Innovative, Holistic, "Cradle-to-Grave" Approach to Implement more Sustainable Nutrition

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Abstract

Creating more sustainable products is a major topic throughout the consumer goods industry. To succeed, it is necessary to follow a holistic, "cradle-to-grave" approach which involves stakeholders throughout the entire value chain while focusing on consumer goods. Focusing only on one specific value chain step can create unintended consequences in a later stage of a products life cycle. This paper shows how applied science and value chain management through BASF's Sustainability, Eco-Efficiency and Traceability (SET) Initiative meets those needs. Life cycle assessment (LCA) is the quantitative technique to determine multiple environmental, social and economic impacts of a product and points out potential tradeoffs. However LCA alone cannot comprise all impacts. Therefore BASF's efforts are not just fundamentally based on this technique but also go beyond it. This paper first explains the three pillars of the initiative, consisting of the Hot Spot Analysis (a qualitative tool), the Eco-Efficiency Analysis (a unique LCA approach) and the traceability strategy for supply chain transparency. It secondly presents examples for the 3 pillars for the pork value chain.

Keywords: *BASF sustainability, Eco-Efficiency Analysis, life cycle assessment, livestock, pork, SET Initiative, sustainable supply chain*

1 Introduction

Feeding the world in 2050 and beyond is a challenge particularly when it comes to more sustainable nutrition production.

According to the *UN 2010 Revision* of *World Population Prospects*, the world population is expected to increase from 6.9 billion in mid-2011 to 9.3 billion in 2050 (medium variant). Besides the population increase additional factors could drive up global food prices and threaten long-term food security: climate change bringing floods and drought, growing biofuel demand and national policies to protect domestic markets. Therefore investments in agriculture remain critical to sustainable long-term food security. For example, higher feed conversion rates, cost-effective irrigation and improved practices and seeds – developed through agricultural research – can reduce the production risks and reduce price volatility (FAO, 2011).

In order to make focused investments and monitor their benefits, the current state of the sustainability of a product needs to be captured and monitored to reduce the impact over time.

Multiple research projects have been carried out in the food and feed industry, which show how current and future sustainability opportunities can be leveraged for everybody's benefit.

A 45 percent increase (at a growth rate of 1.9 percent) of the world meat demand is expected over the next 20 years (Rabobank, 2011). The increase is due to population growth, increasing prosperity of currently less developed countries and changing preferences. Consumers experiencing an income growth tend to shift from a vegetable-based diet to a protein-based diet. With the meat production having a significant impact on our planet (FAO, 2006), this product category was chosen as example for section three of this paper. It is now time for the feed / meat value chain to optimize their product sustainability step by step. How this can be achieved is shown on certain steps and issues of the pork value chain, applying the SET concept.

2 The three pillars of the SET Initiative

How to improve product sustainability? The end consumer good is the stage in the supply chain that needs to be in the focus regarding sustainability. When sustainability gets measurable, it becomes brand relevant. In order to achieve a more sustainable end consumer good the entire value chain needs to be assessed. The SET approach is holistic by looking at the entire value chain and at the same time incorporating as many relevant parameters as possible. SET is not related to just a single parameter (i.e. Carbon Footprint).

There is not such a thing as "the" sustainable product, but products can be more sustainable through continuous improvement over time. "Sustainability is a journey, not a destination" and therefore any category, no matter if conventional, organic, natural, carbon neutral, etc., can improve.

The key three pillars of the SET approach are explained in the following paragraphs. These pillars describe the current approach that needs to adapt and advance over time as more data and knowledge on interaction of different sustainability parameters become available.

2.1 Hot Spot Analysis

The Hot Spot Analysis is a qualitative assessment, which helps identify major concerns related to the sustainability of a product. The identification of the hotspots is based on structured stakeholder interviews and relevant publications dealing with the entire value chain. When doing stakeholder interviews the first step is an inside-out view were corporate value chain partners express what they think the key issues are. Afterwards an outside-in view is performed were external stakeholders, such as NGOs, governmental bodies, and consumers with sustainability consciousness, are asked to express their opinion.

