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Combining REACH, environmental and economic performance indicators for strategic sustainable product development

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ABSTRACT

The objective of the work presented was to provide a paint production company with a tool for strategic decisions in product development that could combine environmental and economic indicators with REACH information. The tool was to be in a form that would provide visual representation of several factors that are important for the company's product development, in a form that could be incorporated into current product development processes. The paper describes the indicators used, shows visual results from the trial of the strategy matrix tool, and outlines and discusses potential limitations.

The offshore coatings products analysed were within the VOC (volatile organic compounds) concentration proposed by the European Directive limiting the VOC content in products (Ökopol, 2009). The products that have the lowest VOC concentrations score the highest (worst) on Total REACH Score. The trial has led to the tool being incorporated at specific "gates" (or milestones) in the company's product development process. The paper shows that close collaborative effort yielded a practically useful tool for strategic decision-making.

1. Introduction

Companies designing new or redesigning existing products in Europe today need to consider both regulatory and environmental performance requirements in their strategy development, as well as during their product development processes. Economic aspects are also very important in order for a business to achieve financially sustainable product development. The aim of this paper is to describe an approach to combining three types of indicator, i.e. regulatory, health/environmental and economic, in order to improve a coatings company's strategic work towards developing more sustainable products.

The strategy matrix tool (referred to as the Strategy Tool) described in this paper is based on performance indicators described below. The tool presented enables REACH aspects to be considered at the same time as environmental and economic performance indicators. This tool has been developed in order for the company to obtain a strategic overview of a set of products in a given product range. This paper presents the basis for the Strategy Tool and the results from testing the tool for six products in the company's offshore range. The information obtained can be used to identify important factors requiring improvement in the company's overall product portfolio, as well as in individual products. This information can be used for providing input into strategic decisions for the company (such as where to concentrate marketing efforts), as well as product development.

The methodology and discussion sections of this paper refer to other relevant work. Previous publications exist where risk phrases (R-phrases) and hazard symbols are used as a basis for ranking of chemical hazard aspects associated with products, e.g. Saling et al. (2002), Landsiedel and Saling (2002), Bunke et al. (2003), Saling et al. (2005), Willum (2006), Kölsch et al. (2008) and Bidoki and Wittlinger (2010). BASF have used an approach that ranks R-phrases for many products, such as diesel and biodiesel (Kölsch et al., 2008), and PVC and alternative plastics (Bidoki and Wittlinger, 2010). Comparisons between risk assessment and LCA and the use of risk assessment data in LCA assessments (which provide environmental indicators for product development) have been considered by authors such as Owens (1997), Olsen et al. (2001), Cowell et al. (2002), Willum (2006), Pennington et al. (2006) and Askham (2012). There are also publications considering product development based on economic indicators in combination with environmental performance indicators, e.g. Brezet and van Hemel

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(1997), De Wit and Meyer (2004), and Rüdenauer et al. (2005). These economic indicators can be based on current or previous financial year data, such as annual turnover and net profit (De Wit and Meyer, 2004; Hanssen and Asbjørnsen, 1996), or estimated future market potential (Brezet and van Hemel (1997)). Life cycle costs, defined as "total costs of ownership" for a product (Rüdenauer et al., 2005) can also be the basis for the financial indicator - although in some cases production costs are used (e.g. Häyhä et al., 2011).

This paper presents the combination of chemical hazard indicators with economic and VOC content indicators for a paint production company. The specific indicators used are presented in Material and Methods. The combination of indicators is discussed, including the implicit weighting involved in such an exercise.

The work presented here has been performed as part of the Innochem project (Hanssen, 2011) Innochem is a collaborative project involving companies (Jotun and HÅG) and research institutions (Ostfold Research, NIVA and Aalborg University) financed by the Norwegian Research Council (BIA program, Brenna, 2012), the Confederation of Norwegian Enterprise and participating companies.

