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INNOVATIVENESS:
RESULTS FROM ACTION RESEARCH AT A
MULTINATIONAL CORPORATION IN GERMANY**

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**MEASURING SUSTAINABILITY BY ENVIRONMENTAL
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RESULTS FROM ACTION RESEARCH
AT A MULTINATIONAL CORPORATION IN GERMANY**

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ABSTRACT

Corporate sustainability is increasingly regarded as a management task. Thereby, especially environmental performance is becoming an important indicator. This paper addresses a measurement approach of evaluating environmental performance from an innovation perspective. Based on the insights from action research at a multinational corporation in Germany, we stress the importance of environmental innovations and propose to measure sustainability in terms of environmental innovativeness. We present a step-by-step methodology for developing an indicator called “Environmental Innovation Power (EIP)”. We end the paper with a discussion and a brief conclusion.

Keywords

Corporate Social Performance, Environmental Innovation, Performance Indicators, Innovation Process

INTRODUCTION

Next to being profitable, companies are increasingly facing pressures to also act socially and environmentally responsible – in other words, to strive towards sustainability. Further, in the wake of recent corporate scandals, there is huge pressure for businesses to be accountable and transparent in their activities, i.e. to provide stakeholders with sufficient, accurate, understandable, and timely information about progress in these dimensions (Swift 2001: 17). In order to address these external demands, firms are required to more professionally manage and control social and environmental responsibility. This, however, requires firms to establish new tools and metrics. Therefore, the most urgent requirements is to develop theoretically based, standardized, and aggregated measures and to perform regular evaluations to provide the stakeholders with meaningful guidelines and a uniform basis for information (Tyteca 1996; Ditz & Ranganathan 1997; Ilinitich et al. 1998; Jung et al. 2001; Olsthoorn et al. 2001).

We are especially interested in the environmental dimension of sustainability and, accordingly, in environmental performance. It appears, however, that the process of measuring corporate environmental performance is still in its infancy (Curkovic 2003). This is, at least partly, due to the lack of academic studies in this field (Kolk & Mauser 2002). Moreover, to date, environmental performance so far focuses on measuring operational and management performance (Young & Welford 1998; Thoresen 1999; Jung, Kim & Rhee 2001; Curkovic 2003), whilst neglecting the importance of products and technologies, as well as the related innovation processes. However, in recent years the importance of innovations are frequently discussed in regards to sustainability (Larson 2000; Berkhout & Green 2002; Hines & Marin 2004; Wagner & LLerena 2008), both in the form of incremental and radical innovations (Herbig 1994; Freemann & Soete 1997; Koberg et al. 2003) as well as process and product innovations (Wagner 2007). In particular, product-oriented environmental innovations (Foster & Green 2002; Gordon 2008; Eiadat et al. 2008) play a role. Environmental innovations are interesting because they are driven by core competencies (Chen 2008) and can directly link to competitive advantages (Bansal 2005; Chen et al. 2006; Wagner 2007). Thus, they contribute to sustainability performance as well as corporate competitiveness (Porter & van der Linde 1995; Fuzzler 1996; Lee & Ball 2003; Könnölä & Unruh 2007; Reid & Miedzinski 2008). We therefore propose to evaluate environmental responsibility by measuring environmental innovation performance.

Our work focuses on environmental innovation defined as the production, assimilation or exploitation of a product or service that is novel to the organisation and which results in a reduction of environmental risk, pollution and other negative impacts of resources use compared to relevant alternatives (Kemp & Pearson 2007: 7). The development of such innovations depends on the environmental considerations in the management and mainly in the innovation process (Azzone & Noci 1998; Foster & Green 2000). Hence, we are especially interested in the evaluation and measurement of the innovation process (cf. Smith 2005).

Accordingly, this paper addresses the following research questions: *How can corporations develop indicators for the assessment and control of their innovation process in regards to environmental innovations? Moreover, how can corporations use environmental innovations for the quantitative as well as qualitative evaluation of environmental responsibility?*

The paper is organized as follows. First, we briefly review the previous literature addressing the relevance of sustainability and environmental innovations. Second, we present empirical action research at a large Multinational Corporation (MNC) in the chemical industry and develop indicators, which allow to measure environmental responsibility in regards to environmental innovativeness. A six-step process to develop these indicators is described. We finally discuss the findings, outline the limitations and finish this work with a brief conclusion.

