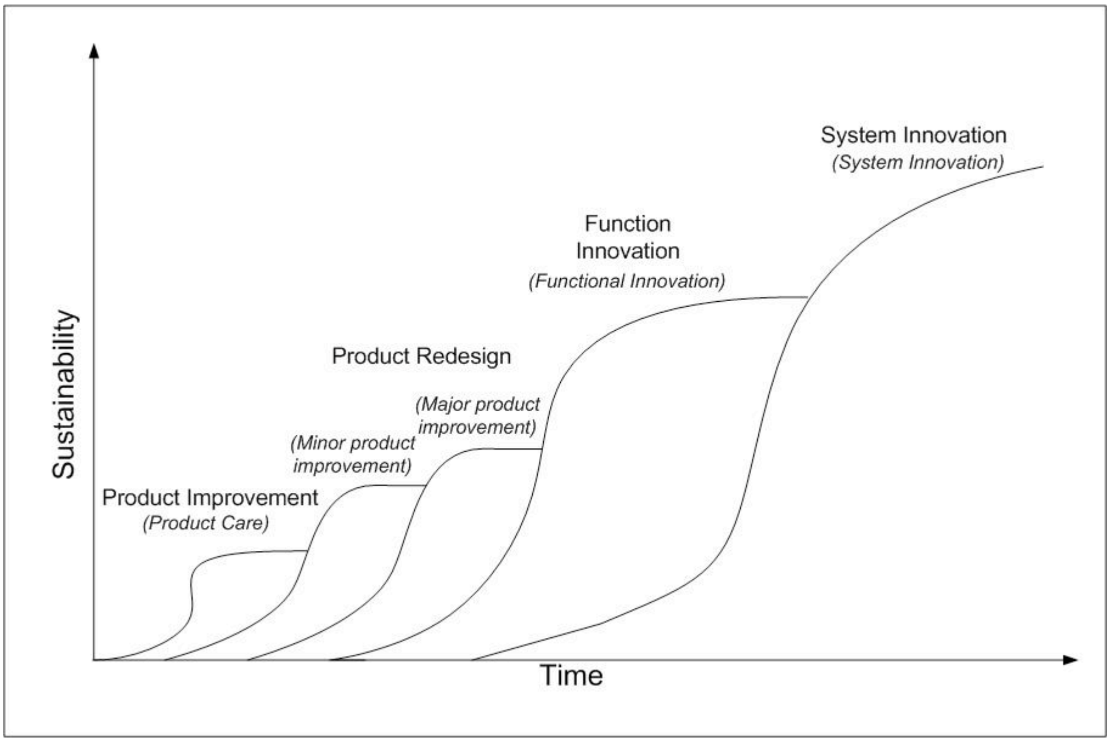


Figure 1. Levels of innovation (based on Brezet (1997) and Halila and Hörte (2006))

Halila and Hörte (2006) criticised the four-level typology of Brezet (1997) and defined a six level typology to improve the understanding of eco-innovations. They based their new classification on three criteria; a) the degree of creativity and the kind of knowledge on which the innovation was based; b) the extent of the innovation (product component, product itself, function within a system or the complete system) and c) the expected environmental effect. The six classes they proposed were product care, minor product improvement, major product improvement, functional innovation, system innovation and scientific breakthrough. This new classification brings clarity to the levels proposed by Brezet by enabling differentiation between minor and major innovations at product redesign level and articulating the difference between function innovation and system innovation. Nevertheless, even though useful for analysis purposes, this new classification does not propose anything novel in explaining the conditions of system innovation. The sixth level, which is scientific breakthrough, is, in our understanding, not an appropriate category for classification of technological innovations. Scientific breakthroughs are very important in enabling system innovation through broadening the knowledge base of basic science; however they are neither a level nor a class of technological innovation. Therefore, we use the four-level typology of Brezet (1997) while acknowledging Halila and Hörte's (2006) clarification with the exception of the sixth class they proposed.

