News Release

BASF
The Chemical Company

September 15/16, 2005
P 356e
Tomke Prey
Phone: +49 621 60-59066
Fax: +49 621 60-92693
tomke.prey@basf-ag.de

„Journalists and Scientists in Dialogue –
Innovation for our Nutrition“
on September 15/16, 2005 in Speyer

Optimization of Products and the Product Portfolio:
Eco-Efficiency Analysis Investigates Animal Feeds

Presentation by Dr. Andreas Kicherer
Eco-Efficiency Analysis
Competence Center for the Environment, Safety and Energy
BASF Aktiengesellschaft, Ludwigshafen

BASF Aktiengesellschaft
67056 Ludwigshafen, Germany
Phone:+49 621 60-0
http://www.basf.com
Corporate Media Relations
Phone: +49 621 60-20710
Fax:: +49 621 60-92693

With its values and principles as well as its Strategy 2015, BASF is pursuing the vision of sustainable development. Sustainable development is based on three pillars: the economy, the environment, and social and societal aspects. Without economic success, a business enterprise cannot sustainable produce products, nor can it develop sustainable products and processes. Conversely, having the goal of sustainable development also helps to guarantee long-term and increase economic success. Thus, BASF, through its sustainability program, is not only meeting the demands of its shareholders and its obligations to them, but also those of its stakeholders. It is doing this by combining economic success with environmental protection and social responsibility.

In order to support sustainability management, a strategic decision-making instrument, which has been used at BASF since 1996 was developed: The eco-efficiency analysis. This analysis makes the individual aspects of the entire sustainability concept readily apparent, measurable, and communicable, and it therefore forms the interface between strategic sustainability management and product evaluation/decision-making. In 2002 this method was the first method to be globally certified by the TÜV, and it is now identified by its own unique label. This approach successfully evaluates the environmental and economical aspects of sustainability with equal weighting. The third pillar (social/societal aspects) can also be included in the evaluation by means of the SEEbalance® Analysis (socio-eco-efficiency). This was developed within BASF as part of a project sponsored by the German Federal Ministry of Education and Research in cooperation with the Universities of Karlsruhe and Jena, as well as the Ökoinstitut Freiburg (Fig. 1).

The eco-efficiency analysis helps our clients, both within BASF and on the outside, decide which products and processes are the best suited for their applications, both from the economical as well as the environmental standpoint. Alternative products or processes are compared and evaluated in specific terms. Thus, the eco-efficiency analysis determines whether a given product is more sustainable than an alternative product that offers the same benefits for the customer. All economical and environmental disadvantages are determined from the point of view of the final customer, and the entire life cycle of the products and processes is observed from the crade to the grave. In addition to the determination of the current situation, various scenarios are modelled in order to review the decisions that result from the eco-efficiency analysis and to determine whether they are viable for the future. The eco-efficiency analysis is used within the BASF Group throughout the world and is not limited to Germany. In addition to Europe, for example, projects are already being carried out in the USA, Brazil, Marocco, China, and Japan. In total, we have used this standard tool for over 240 analyses.

Example – Preserving animal feed grains

In 1999 the Fine Chemicals Operating Division contracted to have an eco-efficiency analysis performed that would study the preservation of feed grains. This analysis was updated in 2005. The purpose of this study is to explore the strategic alignment of the business in grain preservation products. The preservation of 100 metric tons of feed grain was found to be the customer-specific advantage (Fig. 2).

Background: If feed grains have too much water content when they are harvested as a result of unfavourable weather conditions, for example a 20 percent water content, the grain must be preserved in order to prevent it from going bad during storage. In principle, there are a number of ways to achieve this preservation:

1. The grain can be dried to 14 percent by weight. This can be done in a batch dryer or in a continuous dryer. These dryers are normally fueled with heating oil.
2. Another option is to dry the grain in an air-tight silo, thereby protecting it from spoilage.
3. However, the grain can also be preserved chemically. To do this, small amounts of propionic acid are used. Propionic acid is an organic acid (similar to acetic acid) that is also formed naturally in animal organisms. The preserving effect is due to the fact that the grain is stored in an acidic condition. BASF sells propionic acid either as a solution under the brand name Luprosil® or in the form of a solid salt under the brand name Lupro-Grain®.