RELEVANCE OF INNOVATIONS FOR MEASURING ENVIRONMENTAL RESPONSIBILITY

Sustainability innovation or environmental innovation has been broadly defined as the process of developing new ideas, behaviour, products and processes that contribute to a reduction in environmental burdens or to ecologically specified sustainability targets (Rennings 2000). Thus, sustainability innovation is an emerging and fundamental force for change in business and society (Larson 2000: 304). Learning to be innovative in addressing societal problems is a fundamental requirement for those seeking a more sustainable future (Hines & Marin 2004: 201).

The enormity of the task that lies ahead is clear, as it requires greater engagement with a wide set of stakeholders, and a greater integration between existing research streams in the areas of environment and innovation (Berkhout & Green 2002; Reid & Miedzinski 2008).

New innovations turn into sustainable business assets only if they are acceptable to society in large (Dormann and Holliday 2002: 3). Thus, understanding and anticipating societal needs and the impacts of innovation are seen as key to ensuring that such approaches become an everyday part of business. Since we are especially interested in the evaluation and measurement of the innovation process further understanding of innovation in environmental management at the level of the firm in the future could provide the necessary information on developing indicators on corporate environmental responsibility.

According to Larson (2000: 305) the literature exploring the motivating forces in business, technological innovation, and the environment can be grouped into three general areas: the public policy view (cf. Porter 1991; Allenby 1999), a voluntary standards perspective (cf. Nash & Ehrenfeld 1997), and a resource-based view. We are especially interested in the latter in which ecological considerations are incorporated into strategic management, and efficiency improvements are achieved through pollution prevention and product stewardship (Hart 1995 & 1997; Barney 1991). Especially Hart's concepts of "clean technology" and "sustainability vision" argue for innovation. Thus, it also answers very much our view of realising corporate environmental responsibility and serves as our basic idea.

In regards to sustainability it is important to anticipate trends on a strategic level. Based on these information, processes and products could be developed, which avoid negative environmental impacts and, thus, allow to improve environmental performance (Aragón-Correa 1998; Hart & Ahuja 1996; Russo & Fouts 1997; Sharma & Vredenburg 1998; Wagner 2007). The challenge to continuously improve environmental performance could be at the same time seen as driver for innovations (Fiksel 1996: 48).

Environmental innovations are necessary to simultaneously guarantee business success as well as an increase of environmental performance (Huppel et al. 2008). As such, environmental innovations need to create double positive externalities. Their systematic planning, implementation and control are an indispensable precondition for companies to secure a strategic advancement in a world of environmental challenges, like for example climate change and lack of resources.

Distinguishing innovations regarding their environmental consideration is difficult (Reid & Miedzinski 2008: 2). This is because environmental performance improvements are often linked with improvements in product performance, manufacturing efficiency, or cost. Firms do often not distinguish between projects aimed at any of these three objectives (Foster & Green 2000) or projects intended to address environmental concerns. Thus, the challenge in developing useful environmental innovation indicators lies in the differentiation between environmental innovations – for instance elimination of harmful product components, new clean replacement technologies, or systemic innovation in the production system – and “traditional” innovations, which are being developed for reasons of saving costs, or providing better service to customers.

Although we are well aware that measuring environmental innovation, both from a process perspective and a result of innovation activity, is a substantial challenge (Reid & Miedzinski 2008: 7), we try to force this challenge focusing on environmental innovations on evaluating corporate environmental responsibility.

METHOD

This paper is based on the methodology of action research (Greenwood & Levin 2007; Herr & Anderson 2005; Reason & Bradbury 2008). Often early works of Kurt Lewin (1946) are referenced as the first application in social sciences (Herr & Anderson 2005: 11).