1.1. REACH

The directive for Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) was adopted by the European Union (EU) in December 2006, and requires companies importing or producing chemicals (>1 tonnes/year) in the EU and EEA regions to register these chemicals with the EU's Chemicals Agency (ECHA). REACH requirements are relevant for both individual substances and substances in mixtures (e.g. paint), although the registration demand is for substances only. Companies manufacturing or importing substances are required to register the substance's identity, classification and labelling, test results and propose further toxicity tests for the substance, exposure potential to humans and different environmental compartments, and recommendations for safe use. The requirements for REACH increase with quantities of chemicals imported, or produced. Quantities greater than 10 tonnes/year/producer or importer mean that a risk assessment ("Chemical Safety Report", CSR) is required for the substance. If a chemicals company does not comply with REACH, it cannot sell its products in the markets of the European Union or the European Economic Area (Commission of the European Communities, 2007).

REACH places the responsibility on industry to carry out chemical safety assessments and manage the risks that chemicals may pose to health and the environment. REACH entered into force on 1st June 2007 to streamline and improve the EU's former legislative framework on chemicals. The aims of REACH are (ECHA, 2010; van Leeuwen and Vermeire, 2007): to improve the protection of human health and the environment from the risks that can be posed by chemicals; to enhance the competitiveness of the EU chemicals industry; to promote alternative methods for the assessment of hazards of substances; and to ensure the free circulation of substances within the internal market of the EU.

1.2. The tool

The methodological basis for the strategy tool presented in this paper is in a similar form to the Eco-portfolio matrix presented by Brezet and van Hemel (1997), and the portfolio strategy matrix (Hedley, 2004); both of which were inspired by the Boston Consulting Group's general Growth-Share Matrix (Kotler in Brezet and van Hemel (1997)). In the Eco-portfolio matrix, the *y*-axis is a scale of potential environmental merit, while the *x*-axis represents market potential. The Strategy Tool presented here contains more complex environmental information, with each axis representing product qualities; the *y*-axis (VOC concentration) is one indicator of environmental quality, while the *x*-axis represents an indicator incorporating three different REACH aspects. REACH Complexity and health and environmental risk indicators are combined (as described above) to make the index represented along the *x*-axis, called Total REACH score. Financial information (raw materials costs) was incorporated in the size of the spheres presented in the figures. Thus the Strategy Tool presented here presents a more complex picture than the Eco-portfolio matrix, incorporating several environmental quality indicators into the tool.

2. Material and methods

The indicators and the reasons for their selection are described in 2.1; 2.2 provides a brief description of the development process.

2.1. Indicator selection

The choice of performance indicators was made in close collaboration with the company; these indicators were then developed further and made operational by the authors. They represent product related aspects that are important for the company and cover regulatory requirements imposed by REACH, legislation for classification and labelling of substances (Council Directive 67/548/EEC) and preparations (Directive, 1999/45/EC), draft directive on the limitation of emissions of volatile organic compounds (Ökopol, 2009) and financial performance. The indicators are presented in more detail below.

2.1.1. REACH Complexity

REACH Complexity depends on the number of exposure scenarios required. Exposure scenarios are required (Article 14, Commission of the European Communities, 2007) if company products contain chemicals that meet certain criteria: they require chemical safety reports under REACH and meet the criteria for classification as dangerous, or are assessed to be a PBT (persistent, bioaccumulative and toxic) or vPvB (very persistent and very bioaccumulative), and are contained in the products above specified limits. The number of substances in the product that meet these requirements dictate how many different substance exposure scenarios will be covered for in the exposure scenario of the product. The scale for REACH Complexity is shown in Table 1.

2.1.2. Health and environmental risk

The health and environmental risks associated with the products were expressed by two indicators called "environmental class" and "health hazard class". "Environmental class" is based upon the risk phrases (R-phrases) for effects on the environment associated with chemicals in line with European hazard labelling directives

Table 1
Scoring system for number of substances with exposure scenarios in the product.

Number of exposure scenarios required	Score
0	0
1–2	1
3–5	5
>5	10

(Council Directive 67/548/EEC, 1967, Directive 1999/45/EC, 1999).[1] "Health hazard class" is based upon the R-phrases for human health. This indicator is also affected by the future adoption of CLP for mixtures of substances (as described for "environmental class" above).