Desk research is also done to benchmark current sustainability efforts with competitors. Both on a corporate as well as product level it is explored what the basic, additional and advanced sustainability standards are. In such a sustainability pyramid (Figure 1) the different initiatives and standards can downgrade over time. They downgrade as additional standards become industry average or basic standards get gradually included in the legislation. For example, at the beginning fish certified by the Marine Stewardship Council might have been considered an advanced standard, it is today more an additional or basic standards as it became a rather common practice in the fishing industry.

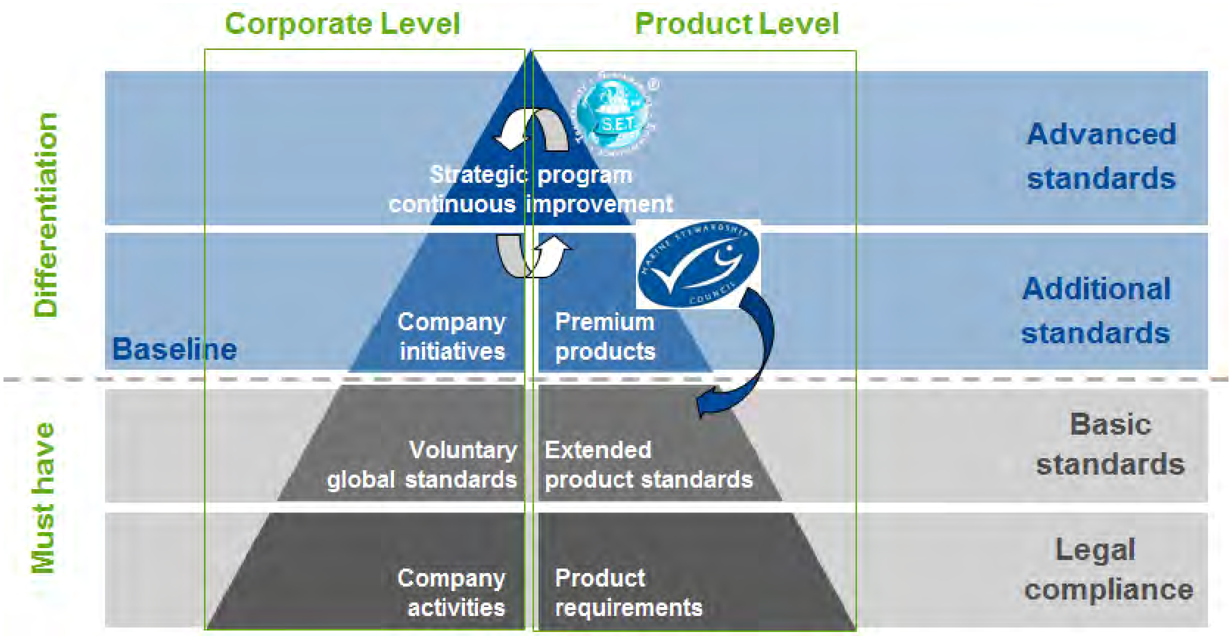

Figure 1. Sustainability Pyramid

The Hot Spot Analysis, as qualitative analysis, is needed as today not all sustainability impacts are quantifiable through life cycle impact assessment. The latest impact assessment methods, such as ReCiPe (Goedkoop et al., 2009) or the Eco-Efficiency Analysis (Saling et al., 2002), cover up to 18 midpoint impacts but issues such as fair trade, animal welfare, overfishing, GMOs, germs, political persecution, and human exploitation are not yet addressed.

Hot Spots can differ by region or market segment as the supply of raw materials, the consumer perception or the production mechanisms might be different. An indication which values end consumers care about are, for example ecolabels addressing certain hot spots. Today the number of ecolabels seems endless and they go from single criteria focused to multi-criteria but are hardly ever holistic. Reports such as the Global Ecolabel Monitor (WRI, 2010) and tools such as the SELECT Eco-Label Manager (BASF, 2011a) give an overview of a fair amount of eco-labels.