Reason and Bradbury (2008) underline that action research is participative research which seeks to bring together action and reflection, theory and practice. Therefore, it has the dual purpose of an advancement of knowledge whilst simultaneously achieving practical transformation. Action research is about working toward practical outcomes, and also about creating new forms of understanding. The researcher is actively involved in changes in the context being researched (Huxham & Vangen 2003: 386). He may act as expert or consultant and works on an issue in which the organization and the researcher have a genuine interest for exploration. Therefore, action research can lead to “better” research because the practical and theoretical outcomes of the research process are grounded in the perspective and interests of those immediately concerned, and not filtered through an outside researcher’s preconceptions and interests. Action research allows us to move away from operational measurement into a science of experiential qualities (Reason & Goodwin 1999). The objective of action research is the development and testing of tools and models and to dwell on emergent theories through the participation of company members (Huxham & Vangen 2003: 392f).

The central aim of this research was to develop environmental performance indicators of corporate environmental responsibility. We cooperated with a multinational corporation based in Germany, which is a world leading gases and engineering company and, hence, usually regarded as part of the chemical industry. Between May and November 2008 one of the researchers has joined the organization in

order to collaborate closely. The main instrument of interaction was meetings. Prior to the meeting, a questionnaire was sent to the participants so that they could prepare most of the information needed. Altogether we carried out around fifteen meetings with division managers, members of the corporate responsibility department, and members of the research and development department. Each meeting had a duration of two to three hours.

FINDINGS

As introduced above, we worked together with a MNC based in Germany. The company has more than 50,000 employees and covers sites in around 100 countries. The company strives to position itself as a major player in mastering today's energy challenges, by delivering products and technologies for safeguarding future energy supplies, whilst at the same time protecting the climate and the environment. It is divided into three business divisions. The present action research was carried out in one of the three business divisions, which is specialised in engineering of industrial plants in the phases of planning, project development, and construction. Since innovations are usually managed within projects, the number of R&D projects does often serve as starting point in evaluating an innovation system (Ojanen & Vuola 2003: 14f; Kemp & Pearson 2008: 40; Moris et al. 2008: 124). The same accounts for the present firm, where the environmentally friendly solutions and innovations are managed on a project level. Thus, in the action research, we analysed around 400 of the division's innovation projects, which were all initialised between 2006 and 2008.

Based on the characteristics of these projects, we developed a methodology to calculate and visualise environmental innovativeness. This methodology consists of six major steps. *First*, eco-classes need to be developed and existing innovation projects need to be categorised into these classes. *Second*, eco-weightings have to be developed for each eco-class. *Third*, innovation projects need to be assessed according to their level of maturity in the innovation process. *Fourth*, weightings for each level of maturity need to be developed. *Fifth*, based on the prior steps the aggregated environmental innovativeness indicator has to be calculated. *Sixth*, the resulting indicator needs to be charted into a two-dimensional portfolio, in order to interpret the indicator in more holistic ways. Thereby, some of the steps need only to be executed once, whereas other steps have to be executed periodically. Eco-classes and eco-weightings (step one and two), and the weightings for the level of maturity (step four) need only to be developed once in a company. The other steps need a periodical update. All steps are further explored in the following sections.

First Step: Determining Eco-Classes

In an earlier part of this paper, we already highlighted the difficulty to distinguish between environmental innovation and "traditional" innovations. Accordingly, we developed a methodology which covers *all* innovation projects and, thus, attaches importance to the integration of environmental considerations in the *overall* innovation process of the firm. This is in contrast to some existing sustainability and environmental portfolio approaches in MNCs (cf. GE 2007; Siemens 2008), which focus on selected products and technologies.

In a first step we thus introduce eco-classes which incorporate the entirety of innovations and help to organize them. These eco-classes are defined broadly enough

to guarantee that all innovation projects are covered. We assigned all projects to a single eco-class according to the project's priorities.

The question of whether there are any special characteristics present in environmental innovation is a challenging one. Environmental innovation concepts could be analysed from the perspective of the target for innovation, i.e. a new product, new process, new market, new way of organizing the business or new sources of supply (cf. Schumpeter 1934). Accordingly, defining eco-classes could be done e.g. by focusing on the well-known separation into product or process, by referring to the newness of the offering and the distinction between incremental and radical innovation (Freeman & Soete 1997), or by regarding the difference between architectural and component innovation (Henderson & Clark 1990).