The first and second levels are where most of the efforts are focused at the moment, driven mainly by the regulatory push/push mechanisms. These first two levels have product focus and are performed within the realm of established technologies and social uptake of established technologies. The third level, function innovation, generally constitutes a transition between product focus and system focus. In function innovation, the social function of products or technologies is of concern and questioned. What is meant by social function is what exactly we aim to meet by a specific technology or product and whether there is another way of fulfilling that function. Currently, certain product-service-system (PSS) applications fall into this category. Some PSSs are developed and implemented by a single company such as Interface Ltd. leasing carpets instead of selling them and replacing and recycling the old carpet into new carpets (e.g. Anderson, 1997). Some other PSS solutions require collaboration of several stakeholders, such as councils, NGOs, and in some cases, private companies. Some examples of multi-stakeholder PSSs related to urban mobility solutions can be found in Keskin, Brezet, Börekci and Diehl. (2008). Some historical examples of system innovation are the transition from sailing ships to steam ships, the transition from horse-and-carriage to automobiles, and the transition from piston engine aircrafts to jetliners in American aviation (Geels, 2002a, 2002b, 2005b).

As discussed in Section 2.1 above, system innovation requires not only technological innovation but also substantial changes are necessary at the institutional, social/cultural and organisational levels. As we move towards higher levels of innovation, the socio-technical context influencing technological change on a co-evolutionary basis broadens. Therefore, for a better understanding of system innovation, there is indeed a need for analysing the co-evolutionary influence patterns within the socio-technical system.