2.2 Eco-Efficiency Analysis

The second pillar of the SET initiative is the Eco-Efficiency Analysis (EEA). It is a unique life cycle assessment approach for measuring a product's environmental impact from cradle to grave. To effectively manage sustainability, a company must quantify sustainability in each of its three domains regarding economy, ecology and social responsibility. EEA harmonizes the two domains, economy and ecology, and provides information about the relationship between a product's economic benefits and its impacts on the environment along the entire supply chain. A new three-dimensional tool, Socio-Eco-Efficiency Analysis, known as SEEBalance (Kölsch, 2009; Saling et al., 2007), integrates social metrics into the EEA, but is beyond the scope of this paper.

More than 450 EEA studies have been completed at BASF. The studies are for a diverse range of products, including chemical intermediates, consumer and personal-care products, vitamins, packaging materials, adhesives, and renewable-based products (Takamura et al., 2011; Saling et al. 2006; Müller et al., 2009). As a strategic tool, EEA provides the necessary data to support internal investment and product portfolio decisions. Just as important, it helps customers and other external stake-holders manage the proliferation of eco-confusion by presenting a large amount of complex data in a clear, measurable and easily understood manner.

Trade-offs between different impact categories can only be overcome by assessing all possible parameters, not only one aspect such as global warming potential, reflected with a product's carbon footprint. That is why EEA measures, at a minimum, 11 environmental impacts in six main categories: energy consumption, resource consumption, emissions (to air, water, and land), land use, toxicity potential, and risk potential (Figure 2). The number of impacts assessed gets greater over time as more research is accomplished. The latest developments are the integration of impacts on biodiversity in the AgBalance analysis (Die Zeit, 2011; BASF, 2011b), water use (Schöner, 2009) or land use change (Horn, 2010).

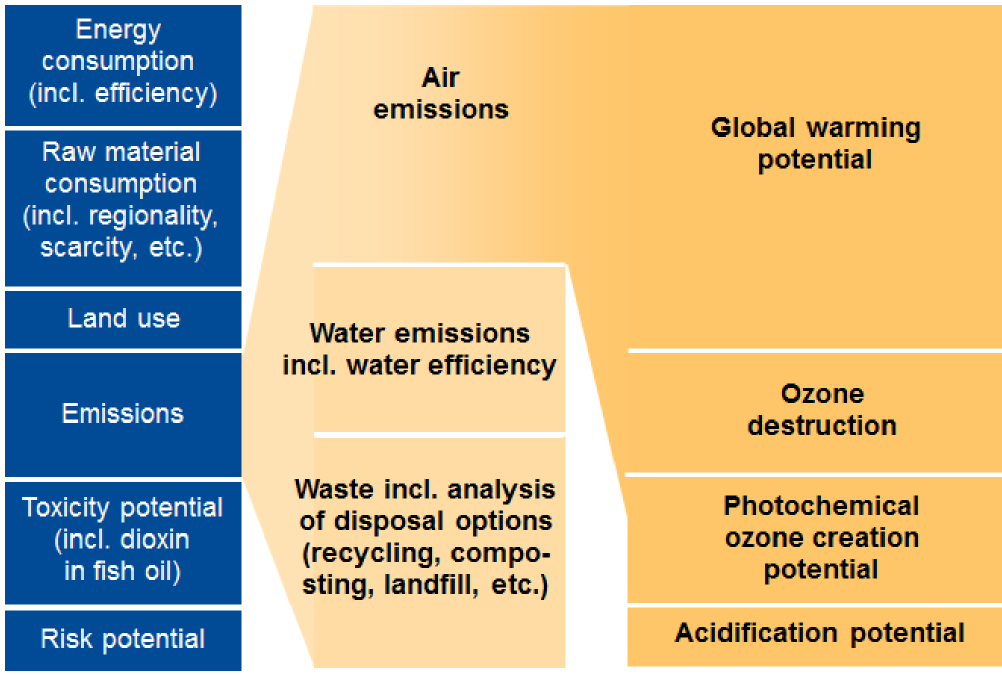

Figure 2. Impact categories in the Eco-Efficiency Analysis

After all of the environmental impacts in each of the categories have been classified and characterized, the data must be presented in a way that facilitates understanding and comparison. This involves data normalization, weighting and aggregation. The environmental fingerprint (Figure 3) provides a clear picture of the relative impacts of the alternatives. The results of the normalization step (the environmental fingerprint) are then multiplied by overall calculation factors and summed over the categories to represent the final environmental impact (described in more detail in Uhlman & Saling, 2010). Although the environmental impact assessment and cost calculations are separate steps of the EEA, the goal is to present both findings in a balanced way that supports clear understanding and facilitates strategic decision-making. This is accomplished through the Eco-Efficiency Portfolio (Figure 4).