Adapted from the topics of 400 projects, we suggest a distinction based on input and output dimensions. The input dimension covers technologies dealing with different types of resources and related processes. The output dimension covers technologies dealing with emissions caused by the former processes. The dimension "other" contains all technologies, which do not have a direct link to environmental issues. These meta-classes may be sub-divided into the following six eco-classes (Table 1):

Insert Table 1 about here

Whilst the above classification may vary according to the industry or sector, the classification in input and output classes is a rather generic approach, which may suit all industries in their undertaking to manage their innovations in an environmental-oriented way.

Eco-class B contains technologies, which are based upon renewable resources. Projects focusing on CO₂-emissions are summarized in eco-class C. Technologies, which, next to CO₂-emissions, also focus on other emissions (solid, fluid, gaseous), are arranged in eco-class E. Eco-class S covers technologies based upon non-renewable resources. Technologies, which aim at increasing energy-efficiency of existing technologies, are grouped in eco-class I. Finally, projects without an obvious environmental reference are assigned to eco-class O.

Sub-dividing the input classes as well as the output classes into further categories allows us to structure the innovations in an environmental-oriented manner. Still, the presented classes need to be related to their environmental impact, which is the subject of the following section.

Second Step: Determining Eco-Weightings

To manage the necessary differentiation between "traditional" innovations and environmental innovations, in a second step, a panel of experts from the MNC weighted the eco-classes. As a result of uncertainty about what "environmental" means in practice, it is difficult to formulate environmental success criteria for innovation projects (Foster & Green 2000: 289). Although this may well be one constraint for the analysis of environmental innovations, other criteria can be identified that are very suitable. Thus, we regarded dimensions and determinants of environmental innovation (cf. Hellström 2007; Kivimaa 2007; Kemp & Pearson 2008; Horbach 2008) and finally established the following three weighting criteria that are appropriate for differentiating

the six classes: (1) Potential of minimizing environmental load; (2) level of novelty; and (3) environmental significance.

The panel of experts determined the correlation of the three weighting criteria with each of the six eco-classes on a scale from 0 to 50 (50 = strong correlation; 0 = no correlation). Thereby, the experts weighted every eco-class in relation to all other eco-classes. The overall weighting for each eco-class, the so called “eco-weighting”, results from adding up the weighting points for each weighting criterion. Normally the weighting criteria interdepend positively – for instance, innovations with a high “potential for minimizing environmental load” do usually have a high “level of novelty” and enjoy “environmental significance” in form of a lobby. The final eco-weightings are presented in Figure 1.

Insert Figure 1 about here

Third Step: Determining the Maturity in the Innovation Process

In a third step, we used the firm’s innovation phase gate process to analyse the innovations in regards to their maturity. The innovation phase gate process consists of six sequential phases – from idea generation to testing based on commercial scale. Each innovation project passes through the innovation phase gate process. The orientation in regards to the six innovation phases allows for a common understanding about the proceeding of the innovation projects. More specifically, it is possible to check whether a technology is arranged at an early stage, at a stage of accelerated development, or at a final stage. Based on this process, it is possible to determine the phase for each innovation and, thus, to generate the technological maturity of all innovations. We therefore developed a controlling method to apply the innovation projects against the innovation phase gate process. A detailed overview of the controlling method is given in Figure 2.

Insert Figure 2 about here

For determining the levels of technological maturity, only innovation projects *within* the innovation phase gate process are relevant. This is important, because there are always unsuccessful projects, which are cancelled at an early stage, and successful projects, which leave the process at a final stage. Also, there are continuously new projects which enter the innovation phase gate process, which need to be considered. Thus, the number of projects is dynamic and has to be determined on a regular basis.

Next to determining the levels of technological maturity for each project, it would be valuable to analyse the projects through in depth evaluation. For better controlling the projects in regards to their advancement and, thus, in regards to their performance as well as maturity, we propose to additionally examine their visible and, especially, their hidden costs. Hidden costs are characterized by their strong capacity to explain the quality or lack of the organization’s operation (Savall & Zardet 2008: 27). Hence, the hidden costs of a project such as overtime or overconsumption (ibid.: xxiii) are significant since they affect the overall project’s success and maturity, and, thus, the overall environmental innovativeness. When determining the technological maturity,

the hidden costs of the projects should always be in mind. Once detected, they make it possible to engage in a process of seeking out solutions for greater efficiency and performance.