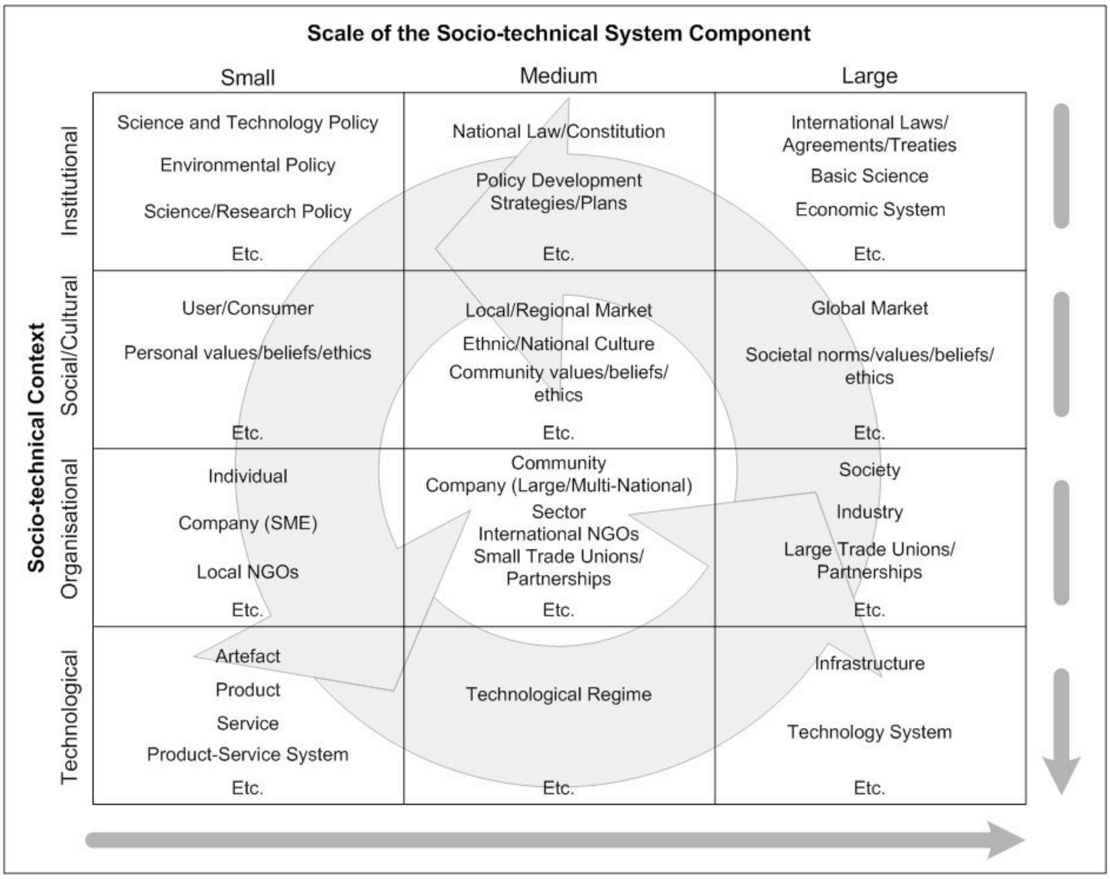


Figure 2. Co-evolutionary influences within the socio-technical system

Figure 2 shows some of the different elements of socio-technical system influencing technological change on a co-evolutionary basis. The circular arrows indicate that the change is indeed continuous and dynamic, and, every element influences each other. In general, society and technology shape each other on an ongoing and bilateral basis (Geels, 2005a, 2005b). Nevertheless, there is a semi-hierarchy of influence patterns from a chronological perspective. Institutional and social/cultural changes generally take place before and influence organisational and technological changes (Gaziulusoy & Boyle, 2007). We use the term semi-hierarchy since there is no strict rule about which comes first in the institutional-social/cultural and organisational-technological couples. But in general, institutional and social/cultural changes are more fundamental and powerful than organisational and technological changes. For example, science and research policy determines the direction of investment and thus influences technological change along that direction. Similarly, international laws and agreements determine the characteristics of international trade unions. Societal norms and values determine, to a large extent, how social organisation is structured. But, even though it is correct to state that institutional arrangements and social/cultural structures determine the direction of change in the other two socio-technical contexts in general, there are many exceptions to this as well especially in the large scale. For example, infrastructure lasts for a long time and many of technological and social activities, as well as development of policies particularly those related to public health or transport, need to be referenced to the characteristics and capacity of the infrastructure.

Despite the hardship associated with analysing the dynamics between different socio-technical contexts, there are easily observable patterns between different scales of the socio-technical system. Complexity increases as the scale becomes larger. Consequently, as the scale gets larger, managing change becomes harder and the pace of change gets slower. Also, smaller scales in one socio-technical context are hierarchically dependent on larger scales in the same context. For example, products are determined by the relevant technological regimes and the technological regimes are determined by the technology system. Similarly, change in the large scale of a particular socio-technical context is likely to require change in smaller scales of the same context. Nevertheless, smaller scale socio-technical system components may or may not induce/influence change in the larger scales of the same socio-technical context. Another aspect which is very relevant to technological change is agency. Agency, as described by Giddens (1984) is the ability to act and influence change over the course of events. In the context of transforming socio-technical systems, agency "is the ability to intervene and alter the balance of selection pressures or adaptive capacity" (Smith, Stirling & Berkhout, 2005, p. 1503). Agency applies to organisational and social/cultural contexts. As the scale gets larger, agency of the socio-technical system component increases, but, organisation and management becomes harder. A community has more agency in influencing change than an individual. However, the organisation and decision/action process undertaken by a community take longer than that of an individual.

The analysis given above with reference to Figure 2 renders the underlying co-evolutionary mechanisms transparent without any point of reference for planning. Therefore, it can aid in planning for system innovation at any level of social organisation. For example, this generic analysis is equally valid for a policy maker and a company manager. Nevertheless, due to different hierarchies and levels of agency, different socio-technical system components in organisational and social/cultural contexts can influence different contexts and scales. Inevitably, the purpose of different entities who plan for system innovation will differ as will the specific planning and implementation tools. Therefore, the specific socio-technical system component which will carry out this analysis should clearly define the purpose of such undertaking (e.g., policy development, curriculum development, product/service development etc.) and understand their agency and the temporal and spatial scale that they can influence and be influenced by.

Since we talk about system innovation within the context of sustainability, sustainability becomes the goal of any planning/implementation effort for system innovation. This underlines the importance of future visions developed on a participatory basis. Visions about system innovations play a number of important functions, such as mapping a possibility space, establishing a heuristic and a stable frame for setting targets and monitoring progress, specifying relevant actors and network(s) of actors and directing investment (Smith et al., 2005).