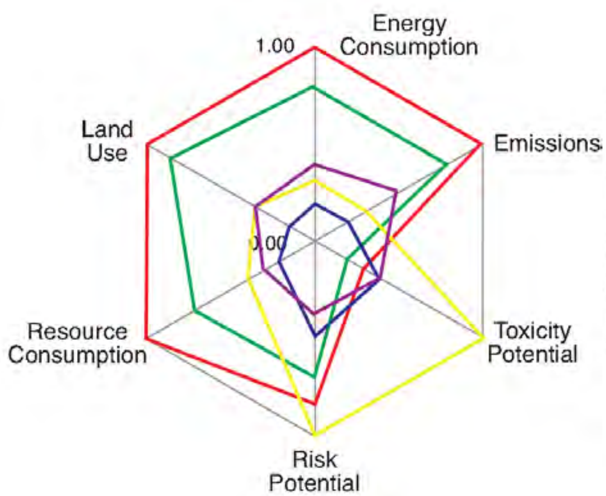

Figure 3. The environmental fingerprint provides a clear picture of the relative impacts of the alternatives

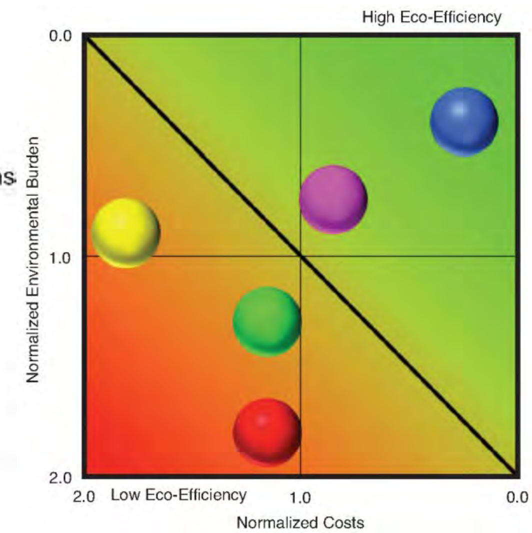

Figure 4. The Eco-Efficiency Portfolio summarizes the calculations of environmental and economic impacts on a single plot

Aggregating so many environmental categories into a single number is controversial but at the same time crucial for decision makers. The EEA Portfolio is always presented together with the detailed results of the individual categories. Other life-cycle impact assessment approaches follow the way to create a single score, such as ReCiPe (Goedkoop et al., 2009) sponsored by the Dutch Government or the draft Product Environmental Footprint Guide by the European Commission (EC, 2011).

This paper does not want to describe the Eco-Efficiency Analysis method in detail as other publications have done so before, furthermore section 3.2 shows how the results of EEA can lead to informed decision making. Please see *Measuring and Communicating Sustainability through Eco-Efficiency Analysis* (Uhlman & Saling, 2010) and *Eco-Efficiency Combining Life Cycle Assessment and Life Cycle Costs via Normalization* (Kicherer et al., 2007) for methodological details.

2.3 Traceability

The third pillar of SET focuses on whole-chain traceability and the need to understand the entire value chain to properly implement sustainability actions. Traceability not only helps trace all of the components that lead up to a final product through the value chain, but also – and more importantly – makes it possible to follow a tailored plan of action and track the progress made over time.

The implementation of global traceability standards, such as GS1s', is needed to achieve whole-chain traceability and identify, capture, share, and monitor the sustainability parameters needed for metrics. The majority of BASF Nutrition Ingredients items are tagged with GS1 barcodes that contain Global Trade Item Numbers® (GTINs®) and Global Location Numbers

(GLNs) for unique identification (GS1, 2011). The combination of standards and a whole-chain traceability system, such as the Global Traceability Network, allows to link tagged products with all of the ingredients used to create their products. The Global Traceability Network (GTNet), an Internet-based platform from TraceTracker, is a platform that allows flexible traceability information exchange. It has standardized, GS1 EPCIS-based traceability infrastructure (TraceTracker, 2011). With GTNet traceability along the value chain from BASF products to consumer products is possible. Whole-chain traceability for example allows meat producers to trace back the enzymes used in their feed as well as trace forward to their retailers' locations. This provides valuable insight for a company's sustainability efforts and bottom-line.