Fourth Step: Determining Weightings for each Level of Maturity

As the technical system can be said to grow mature (Berkhout 1996) over time, we therefore apply, in a fourth step, an expert rating concerning the six phases of technological maturity. Based on the discussions with internal experts from the MNC, we suggest a weighting for the six phases of the innovation phase gate process, respectively for the six levels of technological maturity. Therefore, we focused on success factors of technologies (cf. Lüthje 2007; Verworn & Herstatt 2007; Hu & Shi 2008) for weighting the six levels of technological maturity and propose the following four criteria: (1) Probability of technical success; (2) probability of economical success; (3) level of knowledge; and (4) level of networking.

In this one-time process, the internal experts determined, for each level of technological maturity (innovation phases 1 to 6), the correlation with the four above weighting criteria. Thereby, the experts weighted every level of technological maturity in relation to all other levels on a scale from 0 to 50 (50 = strong correlation; 0 = no correlation). The overall weightings for each level of maturity, the so called “tech-weightings”, result from adding up the weighting points for each weighting criterion. Mature technologies are strongly distinctive in all four dimensions. Regarding a technology, thus, as the level of knowledge increases and the level of networking among customers and co-operation partners stabilizes, the risk is reduced that this technology will fail. At the same time, the probability of technical as well as economical success increases. In contrast, immature technologies are less developed in regards to the four criteria. To summarize, the higher the level of technological maturity is, the higher is the ability to master the technology.

The final weighting points for each level of technological maturity are shown in Figure 3.

Insert Figure 3 about here

Fifth Step: Developing the Environmental Innovation Indicator

Based on the information on eco-classes (step one), eco-weightings (step two), level of technological maturity (step three), and the tech-weightings (step four), we propose a generic calculation matrix. It integrates the six levels of technological maturity as well as the six eco-classes. Further, we assigned the determined weightings and incorporated the number of projects from the innovation phase gate process. The calculation matrix is presented in Figure 4.

Insert Figure 4 about here

Every field within the matrix represents the number of innovation projects for each eco-class (B, C, E, S, I or O) at each level of technological maturity (1, 2, 3, 4, 5 or 6).

Based on the calculation matrix, we finally developed an indicator called “Environmental Innovation Power (EIP)” which measures the environmental innovativeness. Thus, we divided the overall calculation matrix into three sub-matrices and normalised them with the number of all innovation projects within the innovation phase gate process. Therefore, we first calculate the number of projects on the basis of the following formula:

$$\sum P = \sum_{C=B}^O \left(\sum_{L=1}^6 P_{C,L} \right) \quad (1)$$

where P means project
 C stands for the eco-class
 L designates the level of technological maturity
 $P_{C,L}$ is the number of innovation projects for one eco-class at one level of technological maturity

It is possible to determine the entire number of innovation projects by simply adding up the numbers in the fields of the calculation matrix (cf. Figure 4).

Secondly, we transformed all the information into the following formula for the EIP:

$$\text{EIP} = \log \left(\begin{array}{c} \left[\begin{array}{c} 100 \\ 50 \\ 40 \\ 30 \\ 10 \\ 1 \end{array} \right]^T \cdot \left[\begin{array}{ccc} P_{B,1} & \dots & P_{B,6} \\ \vdots & \ddots & \vdots \\ P_{O,1} & \dots & P_{O,6} \end{array} \right] \cdot \left[\begin{array}{c} 1 \\ 3 \\ 10 \\ 25 \\ 50 \\ 100 \end{array} \right] \\ \hline \sum P = \sum_{C=B}^O \left(\sum_{L=1}^6 P_{C,L} \right) \end{array} \right) \quad (2)$$

where $P_{B,l}$ is the number of projects for eco-class B at the first level of technological maturity and so forth
 T indicates a transpose of matrix

The 1x6-matrix (or transpose of 6x1-matrix) is constant and stands for the eco-weighting. The 6x1-matrix which indicates the tech-weighting is constant as well. The 6x6-matrix in the middle of the numerator integrates the number of innovation projects and is variable (cf. Figure 4). Formula (2) multiplies the eco-intensity with the technological maturity and takes the logarithm to achieve a compressed number for ease of evaluation.