The R-phrases used for the "environmental class" and "health hazard class" are grouped into three risk categories: low, medium and high. Table 2 shows which R-phrases are grouped into which category for these indicators. These risk categories are used for R-phrases in Table E.3-1 REACH CSA guidance (ECHA, 2008b). However, the REACH guidance also refers to COSHH Essentials (ECHA, 2008a) as an alternative source of information to compile risk management measures and operational conditions for exposure scenarios under REACH. COSHH Essentials uses a banding approach where hazards are banded (divided into hazard groups) based upon the hazard represented by the R-phrases. As many of the R-phrases are not listed in ECHA 2008b, COSHH (HSE, 1999) was consulted to fill in these gaps. On closer examination of the information about risk categorization for R-phrases in COSHH, some of the REACH and COSHH categories did not concur. This can be seen clearly in Table 2 (e.g. R37). Where there was a discrepancy between these two lists, the worst case scenario was assumed, thus the list in the "Strategy Tool model" column is the basis for this work. The risk phrases that are associated with environmental hazard classification are not grouped and rated by REACH or COSHH Essentials. These are grouped by experts in the paint company, based on the severity of the R-phrases (based, to some extent, on recommendations in Appendix 1, Cefic and DUCC, 2009) and are shaded, in order to distinguish easily between the risk phrases associated with the health and environmental hazards.

Saling et al. (2002) uses R-phrases and hazard symbols as the basis for their logarithmic scoring system (values of 1, 10, 100 or 1000 assigned depending on the level of hazard) and state that in future the assessment base can be "formed directly from R-phrases, which can be linked to assessment numbers". In this Strategy Tool the R-phrases hazard level classifications are weighted with low, medium and high hazard levels being assigned the values 1, 3 and 10 respectively. This weighting is the result of an expert weighting assessment by the company (Jotun). The experts have judged very toxic, toxic by prolonged exposure, sensitization and CMR effects as so severe that they are weighted as 10 in proportion to toxic, harmful and irritating (weight 3) and harmful, irritating (weight 1).

2.1.3. VOC concentration

The European Parliament and The Council Of The European Union (2004) states that "the VOC content of paints, varnishes and vehicle refinishing products gives rise to significant emissions of VOCs into the air, which contribute to the local and transboundary formation of photochemical oxidants in the boundary layer of the troposphere" and that "the VOC content of certain paints and varnishes and vehicle refinishing products should therefore be reduced as much as is technically and economically feasible taking into account climatic conditions". Content limits for the type of coating products included in this strategic work are not set in this directive. Draft proposals are however under development for inclusion in the VOC Directive (Ökopol, 2009), and customer demands for low VOC paint have for a long time been a driving force for paint product development. VOC concentration (g/l) is therefore one of the environmental criteria used for this strategy model. No score is assigned to this indicator; the actual concentration data in g/l are used.

2.1.4. Economic indicator

The economic indicator is meant to represent the economic importance of the product in the product range. There are alternatives for economic indicators that could be used; the most commonly used are annual turnover and net profit (De Wit and Meyer, 2004; Hanssen and Asbjorsen, 1996). Brezet and van Hemel (1997) proposes using the estimated market potential and the desired future contribution of the product towards the company's trading results. However, some of the products included in this strategy work were new products under development that did not have available market price data or estimates of market potential, which meant that other types of indicator had to be used in this context. Raw material cost data for the different raw materials that are used to make the product was considered a reliable indicator of Jotun's cost levels for producing these new products. Raw materials cost data was also considered to be an important economic factor for Jotun when comparing new and existing products. Thus raw materials cost data was used as the economic indicator in the model.

2.2. The development process

The strategy tool presented in this paper is the result of the collaboration between the coatings company Jotun and Ostfold Research. Jotun has a product portfolio that includes decorative paints, marine coatings, protective coatings, powder coatings and yachting products. The specific case products identified as cases to be used for the tool development were coatings relevant for offshore applications, such as oil rigs.