3 Pork case study

After having introduced the concept of the SET initiative, the paper will now explain its practical application through selected examples from a case study that shows the journey towards more sustainable goods. A meat was chosen as example for this case study because among other reports the *Livestock, Environment And Development Initiative Report* by FAO (2006) concluded that "the livestock sector emerges as one of the top two or three most significant contributors to the most serious environmental problems, at every scale from local to global." The meat pork was chosen because with 107 million tons, it covered the largest share of the global meat demand (41 percent) in 2005 and the demand is expected to grow to 148 million tons in 2030 (Rabobank, 2011).

In order to identify the key sustainability topics of pork meat the different value chain steps have to be understood. A "cradle to grave" study on the sustainability optimization in the feed/food value chain of pork production has to include all life cycle phases. The value chain starts with the phase of raw material or agricultural input production that includes the fertilizer, crop protection, seeds, and feed additive production. Those products are then used in the farming-feed production phase to grow cereals, soy, and corn by farmers; this is then processed to flour, plant oil and others in oil mills etc.; those ingredients and feed additives are then used for the feed-mixing by the feed producers. The next phase is the animal breeding and fattening by the pig farmers. This is followed by the slaughtering, processing, packaging, refrigeration and distribution by the meat producer. At the following retail phase there is also energy required for refrigeration and distribution. The same is the case for the use phase taking meat preparation into account. The end of life phase then embraces the recycling and incineration of household litter. The scrap generated during the slaughtering and processing is used in biogas plants, as fertilizer substitute, and in animal carcass disposal plants (Figure 5).

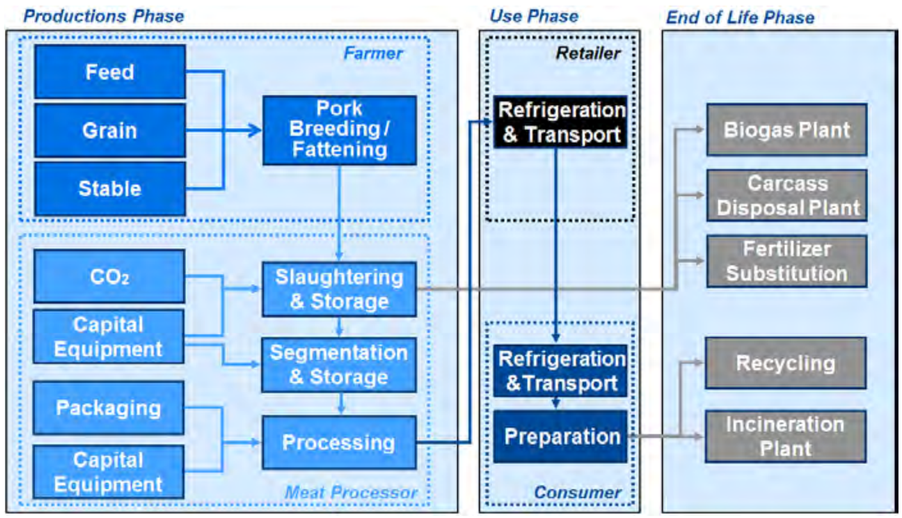

Figure 5. System boundaries of the life cycle assessment

The following sections describe how the three pillars of SET are applied to pork. Not all findings are displayed here, because the concept can also be brought across in a more concise way.

3.1 Pork Hot Spot Analysis

The Hot Spot Analysis, as concept described in section 2.1 of this paper, helps to understand the dynamic and different influences and perceptions of several supply chain actors. The summarized results of a hot spot screening of pork are displayed in Figure 6. The sustainable development (SD) criteria on the y-axis of Figure 6 are clustered and selected according to the importance given by the stakeholders. The x-axis describes the different value chain steps. The consumer goods manufacturer, the pork slaughterer and distributer, recognizes that there are hot spots downstream and mainly upstream the value chain.