3. Manufacturing Companies and Product Development Teams in System Innovation

3.1. Relevance of Manufacturing Companies and Product Development Teams

The manufacturing industry is the major cause of environmental deterioration, as well as the main agent for economic and social development (Schot, Brand & Fischer, 1997). Industry is a subset and an integral part of the society. It facilitates economic and social development as well as cultural exchange. Industry provides products and services for need fulfilment and well-being. It facilitates human development through knowledge generation and technological development and it plays an important role in job creation and employment. The companies are not only responsible to, and driven by, the interests of shareholders but they also are responsible to, and influenced by, all stakeholders that they come in contact with, either directly (consumers, employees, governmental institutions, supply chain, etc.) or indirectly (competitors, educational institutions, public in general).

The manufacturing industry is strictly subject to the irreversible hierarchy of the strong sustainability model. The strong sustainability model suggests that the different kinds of capital contained by environment, society and economy cannot be substituted (Gray, 1992), contrary to the weak sustainability model which rely on the unrealistic assumption that "either unlimited substitution among different kinds of capital is possible or that money is the universal substitute for anything" (Gowdy, 2005, p. 216). Without resources, processes or technologies would not be possible. Without human capital input, physical and intellectual labour requirements would not be met due to the very limited interchangability of different assets provided by hierarchically interdependent environmental, social and economic systems.

In addition, industry and the whole network of production and consumption influence change in the socio-technical system in the short, medium and longer terms by development of new technologies, generation of new knowledge and social meaning all which sooner or later influence changes in norms, values and life styles. Through technological change, social and cultural norms and perceptions change as well. So, industry itself is an agent of change which can facilitate the change required within the socio-technical system needed to achieve sustainability. Society and industry are interdependent, and thus, sustainability of industry is required to sustain society and vice versa. Therefore, as well as top-down approaches like policy development, bottom-up efforts such as planning at company level is needed in order to enable a holistic and thus effective transition to sustainability.

The complexity of socio-technical systems is why so far system innovation has been of interest to the science and technology policies research agenda rather than design theory and practice. The massive scale of required systemic change rendered any interest for planning for system innovation at company level irrelevant. Nevertheless, it is our belief that the recent developments around carbon markets, legislative trends at global level and increasing stakeholder pressures on companies are signals of a sustainability transition taking place and thus there is a need for company-level tools to be used in planning for system innovation.

System innovation requires long-term planning (i.e. 50 years or more) due to the complexity embedded both in natural and social systems and the dynamic nature of sustainability requirements (Gaziulusoy & Boyle, 2007). The time frames required for system innovation are far beyond the ones usually used by companies for planning (Jansen, 2003). Nevertheless, system innovation assumes structural changes to take place in the socio-technical system including the major assumptions of the current economic system and the role and responsibilities of businesses within society. In addition, companies are important actors within the socio-technical regime and will have an important role in developing the technologies of the new system. Therefore, developing tools and methods which would enable active participation of companies through their business practices in planning for system innovation is necessary both in order to effectively implement any plan at policy level and to increase the adaptive capacity of individual companies with regards to the substantial change which will take place through the transition. A framework has to be established to portray the ways companies are and can further be related to system innovation, and issues needing to be solved should be identified and acknowledged in the tools and methods to be developed.

In manufacturing companies, product design/development function is the key business function, or, in other words, product design/development activity is the raison d'être of manufacturing companies. Even though product development is the key business function in a company, successful product development requires input from all major business functions. Therefore, product development teams, as referred to in this paper, involve not only design engineers and industrial designers but essentially anyone who is involved in the process, including but not limited to, sales and marketing specialists, sustainability/ environmental managers, innovation strategists/planners, technical and research experts, etc.

3.2. Criteria Development for the Scenario Method

In order to develop the criteria which need to be met by the scenario method, two sets of requirements were identified. The first set of requirements outlines the structure of the method. The structural requirements are identified based on the theory of system innovation for sustainability and analysis of previous projects aimed to plan for and/or steer system innovation. The second set of requirements is about the content of the scenario method. The content requirements are identified through a review of system innovation typologies, scenario typologies and methods and, drivers and barriers for businesses to adopt sustainability as a default business and product development priority and to undertake radical new product/technology development projects.