The strategy tool was developed in an iterative process. A set of indicators were proposed by a joint team of researchers at Jotun and Ostfold Research during brain storming at working meetings and follow-up investigations into data availability. Data were collected for these potential indicators and preliminary results obtained. These results were presented and discussed with key personnel in Jotun's Innovation and Environment teams, as well as product development personnel in Jotun's laboratory. Based upon these presentations and discussions, revisions were made and the indicators presented in this paper were the result of this work. One example of an indicator tested that is not included here is REACH Risk, which was defined as the risk that a raw material could become unavailable, owing to the supplier's failure to register the material under REACH. A scale for this was developed (based on responses to a questionnaire Jotun had sent to its suppliers, as well as knowledge about the size, capacity and location of the given supplier), but this indicator was deemed more useful at another stage in Jotun's innovation process, where the assessment of suppliers takes place.

The indicators presented in this paper represent product related aspects that are important for the company and cover regulatory requirements imposed by REACH, classification demands for health and environmental hazard and draft VOC demands linked with economic information.

The tool has been developed in the form of an Excel spreadsheet that uses the data entered by the company to calculate the different indicators described (in 2.1.1–4). These indicators are the basis for

[1] Note: R-phrases are to be replaced by a new system defined in the CLP (classification, labelling and packaging) directive, which has been adopted for pure substances by 01.12.2010 and will be adopted for products by 01.12.2015 (CLP regulation, Commission of the European Communities, 2008). CLP uses hazard phrases (H-phrases), rather than R-phrases, introducing the new EU system for classifying and labelling chemicals, based on the United Nations' Globally Harmonised System (UN GHS, 2005). Annex VI (Table 3.1, Commission of the European Communities, 2008) gives harmonised classification and labelling lists, whereas Annex VII (Table 1.1, Commission of the European Communities, 2008) provides a translation from the R-phrases given in directives 67/548 and 1999/45 to the new CLP H-phrases. Thus, it will be possible to translate the tool indicators into H-phrases in the future.

Table 2
R-phrase hazard level classification.

Hazard level	REACH guidance	COSHH	Strategy tool model	Comments
Low (Score = 1)		R20	R20	
		R20/21	R20/21	
		R20/21/22	R20/21/22	
		R20/22	R20/22	
		R21	R21	
		R21/22	R21/22	
		R22	R22	
	R36	R36	R36	
		R36/38	R36/38	
	R38	R38	R38	
			R50	
			R50/53	
Medium (Score = 3)	R23	R23	R23	
		R23/24	R23/24	
		R23/24/25	R23/24/25	
		R23/25	R23/25	
	R24	R24	R24	
		R24/25	R24/25	
	R25	R25	R25	
	R34	R34	R34	
		R35		
		R36/37	R36/37	
	R36/37/38	R36/37/38	R36/37/38	
		R37	R37	
		R37/38	R37/38	
	R40			
	R41	R41	R41	
	R43	R43	R43	ECHA 2008b, p18: "Moderate R43 skin sensitizers are allocated to the moderate hazard category on the basis that exposure to these moderate skin sensitising substances should be well-controlled."
		R48/20	R48/20	
		R48/20/21	R48/20/21	
		R48/20/21/22	R48/20/21/22	
		R48/21	R48/21	
		R48/21/22	R48/21/22	
		R48/22	R48/22	
			51/53	
			52/53	
High (Score = 10)	R26	R26	R26	
		R26/27	R26/27	
		R26/27/28	R26/27/28	
		R26/28	R26/28	
	R27	R27	R27	
		R27/28	R27/28	
	R28	R28	R28	
	R35		R35	
		R40	R40	
	R42	R42	R42	
	R43		R43	ECHA 2008b, p18: "Extreme and strong R43 skin sensitizers are allocated to the high hazard category on the basis that exposure to such potent skin sensitising substances should be strictly contained and dermal contact avoided."
		R42/43	R42/43	
	R45	R45	R45	
	R46	R46	R46	
		R48/23	R48/23	
		R48/23/24	R48/23/24	
		R48/23/24/25	R48/23/24/25	
		R48/23/25	R48/23/25	
		R48/24	R48/24	
		R48/24/25	R48/24/25	
		R48/25	R48/25	
	R49	R49	R49	
			R50/53	
			R53	
		R60	R60	
		R61	R61	
		R62	R62	
		R63	R63	
	R64		R64	
	R68		R68	