We used an eco-efficiency analysis to compare these three processes from an environmental standpoint as well as from an economical one. To do this, the system boundaries must first be defined. These boundaries define all processes (such as the production of electrical power) that are relevant to a process or a production operation. To do this, the entire life cycle of the products must be considered. In order to ensure that we have a broad-based perspective, the analysis includes BASF's own processes as well as upstream processes and our customers' process steps (Fig. 3 and 4).

The different preserving processes also result in different losses during preservation and during the storage of the grain. These grain losses constitute a portion of the analysis as do the manufacturing of the propionic acid and the supply of energy for drying. The materials used to produce the air-tight silos are also included in the calculations. One finds that the propionic acid not only has lower grain losses during the preserving and storing phases, it also offers additional advantages with respect to nutrional physiology: For one, the rate of animals that experience diarrhoea is reduced due to the acidic preservation method, which increases the value of the feed, and for another, higher growth rates are achieved. These effects, however, were not calculated into the base case used in the eco-efficiency analysis. If this were done, the relative ranking of propionic acid would improve even more.

The eco-efficiency portfolio of grain preservation

The final results of the eco-efficiency analysis are presented in a so-called eco-efficiency portfolio. The basic idea behind this portfolio was developed by Schaltegger and Sturm (1992). Their approach is to plot the total costs on the x-axis and the adverse environmental impact on the y-axis. The axes are normalized so that the eco-efficient products (low cost) accompanied by low environmental impact appear in the upper right in the portfolio. The distance in the diagonal line serves as the measure of the eco-efficiency of the process. The greater the distance upward to the right, the more eco-efficient a product or process is, and the greater the distance downward to the left, the less eco-efficient it is. In the eco-efficiency analysis, the environmental impact and the costs are therefore weighted equally (Fig. 5).

The environmental impact in the eco-efficiency analysis is comprised of six main categories: 50 percent are the input variables (primary energy consumption/resources/raw material consumption and land area required), and the other 50 percent are the output variables (emissions, toxicity, and risk potential). A number of target categories are hidden behind each of these main categories. In the case of emissions, the stated categories are soil, air, and water emissions. These in turn are formed from a large number of indicators. The air emissions are comprised, for example, of the global warming potential (GWP), the acidification potential (AP), the summer smog potential (POCP - photochemical ozone creation potential) and the ozone destruction potential (ODP) (Fig. 6).

The strengths and weaknesses in the individual environmental categories can be determined by means of an environmental fingerprint. In each case the worst alternative is set equal to one, and the others are evaluated relative to it. In four of six categories, Luprosil® and Lupro-Grain® have an environmental advantage over the comparison products. For example, relatively few emissions are released in the production of propionic acid for Luprosil® and Lupro-Grain® (Fig. 7).

The first portfolio shows the situation for preserving 100 tons of feed grain (this corresponds to an individual farmer). In this case the propionic acid preservation has significant advantages over all of the other alternatives, both with respect to cost as well as on the environmental side. The cost advantages are viewed in particular to the lower investment costs for propionic acid. In drying, the environmental disadvantages result from the high energy consumption and the loss of feed grain. In the case of the air-tight storage in elevators, the high investment costs in particular are manifest.

The picture is somewhat different if one wants to dry 400 metric tons per year, and not 100 metric tons per year. This could be the case, for example, in a combine of various farmers or a coop. The high relative fixed costs of drying would be reduced with this higher volume. Thus, the cost items for all of the alternatives are similar. However, the environmental advantage of propionic acid preservation continues to be present, so that this process continues to be the most eco-efficient. This ranking can improve even more if additional benefits over and above the preservation per se are achieved (better use of feed, lower partial impact). Thus, scientific studies can provide quantifiable and verifiable data for the eco-efficiency analysis (Fig. 8).