There are several issues listed in Figure 6 that cannot be quantified through life cycle assessment such as animal welfare, demand for transparency, soybean and corn GMOs, or deforestation. Nevertheless, these issues can be addressed through management programs. A pork producer can share best practices with his pig suppliers and require them to meet certain additional standards such as a minimum area available for sows that are above legal requirements. One SET project partner for instance automatically scans all pigs delivered to its slaughterhouses for bruises and other injuries and tracks the delivered batch to the supplier. In case that a batch shows a high number of bruises the conditions in this suppliers stable gets more often audited by the meat processor than others.

SD criteria / Value chain	Raw material incl. seeds	Farming-Feed production	Farming Pig production	Slaughter/ Processing/ Distribution	Retail	Use/ Disposal
GHG emissions		Cereals and soybean: Emissions, high use of N-fertilizers, Deforestation, ILUC	GHG emissions from housing (?)	GHG emissions by transport and cold chain	GHG Storage and cooling	GHG Storage and cooling
Energy use		Diesel and energy use in farming and feed processing	Energy use for housing	Energy by transport and cold chain	Storage and cooling	Storage and cooling
Water scarcity and pollution		Excessive water use Excessive use of fertilizer Eutrophication of reservoirs	Water use for housing management Groundwater pollution through manure			
Waste and air pollution			Manure management, Ammonia emmisions	Slaughter waste use (crazy cow disease)	Waste upon packaging choice	Packaging waste
Product Stewardship & Safety			Animal health: use of antibiotics and other medicaments			
Biodiversity, renewables & animal welfare		Soybean and corn GMOs and monoculture	Animal welfare: pig confinement, cannibalism, castration, available space for sow	Animal welfare: slaughter practice, transport conditions		
Labor & human rights, human capital development				Social standards (slaughterhouse)	Local products	Demographic development
Resource consumption	Phosphate scarcity	Phosphate scarcity Soil health and erosion, Land use				Food waste, abuse of meat consumption
Traceability	Demand for transparency (seeds)	Demand for transparency: GMO, dioxine, regionality, etc.	Demand for transparency: Farming practices, regionality	Demand for transparency: slaughter practices, regionality	Demand for transparency	

High Medium Low

Figure 6. Sustainable development (SD) criteria along the pork value chain

The hot spot "phosphate scarcity" can also be addressed on farm level. By using the phytase enzyme in the pig feed this issue can be addressed as the enzyme increases the digestibility of plant phosphorous and consequently reduces the use of mineral phosphate and the amount of phosphate excreted. When placing the use of phytase in the sustainability pyramid (Figure 1), there are regional differences to consider.

Among other actions, hot spots of the feed production phase can be reduced by using less feed in the fattening process. This is only possible if a higher feed conversion rate can be achieved. Today there are enzymes (for example endo-1,4-beta-xylanase and endo-1.4-beta-blucanase or Natugrain *TS*) available that enable a higher conversion rate because they counteract anti-nutritional effects from non-starch polycaccharides.

3.2 Pork Eco-Efficiency Analysis

The Eco-Efficiency Analysis, the second pillar of the SET initiative, makes environmental and economic criteria measureable. For analyses carried out within this initiative the functional units, or user benefits, are always a consumer goods. In the case of pork, this can for example be a mass of refrigerated pork steak, frozen breaded pork steak, or pork sausages sold in a retail store. The analyses are from 'cradle to grave', which means that the whole life cycle is assessed: from for example the fertilizer used in the feed production, over the pork refrigeration in the retail store, to the disposal after consumption (Figure 5).

The results in Figure 7 are derived from a study of a pork steak that was packaged in a modified atmosphere packaging plastic tray with a plastic upper layer. The consumption by the consumer and the disposal of the packaging are considered as well. Figure 7 shows 5 of the minimum 11 impact categories in the Eco-Efficiency Analysis. Losses, either in the retail phase or at the consumer directly, affect the amount of pork produced and are therefore one of the most significant levers.