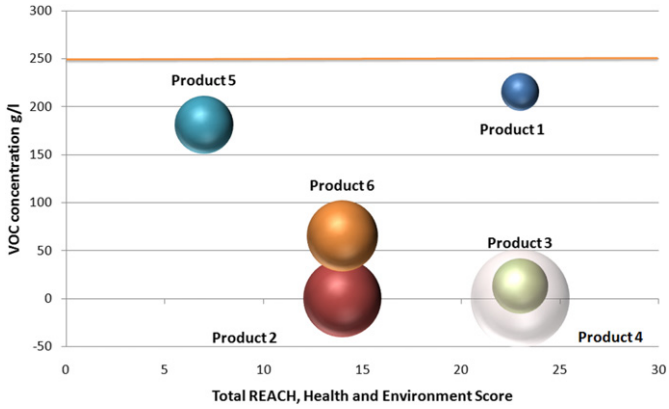

Fig. 1. Economic, REACH score and VOC concentration indicators for coatings products 1–6.

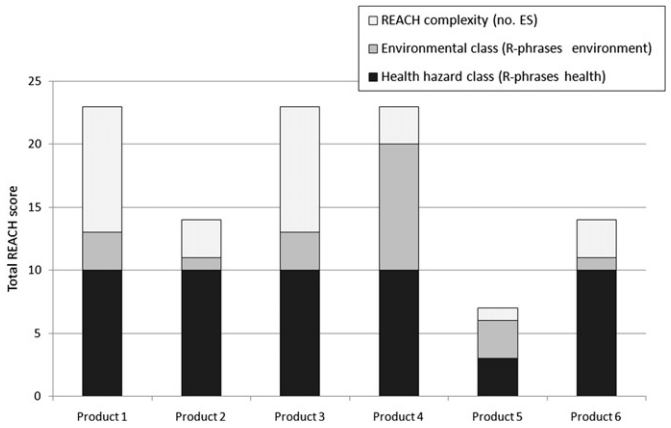

Fig. 3. REACH Complexity, environmental hazard and health hazard for products 1–6.

the graphical representations of product performance generated by the Excel tool, shown in the Results section of this paper. Jotun's product development process is structured with specific "Decision Gates" (or milestones) where the information available from the Strategy Tool will be used.

There were six case products (or components) analysed during the tool development (Products 1–6). These case products are in practice combined in two-component systems to make three layers of coating applied to an offshore installation. The products are sold to the customer as two component solutions, where the customer mixes the two components on site before application. This means that, when considering product function, it is also relevant to combine the relevant components to show the mixed product system, as would be applied by the customer. This means that although Jotun is interested in viewing the results of the tool for each of the individual products (1–6) they are also interested in the results for the two-component products applied by the customer (*X*, *Y* and *Z*).

3. Results

Results are presented for all six case products included in the analyses in two forms. Firstly, the results are presented for individual products (labelled as Products 1–6) and also for the products in their blended form, as each of the six individual products is actually sold as a component in a two-component coating system (labelled as Products *X*, *Y* and *Z*). The customer buys a specified blend ratio of the two components to make product *X*, *Y* or *Z*.

Figs. 1–4 include scales labelled "Total REACH, Health and Environment Score" (referred to in the text in this paper as REACH Score), which is the sum of the REACH related indicators (REACH Complexity, health hazard and environmental hazard). The values obtained for each of these indicators are summed in order to calculate the total REACH, health and environment score.

The size of the spheres presented in Fig. 1 represents the economic indicator (raw materials' cost data). Thus Product 4 has the most expensive raw materials, but a very low VOC concentration. Product 1 has low raw materials costs, but a high VOC concentration and a high REACH Score. The red line indicates the authorities' proposed VOC limit for this type of product (Ökopol, 2009).

As mentioned above, the products presented here are sold to the customer as two component solutions, where the customer mixes the two components on site before application. In Fig. 2, the indicators for the two-component products are weighted according to the mass fractions of the individual components in the mixture.