Table 1. Structural and content requirements for the scenario method

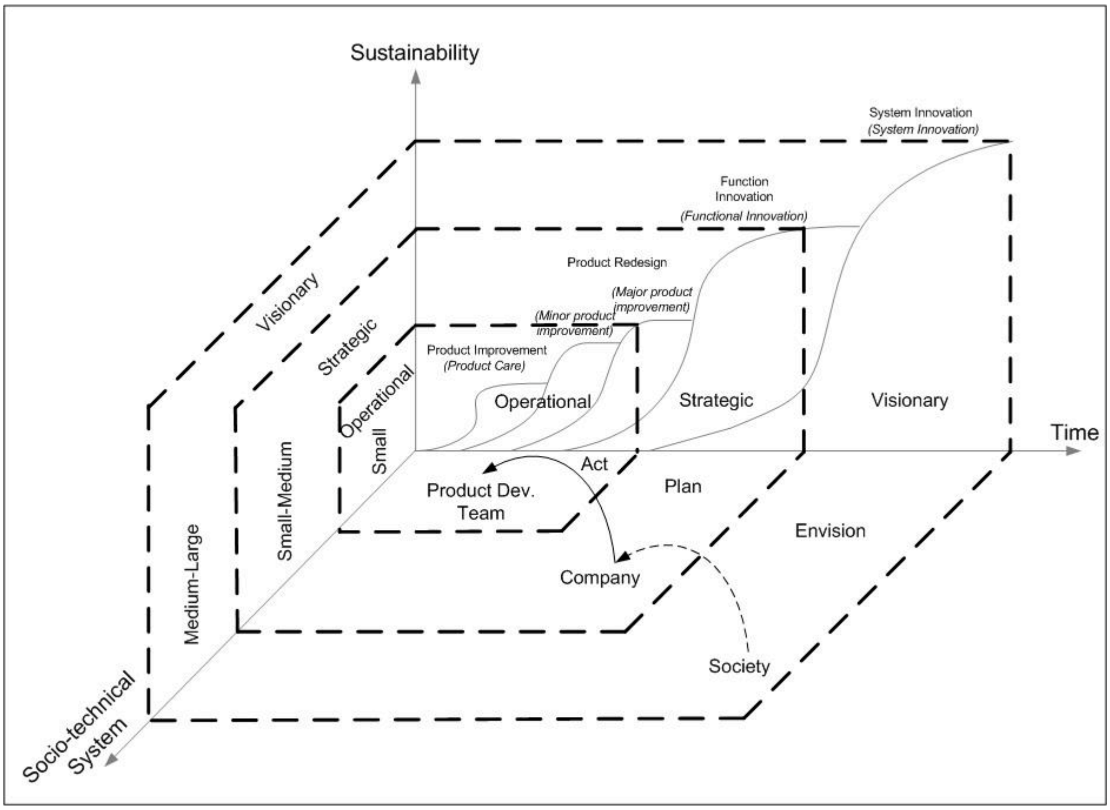
Structural Requirements	*Content Requirements*
SR1. The scenario method needs to be systemic SR2. The scenario method needs to be layered SR3. The scenario method needs to have a double-flow	CR1. The scenario method should enable identification of alternative innovation paths CR2. The scenario method should aid in identification of organisational/human development requirements CR3. The scenario method should aid in identification of technical development requirements CR4. The scenario method should have operational, strategic, visionary periods CR5. The scenario method should have a risk approach to sustainability

The process of identifying these requirements and finally developing criteria was not a linear and step-wise process. Firstly a conceptual framework was developed for sustainable technology development (Gaziulusoy & Boyle, 2007) which outlined the feedback paths between higher levels of innovation (institutional, social/cultural, organisational) and technological innovation. Following this the structural requirements and sustainability measure to be used in the scenario method was developed (Gaziulusoy & Boyle, 2008). Here we present the model we developed to position individual companies and product development teams in the broader context of system level innovation (Figure 3). This model gave way to identification of the remaining content requirements. Table 1 provides the three structural and five content requirements identified over the course of this research. Each one of these requirements could have been accepted as a criterion. But they are somewhat related to each other; some of them reinforce each other and some of them require another. For the purpose of simplifying both the development and execution of the scenario method we decided to generate groups of related requirements and establish criteria in line with these groups. The resulting criteria and brief explanations are given below.