Due to the normalization with the number of projects, the EIP is a finite indicator. Empirical tests show that its values move between 0 and 4, whereby the worst case is calculated for an EIP of 0 and the best case is determined for an EIP of 4. Because of its finiteness, the EIP suits for evaluating the environmental innovativeness in time series comparisons and for setting targets within the parameters of 0 and 4.

Sixth Step: Interpreting the Indicator in a Two-Dimensional Portfolio

Since the EIP exhibits a lot of information, we suggest to rely the results on additional measures and to interpret the outcomes on the basis of a two-dimensional portfolio. Therefore, we propose two additional measures, namely the number of projects as presented in Formula 1, and the average level of technological maturity (ØTM). The latter is counted as follows:

$$\text{ØTM} = \frac{\begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}^T \cdot \begin{bmatrix} P_{B,1} & \dots & P_{B,6} \\ \vdots & \ddots & \vdots \\ P_{O,1} & \dots & P_{O,6} \end{bmatrix} \cdot \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{bmatrix}}{\sum P = \sum_{c \in B} \left(\sum_{l=1}^6 P_{c,l} \right)} \quad (3)$$

where $P_{B,l}$ is the number of projects for eco-class B at the first level of technological maturity and so forth

The formula integrates two constant matrices and one variable matrix in the numerator. The 1x6-matrix is only an auxiliary constant, which, together with the variable 6x6-matrix, determines the number of projects from eco-class B to O at each level of technological maturity. The 6x1-matrix is the second constant and simply represents the six levels of technological maturity. Since the average level of technological maturity can only move between the minimal and maximal levels, i.e. between 1 and 6, this additional measure is finite, too.

For an easier interpretation of the EIP, we transferred the EIP together with the two additional measures $\sum P$ and ØTM into a two-dimensional “environmental innovativeness portfolio”. Thereby, the two additional measures serve as the axes of the diagram. The EIP appears as bubble, whereby the size of the bubble is consistent with the value of the EIP, which varies between 0 and 4. The bigger the bubble appears, the higher is the value of the EIP and therefore the better is the environmental innovation performance. An exemplary portfolio is presented in Figure 5.

 Insert Figure 5 about here

With the two additional measures we can explain the shifting of the bubbles within the diagram and thus interpret the change of the EIP in a longitudinal way.

Finally, we suggest the so called “Environmental Innovation Power Change (EIPC)” to quantify the relative change of the EIP of the actual year compared to a base year. The EIPC is counted as follows:

$$\text{EIPC} = \left(\frac{\text{EIP}_{\text{Actual Year}}}{\text{EIP}_{\text{Base Year}}} \right) \bullet 100 \% \quad (4)$$

Hence, we can make a statement by what percentage the EIP of the actual year has changed in comparison to the EIP of the base year. In Figure 5 the change is shown by +x% or -x%.

DISCUSSION

The action research at the German MNC illustrated the major challenge in measuring environmental innovativeness, namely differentiating innovations regarding their orientation towards sustainability. This is a very important question in that our suggested indicator relies strongly on the differentiation between environmental innovations and “traditional” innovations. Further, it appears that to innovate for sustainability, multifarious components of innovation need to be taken into account (Hines & Marin 2004: 207). However, we tried to meet this challenge by proposing eco-classes and related weightings, in order to differentiate innovations in regards to their ecological aspects. Moreover, we attempted to account environmental innovativeness in a quantitative and transparent way. More important, we showed that it is possible to develop indicators on environmental responsibility aside of the well-known operation and management level.

The paper is limited in several ways. First, our research mainly considers the bunch of projects. Still, we are well aware that each single project contributes individually to the overall environmental performance. Thus, it would be very useful to analyse the hidden impacts and the performance of each project on a micro-level. Further research should propose reliable information on the hidden impacts of a project to guarantee a meaningful evaluation of a firm’s environmental innovativeness - for instance by means of additional indicators concerning the hidden costs of a project.