This figure shows that the product with the lowest raw materials cost has the worst performance for the VOC indicator. Product *X* is also not much better than Product *Y* for Total REACH score. Product *Z* is better than Product *Y* for the REACH indicators, but not for VOC concentration. However, Product *Z* is still well below the legal limit for VOC concentration for these types of products (250 g l^{-1}, see the red line in Fig. 1).

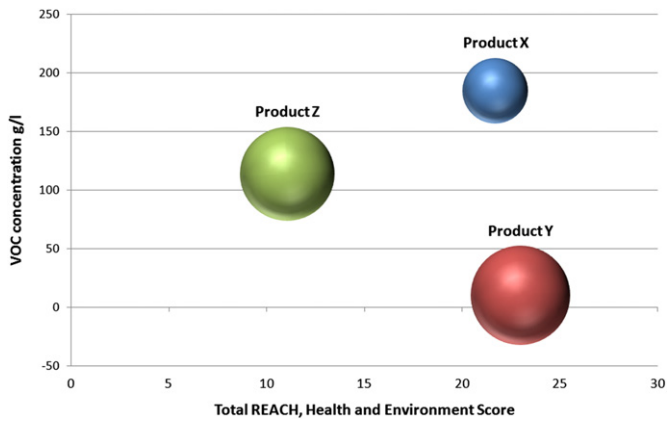

Fig. 2. Economic, REACH score and VOC concentration indicators for two-component products *X*, *Y*, and *Z*.

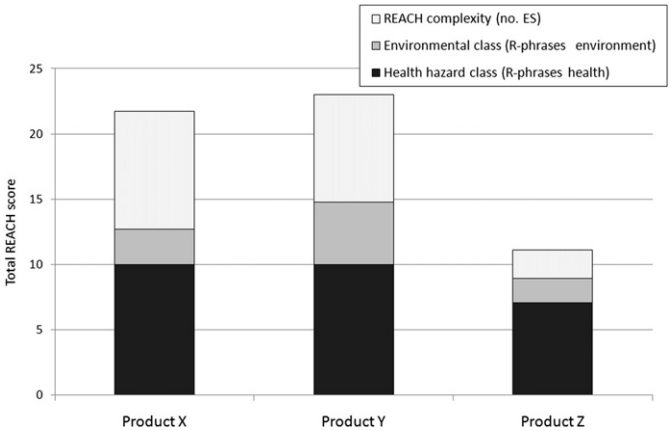

Fig. 4. REACH Complexity, environmental hazard and health hazard for two-component coatings products *X*, *Y* and *Z*.

In order to understand the factors contributing to the *x*-axis value (Total REACH Score) for the products shown in Figs. 1 and 2, the strategy tool also includes Figs. 3 and 4. These Figures illustrate the total REACH Score, decoupling the individual contributory indicators - presenting the user with the background information for this indicator in various forms.

Fig. 3 shows that the score obtained for the human health hazard indicator is the same for Products 1–4 and 6. The REACH Complexity score is greatest for Products 1 and 3, whereas the high REACH score for Product 4 is due to R-phrases indicating that the product has a greater potential hazard to the environment, as well as human health. Products 2 and 6 have the lowest environmental classification. Fig. 3 also shows that Product 5 has the lowest REACH score, which is a result of the lowest scores for health hazard and REACH Complexity (needing few exposure scenarios).

As previously, Fig. 4 uses weighted contributions from individual components in a two-component mixture. The difference between Product *X* and Product *Y* is mainly due to environmental hazard information, whereas Product *Z* performs better than both of the other products for all of the indicators included in Fig. 4.