Criterion 1 (SR1, SR2, CR4): The scenario method should link the planning periods applicable to companies (operational and strategic) to the long-term planning period (visionary) in order to enable companies to address long-term societal visions in their strategies and effectively implement these strategies in product development.

Figure 3 combines the levels of innovation (Figure 1) and the different scales of socio-technical contexts (Figure 2) in order to link system innovation to individual companies' activities in a meaningful way. As shown in Figure 3, the planning periods applicable to the levels of innovation can be defined as operational in the short-term, strategic in the medium-term and visionary in the long-term. The short-term used here covers ten years which is the longest business planning period for most companies. We acknowledge that there are indeed shorter periods that businesses need to make decisions and take action within, such as daily, monthly or annual periods. In addition, product development cycles are getting shorter as the global competition increases and lean product development practices become more widespread. Nevertheless, it is empirically proven that as the innovativeness of products gets higher the development cycle becomes longer (Griffin, 1997a, 1997b). In cases of radical innovation, the technological and market uncertainties require longer learning periods and therefore more time needs to be invested (Herrmann, Gassmann & Eisert, 2007). Case studies (e.g. Lynn, Morone & Paulson, 1996; Veryzer Jr., 1998; Abetti, 2000) have shown that for radical innovations, time-to-market cycles as long as and sometimes longer than ten years is common. Therefore, this period of ten years is literally the operational period for radically new product development and needs feedback from longer planning periods if we aim for a deliberation towards sustainability. The strategic period should shape the operational period through the setting of goals at the organisational (company) level. Individual companies have very limited agency to influence change at the systemic level. Nevertheless, it should be emphasised once again that companies are part of society and thus, even though they fall into small/medium scale within the socio-technical system, their strategic goals should not be contradictory to visions of society and thus their strategic goals should be aligned with the meta-goals desired at societal level to achieve sustainability. Therefore, the planning periods applicable to companies (operational and strategic) need to be linked to the long-term planning period, theoretically at the end of which the whole socio-technical system should have been transformed. As a result, companies should acknowledge the long-term visions of the society during their strategy development which then will guide the product development decisions.

Figure 3. Planning periods



Criterion 2 (SR1, CR2, CR3): The scenario method should aid companies in identifying not only technology development requirements but also organisational/human development requirements and should facilitate integration of all business functions in line with the company strategy.

The organisational/human context will determine the success of any technical activity since the capacity, knowledge and capability to innovate is generated, assessed, developed and used within the organisational context (Jorna, 2006). Gaziulusoy and Boyle (2007) indicate that organisational innovations should cover a longer time span than technological innovations in order to be able to influence technological innovations towards sustainability. The scenario method which will be used at company level should not only help to identify technical/engineering requirements related to product development function but also should address organisational/human dimensions of company governance. Therefore, the scenario method should enable technological development with reference to organisational vision which should cover a longer time span in planning; i.e. which should oversee a company's product development path and guide it towards system innovation for sustainability. In this context, organisational planning plays an interface role between purely technological innovations achieved within the product development team and system innovation which will be achieved within the wider socio-technical system.

Criterion 3 (SR1, SR3, CR2, CR3, CR4): The scenario method should aid companies in developing an integrated business strategy aligned with societal level sustainability visions and day-to-day business activities.

The scenario method should aid in integrating the implications of a normative sustainability vision, which needs to be achieved in the long-term and at a socio-technical system level, into day-to-day business activities. This requires internalisation of sustainability into company strategy through generic tools like Strengths Weaknesses Opportunities and Threats (SWOT) analysis, results of which should be aligned with other business priorities. This would enable internalisation of innovation for sustainability at product development (operational) level through identification of design criteria. Since successful product development requires integration of all major business functions within a company and since company strategy needs to be referenced to future visions in order to guide product development towards system innovation, the scenario method should enable integration of business functions in line with the organisational/strategic plan. Johansson, Greif and Fleischer (2007) provide a review of several studies which identify barriers to integration of business functions. They also refer to the studies which identify mechanisms facilitating integration which can be of technological and/or organisational nature. Therefore, construction and organisation of product development teams will play a very important role in any attempt for system level innovation to be successful. The organisational and technological barriers to integration of business functions need to be acknowledged along with possible facilitating mechanisms in developing a scenario method for the use of companies.