Comparison of various diets for fish production

Previously an eco-efficiency analysis of the production of astaxanthin (vitamin A precursor that is used in the breeding of salmon) met with a good deal of interests in presentations, and our customers asked us to extend the analysis to the entire feed mix and to fish production in general. The extremely complex formulations used in fish feed (fish oil and fish meal, grain, vegetable oils, soybean flour, gluten, vitamin mixtures, astaxanthin, etc.) were also included in the analysis as well as the manufacturing of the raw materials and the environmental impact during the feeding of the fish.

Thus, in this analysis the entire salmon production process was examined closely in order to help our customers make their processes as eco-efficient as possible. In a fish farm in western Norway, four different diets are used to raise a salmon to a weight of four kilograms. These diets differ greatly in their composition. The industry standard is half fish meal and fish oil, with the other half consisting of vegetable raw materials and feed additives. In the so-called Marine diet the percentage of fish oil and fish meal is increased significantly, while in the High-Quality diet and in the Least-Cost diet this content is significantly lower (Fig. 9). In this analysis, the percentage of fish products in the diet is extremely important, since one of the problems, that is addressed in the eco-efficiency analysis, is the overfishing of the world's oceans and seas within the context of raw material consumption. The dioxin contents in fish oils of various origins were taken into account.

With the current relevant conditions, the Industry Standard is the most eco-efficient variant, followed closely by the High-Quality and the Least-Cost diet (Fig. 10). Because of the high fish content and the problems associated with the dioxin content in fish oils from fish taken in the Northern Hemisphere, the Marine diet is the option that has the lowest eco-efficiency. A further disadvantage of the Marine diet is its higher values related to raw material consumption if a non-sustainable fishery is assumed. By means of sensitivity analyses, it was possible to show that the industry standard and the High-Quality Vegetarian diet also are the most eco-efficient options, even under changed basic conditions.

We have also presented this analysis to our customers in the fish feed and production industry at congresses and meetings. The responses were very positive and attendees said that they were extremely interested in utilizing the results. For this reason, the eco-efficiency analysis is currently being developed further into a computer program that our customers and their customers can use to optimize their products and make them even more eco-efficient.

Consequences of eco-efficiency analyses

There are various recommendations that can be used to position the product relative to competing products (Fig. 11).

1. **Star:** The product is superior both from a cost standpoint as well as from an environmental standpoint: The marketing activities should be intensified (also using eco-efficiency analysis arguments).

2. **Ökofrosch**: The product is expensive, but has a lower environmental impact than the competing products. Marketing is mainly to "environmentally oriented customers." In order to obtain significant market advantages, the costs for the customer are to be reduced by improving product qualities.

3. **Sparschwein:** The product has cost advantages and disadvantages in the environmental evaluation. The environmental disadvantages are being determined and possible improvements are being sought. If the product cannot be improved, alternative products must be sought.

4. **Dinosaurier:** Both the costs as well as the environmental impact are high. The product must be improved relative to cost and environmental considerations. If this is not done, an attempt must be made to locate alternative products. The investigated product is no longer active in this market segment.

Some selected examples have already shown that action taken on the basis of eco-efficiency perspectives has had an effect on the market. While products that have low eco-efficiency have been taken off the market or have had plants close, eco-efficient products have been very successful in the market. Market shares increased and production capacities were expanded. Thus the market rewards eco-efficient products more than products that are less eco-efficient.

Areas where eco-efficiency analyses can be used

Of the previously performed 240 eco-efficiency analyses, about half were used for internal strategy and research decisions. In these cases, strategies for sustainable uses of our products were developed, and capital spending decisions were backed up. The groundwork for sustainable products can be carried out early on in research and development. The other half of the analysis was performed in cooperation with outside partners. Products were performed in the public policy arena (Environmental Ministry of the State of Rhineland Palatinate, parliamentary coalition Alliance 90/The Greens, European Parliament) and in a large number of BASF customers (such as Wella AG, Bosch-Siemens-Hausgeräte, Alois Müller GmbH). Since transparency is critical to the credibility of the results, we work very closely with our many customers and we provide many of our analyses as well as the theoretical methodology to outside interest groups.