Second, the EIP indicators depend on appropriate eco-weightings for the eco-classes in order to achieve the necessary differentiation between environmental innovations and traditional innovations. These weighting factors as well as the tech-weighting factors are significant for the calculation of the indicators and determine the evaluation results. Therefore, the weightings have to be used with care and, if necessary, have to be adjusted in the future. In the present work, these weightings are exclusively based on the evaluation by internal experts. Further research should clarify, in how far the involvement of external experts, and maybe other stakeholders, could be helpful to objectify this evaluation.

Third, the research is uncertain in that the long-term impact of the EIP indicators is unknown. In how far does the indicator motivate stronger engagement in environmental innovation? Which additional instruments, like for example incentive and reward systems, are necessary to apply the indicator as management tool? Further,

longitudinal research is required to better understand how such indicators for evaluation environmental responsibility develop.

Fourth, our findings are based on the experiences in a single firm and, thus, on a single industry. Further research should transfer and adapt the findings to other industries. Whilst we think that our presented methodology is generic in most aspects, the definition and weighting of eco-classes remains rather industry-specific.

CONCLUSION

We started this paper with the argument that environmental innovations could be an indicator for acting environmentally responsible. Based on the insight that few measures are available yet, we engaged in an action research project in which we developed a six-step methodology for measuring environmental innovativeness. This paper proposed to use the EIP and EIPC indicators as a measure of environmental innovativeness and, thus, as a component of overall environmental responsibility. Especially for “environmental pioneers” aiming for active environmental protection, the EIP could be a significant instrument to measure corporate environmental responsibility.

This study is a constructive move to face the need for evaluation metrics of corporate environmental responsibility. Our intention and aspiration is that this paper will provide stimulus for further debate and testing.

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TABLES AND FIGURES

TABLE 1
Six Eco-Classes

Meta-Class		Eco-Class
Input:	▪	B: Technologies based on non-fossil feedstock
	▪	S: Technologies based on fossil feedstock
	▪	I: Technologies focused on energy efficiency
Output:	▪	C: Technologies focused on CO₂
	▪	E: Technologies focused on emissions
Other:	▪	O: Other

FIGURE 1
Derivation of the Eco-Weighting for each Eco-Class

Eco-Classes \ Weighting criteria	1. Potential of minimizing environmental load	2. Level of novelty	3. Environmental significance	Eco-Weighting
B	50	25	25	= 100
C	25	10	15	= 50
E	25	10	5	= 40
S	10	15	5	= 30
I	5	5	0	= 10
O	1	0	0	= 1

FIGURE 2:

Controlling Method based on the Innovation Phase Gate Process (the level of Technological Maturity for each project is indicated by the check mark on the outer right column)

Innovation Phase Gate Process		Idea generation	Pre-studies	Feasibility studies	Testing based on laboratory scale	Testing based on pilot scale	Testing based on commercial scale
		1	2	3	4	5	6
Eco-Classes	Projects	TM					
B	Project B1	✓	✓				
	Project B2	✓	✓				
	...						
$P_{B,L}$ where L=1-6			2				
C	Project C1	✓					
	Project C2	✓	✓				
	...						
$P_{C,L}$ where L=1-6		1	1				
...		

FIGURE 3

Derivation of the Tech-Weighting for each level of Technological Maturity

Level of technological maturity \ Weighting criteria	1. Probability of technical success	2. Probability of economical success	3. Level of knowledge	4. Level of networking	Tech-Weighting
1	0	1	0	0	= 1
2	1	1	1	0	= 3
3	5	2	2	1	= 10
4	10	5	5	5	= 25
5	20	15	5	10	= 50
6	50	25	10	15	= 100

FIGURE 4
Matrix for Calculating the EIP

		Tech-Weighting	1	3	10	25	50	100
Eco-Weighting	Level of techn. maturity Eco-Classes	1	2	3	4	5	6	
		100	B	$P_{B,1}$
50	C	...	...	...	...	...	...	...
40	E	...	...	...	...	...	...	...
30	S	...	...	...	...	...	...	...
10	I	...	...	...	...	...	...	...
1	O	$P_{O,1}$	...	...	...	...	...	$P_{O,6}$

FIGURE 5

Environmental Innovativeness Portfolio for Interpreting the EIP in regards to the number of projects and average level of technological maturity