4. Discussion

The REACH Complexity, health and environmental indicators used are given equal weight in the strategy model. However, other companies performing this type of strategic analysis may have other priorities and choose to weight these REACH aspects differently. It is entirely possible that producers further up in the supply chain would need to have a greater emphasis on REACH Complexity, particularly as the burden for documentation lies with the producers, or importers of a given product (Commission of the European Communities, 2007). Weighting of parameters concerning human health, occupational health and the environment is a difficult area (Steen, 2006; Cortner, 2000; Finnveden, 1997) and inevitably means introducing bias (Wilholt, 2008). Assigning equal value to each indicator is also giving them equal weight and is in itself a form of valuation. The valuations used in the work presented here have been made through collaboration with experts in the company and reflect the ranking of issues that these experts have deemed most appropriate for the purpose (to include REACH Complexity, health and environmental indicators in their product development process). Further work on the implications and results of these value choices would strengthen the tool.

Olsen et al. (2001) identify areas of more thorough analysis of the potential cooperation between risk assessment (RA) and LCA that would be advantageous, including using RA in the priority setting of product groups submitted to an LCA. The Strategy Tool information presented in Figs. 1 and 2 does this. The REACH Complexity and Health and Environmental Risk indicators, that are combined to make the Total REACH Score, both use RA information. It can be used strategically to consider a company's product portfolio and identify products with improvement potential, which could then be the subject of LCA work. Products that have good VOC and REACH performance can be easily identified and thus targeted for greater marketing efforts. Products that have poor performance (whether REACH score, VOC concentration, or economically) can be identified and compared to the best products; transferring knowledge about good performance and identifying strategic improvement options for the other products. The most drastic of these options may be that the company decides to remove a given product from their portfolio entirely.

VOC concentration has been chosen as an important indicator for these specific products for Jotun. The tool can be readily adapted to environmental indicators that are relevant for other companies and other product groups. The work presented here assumes that product experts in the company know the most pressing environmental issues for their product group. This also relies on the authorities choosing the appropriate focus for this industry. There are several examples in modern history where product development has been driven by a specific driver, or indicator and led to unexpected consequences. Well known examples are the unexpected effects of pesticides and biocides in focus in the 1960s (Carson, 1962) and brominated flame retardants. These flame retardants are in wide use in society today, in electronics, furniture and other applications. They are useful chemicals, helping to inhibit the spread of fire, and are thus meant to save lives. However, in the long term they have been seen to build up in human body fat and in the body fat of other mammals, having long term effects on the health and ability of organisms to reproduce (Macgregor et al., 2010; Brown et al., 2006; Norén and Meironyté, 2000). Such unintended consequences might have been avoided had multiple drivers been taken into account during product development; the Strategy Tool provides product developers valuable information towards avoiding such a scenario. The authors do not claim that this tool eliminates this problem, but the presentation of several indicators at once enhances the ability of product developers to understand complex trade-offs between different health and environmental aspects in the product development process.

The Strategy Tool presented in this paper has been described internally in Jotun as showing the "environmental/health footprint" of new (and existing) products. The environmental performance of new, or existing products can be compared to a reference product (whether that be best in class, new, or old products). The tool has already been used in Jotun to generally raise consciousness about these aspects and include them in the product development process. It has also been identified as particularly useful in development work and selection of raw materials where environmental and/or health aspects are important drivers. The results obtained from preliminary use of the tool have also given the product development team a visualisation of several environmental issues at once, which has led to changes in thinking in some areas. An example of this is the drive to reduce VOC content to the lowest possible level. The strategy tool has enabled them to see that this reduction comes at a price, with some common solutions to the VOC problem leading to an increase in hazard levels (for example a higher content of low molecular weight epoxy, Tavakoli, 2003). Thus continuing to develop products with a good margin under the VOC limit can be more important than a coating solution without VOC content.

The team at Jotun has identified that it is a resource intensive exercise to register test raw materials in the strategy tool and will not recommend this in all projects. However, the company sees specific product applications where it can be used to support documentation and communication of environmental/health specifications. Benefits are foreseen in generally supporting learning about existing and new technologies, as well as communication of environmental and health aspects internally. It is possible that the information may also be used for external communication in the future, but its current status is as an internal tool.