The compound feed use during the fattening process is the most important influencing factor. As the first bar of Figure 7 shows, feed is responsible for about 70 percent of the carbon footprint of pork and the feed for fattening makes up 50 percent. The proportionate share of the sow (feed and housing) is significant with 15 percent even though the number of piglets per sow (allocated) is high. The energy use during the compound feed mixing and the slaughtering and segmentation of the pig make up less than 5 percent of the carbon footprint. The processing of the pork itself has a very small impact on the carbon emissions, but the packaging materials are also allocated to this step and therefore the processing shows up in Figure 7.

The raw material consumption is also dominated by the feed supply (second bar of Figure 7). One reason is the fossil fuel used during the agricultural production. Another reason is the raw material used for the crop growth, such as phosphorous. Water emissions are shown in the unit "% water needed for dilution" in bar three of Figure 7. These emissions are defined as the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards. Water emissions are calculated as the volume of water that is required to dilute pollutants to such an extent, that the quality of the water remains above agreed water quality standards (Water Footprint Network, 2011). This environmental category is also dominated by the crop production mainly due to nutrient runoff.

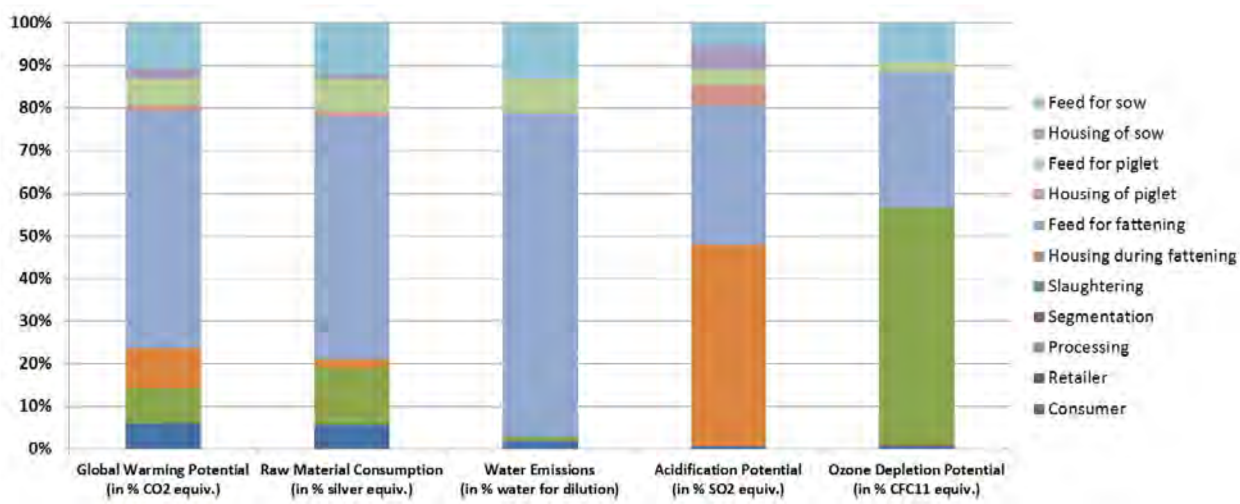

Figure 7. Environmental impact categories per functional unit over the defined live cycle steps

The first three bars of Figure 7 show differences for the impact of 'housing during fattening' and 'processing (incl. packaging)'. More significant are the differences for the two bars to the right showing the acidification potential and ozone depletion potential. In case of the acidification potential the livestock husbandry and the slurry, as part of housing of the sow, the piglet and the fattening pig, play a more significant role than in the other impact categories. The ozone depletion potential is to 50 percent associated with the processing and this contribution comes from the plastic packaging of this stage.

Just these five impact categories (Figure 7) prove that assessing a single parameter is not enough when addressing environmental concerns. By looking at as many categories as possible and the whole value chain, trade-offs can be identified. For example reducing the amount of packaging material in the processing step can result in a lower ozone depletion but less packaging might increase the product loss in the stores or at the consumer.

Calculating the impacts through an Eco-Efficiency Analysis enables an identification of the levers for most positive improvement. Updating the input parameters periodically enables a quantification of environmental improvements over time. How the input parameters along the value chain can be captured for the Eco-Efficiency Analysis and what other use it has, will be exemplary explained in the following section on traceability.