Criterion 4 (SR3, CR1): The scenario method should have a double-flow approach in order to link present and future in a realistic way and enable identification of alternative innovation paths which are possible from a technological point of view, acceptable from a social/cultural point of view and desirable from a sustainability point of view.

Gaziulusoy and Boyle (2008) provided a critique of scenario methodologies used previously to plan for sustainable technology development. The criticism they brought regarding the flow directions of previously used methodologies were:

> Starting only from the future may result in not being able to acknowledge the lock-ins needing to be overcome and which are embedded in the present socio-technical system. On the contrary, for a backwards scenario building approach, following only a forward flow of strict

> causality may limit multiplicity of paths or even the possibility of developing a path for periods longer than medium-term (p. 903).

They proposed a double-flow approach to scenario development where two sets of scenarios would be developed, one set starting from the present and the other from the future while aiming for alignment at the medium-term.

Criterion 5 (SR1, SR2, CR2, CR3, CR5): The scenario method should have a layered risk approach to sustainability in order to incorporate societal-level sustainability vision into companies' organisational and product development strategy.

Thompson et al., as cited in Jansen (2003), point out that the eco-efficiency factor we should achieve in line with growing population and desired welfare level varies from 2 to 50 depending on assumptions. Jansen (2003) states that achieving these eco-efficiencies is already a very challenging undertaking; however, even the most ambitious targets will not be sufficient in the long run for two reasons. First, because eco-efficiency improves only environmental performance and does not address any of the social issues which require solving and, second, because eco-efficient growth will reach the earth's limits eventually. Gaziulusoy and Boyle (2008) provided a critique of sustainability assessment methods and suggested using risk-to-sustainability as a measure, referenced to Boyle's (2004) risk assessment framework. They pointed out that both the required length of long-term planning and risks are context dependent and should be determined in line with, as defined by Costanza and Patten (1995), the nominal life span of the operational context. In line with this analysis, they suggested using the categorisation below in scenario development:

> - Sustainability risks: Overarching global risks posing threat to proper functioning of the society (e.g. climate change, peak oil, etc.). These are also referred to as first order risks; and
> - Contextual risks: Context dependent risks rising as a consequence of sustainability risks and pose threat to a specific operational context and/or sub-system (e.g. cities, industry, sectors, companies, etc.). These are also referred to as second-order risks (p. 897).

Analysing contextual risks at company level contributes to fulfilment of internalising sustainability in a company strategy and having a layered approach to risk analysis helps individual companies in contributing to establishment of meta-goals or long-term visions at society level. In addition, this layered approach enables addressing the complexity and dynamism of hierarchical and irreversible interdependencies of environmental, social and economic systems through analysis of first order risks followed by identifying their implications on the company. Developing strategies which take these implications into consideration will guide product development pathways towards system innovation and improve adaptive capacity of companies.

4. Conclusion

The change required to achieve sustainability calls for innovation at system level. System innovation does not only take place in the technological context but also requires substantial change within all contexts of the socio-technical system. In addition, due to the complexity of the socio-technical system and the scale of required change, system innovation necessitates long-term planning which is beyond the normal planning and operating periods of companies. Nevertheless, companies are important actors and change agents within the socio-technical system. Therefore, there is an increasing need for tools/methods which can be used by companies to plan and develop products/services of the new technology system.

This paper presented results of ongoing research which proposes to develop a scenario method to help companies and product development teams in planning for system innovation. In line with the developed criteria, the scenario method should:

- link the planning periods applicable to companies (operational and strategic) to the long-term planning period (visionary) in order to enable companies to address long-term societal visions in their strategies and effectively implement these strategies in product development;

- aid companies in identifying not only technology development requirements but also organisational/human development requirements and should facilitate integration of all business functions in line with the company strategy;
- aid companies in developing an integrated business strategy aligned with societal level sustainability visions and day-to-day business activities;
- have a double-flow approach in order to link present and future in a realistic way and enable identification of alternative innovation paths which are possible from a technological point of view, acceptable from a social/cultural point of view and desirable from a sustainability point of view; and
- have a layered risk approach to sustainability in order to incorporate societal-level sustainability vision into companies' organisational and product development strategy.

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