Several limitations came to light throughout the process of developing and using the Strategy Tool. Whole paint systems (consisting of several multi-component products) are too complicated for the current version of the tool; although it would be relatively simple to adapt it to include the levels of additional information that would be needed for a multi-layer two-component product system (as is the case for coatings products applied to offshore installations today). Additional performance requirements such as application properties, durability and corrosion protection are also important in the product development process and are not currently included. Inclusion of these product qualities could be

explored in future development work. The *x*-axis in Figs. 1 and 2 represents an aggregated indicator, incorporating several REACH factors; perhaps the *y*-axis could also represent an aggregated product quality indicator in the future.

The cost dimension of the tool could be improved. The present use of raw material costs does not adequately reflect the economic drivers for Jotun in the development of a new product. The indicator is a reasonable screening approach to compare products, but expected margins and potential market price analysis would add value to this information. This is however not possible when the tool is being used in an R&D process to assess new products that have not yet been released onto the market.

The tool in its current form communicates information about meeting requirements in REACH legislation, classification and labelling legislation and VOC requirements. It will also enable Jotun to show development beyond legislative requirements. Further consideration should be given to whether it is important to incorporate other legislative requirements in Jotun's version of the tool in the future. The Strategy Tool gives a framework and an infrastructure that can be adapted to consider product development issues in the light of pertinent legislative requirements for any other groups of products. Further work, testing the tool with products produced by the other industrial partner in the Innochem project, HÅG, will contribute to verifying this.

Training is important for employees using the tool. It is important to select comparable products and enter the data correctly. Interpretation of the figures also requires some training. For example, if one product scores 10 on a given scale, how much better is that than scoring 12? Including limit values on the figures (such as the one for VOC in Fig. 2) aids the reader in their interpretation. Interpretation of the information presented is a challenge to those who have not used the Strategy Tool previously. However, those key personnel involved in the development of the tool can act as expert users in their teams and spread the knowledge about the data input required and the interpretation of the results. Learning by doing will be an important way of implementing the tool actively in Jotun's organisation and increasing the know-how about the tool (Ryle, 1949; Lundvall and Johnson, 1994; Klev and Levin, 2009). The tool will be included at the relevant Decision Gate in the Jotun innovation process.

As mentioned above, coatings are products where durability is important, which is an aspect not addressed in the tool in its current form. The tool has two ways in which it considers environmental aspects; environmental risk phrases and VOC concentration. Carbon footprint, the life cycle perspective (including durability in the form of functional lifetime, Lagerstedt et al., 2003; Hanssen, 1997) and potentially positive environmental contributions resulting from using the product are not covered in the current Strategy Tool. Further case study work using different environmental indicators for a range of products will be performed in the Innochem project, in order to explore how choosing different environmental indicators can affect product development and company strategy. HÅG (now part of Scandinavian Business Seating) produces very different products to Jotun (seating solutions, as opposed to coatings). HÅG has previously commissioned life cycle assessments (LCA) for several of their products. Thus there is extensive LCA-based environmental information available for these seating solutions (The Norwegian EPD Foundation, 2011), which will enable further examination of the ramifications of using different environmental indicators in the Strategy Tool.

5. Conclusions

This paper demonstrates a methodology and approach for making tangible improvements in strategy and product development processes through close work with company experts. We have shown how the Strategy Tool can be (and is being) used practically, as an integrated part of company development and innovation processes, streamlining decision-making and hence having a direct influence on the company bottom line. A framework has been developed for analysing multiple product development drivers simultaneously, in light of specific legislative and/or environmental requirements. The framework can be adapted for a variety of products and for companies working in quite different fields, in response to differing requirements.

Combining health, environment and financial data, with different levels of detail, enables the company to screen potential new product solutions and benchmark these against others in their portfolio. This screening process can identify hot spots and strengths and weaknesses at a relatively early stage in product development. This will enable the company to intensify their efforts on the best products, minimising wasted resources on product development of products that do not meet the standards required for these issues that the company has identified as strategically important for the particular products being developed.

The work presented in this paper shows how REACH aspects can be considered at the same time as environmental and economic performance indicators. Presentation of several indicators at once enhances the ability of product developers to understand complex trade-offs between different health and environmental aspects in the product development process. Integrating the strategy tool into the existing innovation processes in the company is important in order to maximise the efficiency of use of the information produced and minimise the additional work required by the teams involved.

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