3.3 Pork Traceability

Following a tailored plan of action and tracking the progress made over time requires whole-chain traceability. An eco-efficiency analysis shows that a lot of the environmental burden is due to the consumption of feed by the pigs. A traceability network enables a meat processor to trace the feed conversion rates by the pigs of all its suppliers and document improvement over time. Not just the processor can trace parameters of the farmer but also the farmer can evaluate the composition of the feed and trace information from his feed supplier. The feed supplier can improve the sustainability of pork production by delivering feed premixes that first enable a higher feed conversion rate and secondly have a lower environmental impact due to its composition.

The subtherapeutic use of antibiotics in livestock farming and therefore the antibiotic residues in the meat is also an important sustainability criterion along the pork value chain (Figure 6). Consistently checking for antibiotic residue levels, enables the meat processor to insure that antibiotics are not give to pigs subtherapeuticly by farmers. Checking the residue levels is the first step that needs to be followed by tracking them back to the farm level which enables a targeted providing of farm level management programs. A traceability network therefore enables a proactive pork processor to set an advanced standard (Figure 1) by establishing internal maximum residue limits (or MRLs) which are well below the legal requirements.

The animal welfare on farms can be improved through on farm management programs, but the efficiency of such programs needs to be monitored to evaluate improvement. As mentioned before, one of the pork processers who uses the SET approach scans all pigs upon their arrival in the slaughterhouse. Scanning the batches of pigs delivered enables the processor to determine if a specific batch has injuries and bruise. This can then be traced back to the farm and allows the evaluation of animal welfare improvement over time on the farm and during the transport.

Effects on the environment can be global, for example caused by greenhouse gas emissions, or regional specific, for example as caused by water use. For water use, catchy results, such as the production of one kilogram of pork requires 6000 litres of water, are picked up by the media (Shafy, 2009). This amount of water is scientifically correct and mainly goes back to the feed production for the pigs (Mekonnen & Hoekstra, 2010). In order to determine, if the majority of this water use has definite negative impacts, further information is required. The evaluation of the impact on water availability of the pork production requires information on the origin of the feed, the feed composition, and the feed conversion efficiency of the pigs. About 82 percent of these 6000 litres go back to green water use during the feed production (Mekonnen & Hoekstra, 2010). If this feed production takes place in watersheds without negative impacts to the groundwater recharging rates, such as in Ireland, the water availability is not harmed. In case that the feed production takes place in regions where water scarcity is an issue, such as Morocco, the negative impact on water availability of pigs fed with such feed is significant. This concludes that a pork specific water use assessment is only possible when the feed production origin is tracked.

4 Conclusions

Feeding the world in 2050 and beyond is a challenge that requires more sustainable nutrition production. One might claim that this challenge could be approached by a personally change of consumption patterns by the current population. Still an increase in production is inevitable as a result of the population growth. Therefore nutrition products need to be produced more efficiently with a decreasing environmental and social impact.

The SET initiative plays a key role in mastering this challenge. With its three pillars it is a leading edge innovative and holistic approach today. Our knowledge on sustainability topics is consistently growing and hence this approach will further advance over time as well. One of the key conclusions is that every product can be more sustainable over time and there is no such thing as a sustainable product. Enabling more sustainable products needs to involve the whole value chain and the approach needs to be value chain and regional specific.

Using the case of the pork value chain in the BASF’s SET approach, the dynamics and different perceptions of several supply chain actors are understood. This holistic understanding enables the creation of an action plan that helps to counter current hot spots. Today there is not one quantitative assessment that can identify all environmental, social, or economic issues associated with a certain consumer good. Nevertheless, life cycle assessment captures as many environmental aspects as possible today and combining it with a more qualitative assessment, in the hot spot analysis, leads to a holistic view on the sustainability criteria.

Overall, the SET initiative enables consumer goods producers to move into a new dimension of more sustainable nutrition products. The more value chain players get involved the greater will be the common success. With BASF driving sustainable solutions its customers (and also their customers and suppliers) can leap into the driving seat of their industry as well.

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