BASF
The Chemical Company

Submission for Verification of Eco-efficiency Analysis Under NSF Protocol P352, Part B

Almond Eco-Efficiency Analysis Final Report - August 2011

NSF

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Table of Contents

1. Purpose and Intent of this Guidance Document

1.1. The purpose of this submission is to provide a written report of the methods and findings of BASF Corporation's "Almond Eco-Efficiency Analysis", with the intent of having it verified under the requirements of NSF Protocol P352, Part B: Verification of Eco-Efficiency Analysis Studies.

1.2. The Almond Eco-Efficiency Analysis was performed by BASF according to the methodology validated by NSF International under the requirements of Protocol P352. More information on BASF's methodology and the NSF validation can be obtained at http://www.nsf.org/info/eco_efficiency.

2. Content of this Guidance Document

2.1. This submission outlines the methodology, study goals, design criteria, target audience, customer benefits (CB), process alternatives, system boundaries, and scenario analysis for the Almond Eco-Efficiency Analysis (EEA) study, which will be conducted in accordance with BASF Corporation's EEA (BASF EEA) methodology. This submission will provide a discussion of the basis of the eco-analysis preparation and verification work.

2.2. As required under NSF P352 Part B, along with this document, BASF is submitting the final computerized model programmed in Microsoft® Excel. The computerized model, together with this document, will aid in the final review and ensure that the data and critical review findings have been satisfactorily addressed.

3. BASF's EEA Methodology

3.1. Overview:

BASF EEA involves measuring the life cycle environmental impacts and life cycle costs for product alternatives for a defined level of output. At a minimum, BASF EEA evaluates the environmental impact of the production, use, and disposal of a product or process in the areas of energy and resource consumption, emissions, toxicity and risk potential, and land use. The EEA also evaluates the life cycle costs associated with the product or process by calculating the costs related to, at a minimum, materials, labor, manufacturing, waste disposal, and energy.

3.2. Preconditions:

The basic preconditions of this eco-efficiency analysis are that all alternatives that are being evaluated are being compared against a common functional unit or Customer Benefit (CB). This allows for an objective comparison between the various alternatives. The scoping and definition of the Customer Benefit are aligned with the goals and objectives of the study. Data gathering and constructing the system boundaries are consistent with the CB and consider both the environmental and economic impacts of each alternative over their life cycle in order to achieve the specified CB. An overview of the scope of the environmental and economic assessment carried out is defined below.

3.2.1. Environmental Burden Metrics:

For BASF EEA environmental burden is characterized using eleven categories, at a minimum, including: primary energy consumption, raw material consumption, green house gas emissions (GHG), ozone depletion potential (ODP), acidification potential (AP), photochemical ozone creation potential (POCP), water emissions, solid waste emissions, toxicity potential, risk potential, and land use. These are shown below in Figure 1. Metrics shown in yellow represent the six main categories of environmental burden that are used to construct the environmental fingerprint, burdens in blue represent all elements of the emissions category, and green show air emissions.

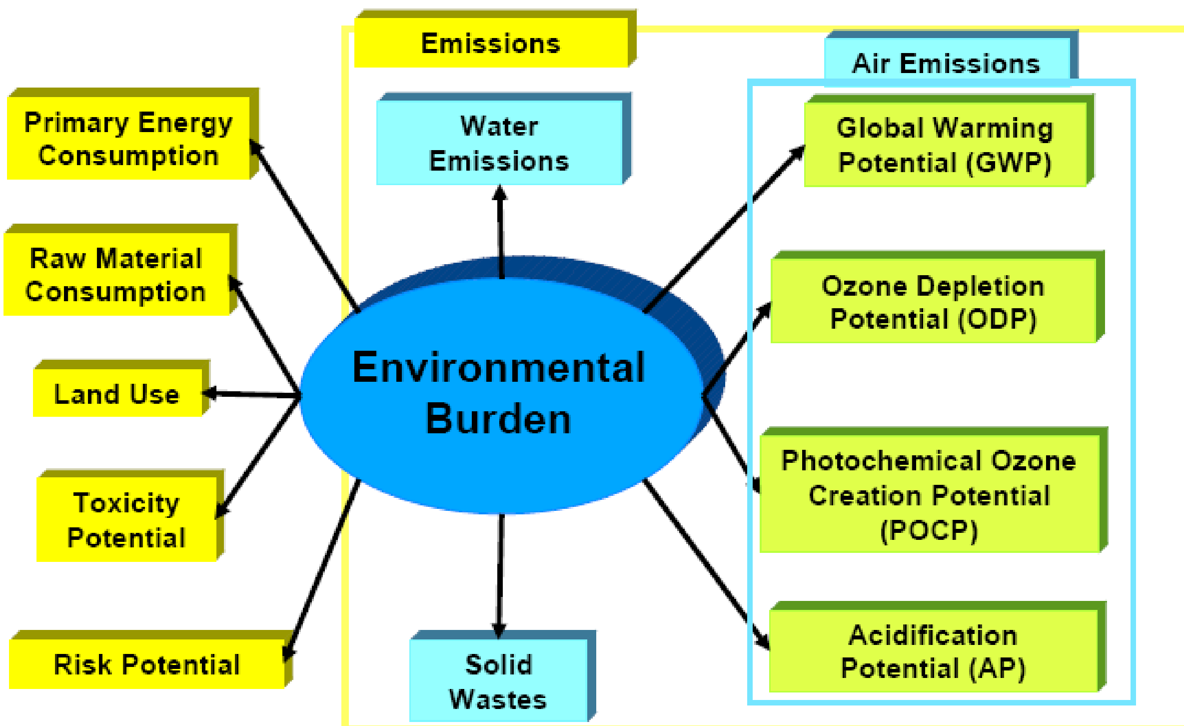

Figure 1. Environmental Impact categories

3.2.2. Economic Metrics:

It is the intent of the BASF EEA methodology to assess the economics of products or processes over their life cycle and to determine an overall total cost of ownership for the defined customer benefit ($/CB). The approaches for calculating costs vary from study to study. When chemical products of manufacturing are being compared, the sale price paid by the customer is predominately used. When different production methods are compared, the relevant costs include the purchase and installation of capital equipment, depreciation, and operating costs. The costs incurred are summed and combined in appropriate units (e.g. dollar or EURO) without additional weighting of individual financial amounts. The BASF EEA methodology will incorporate:

- the real costs that occur in the process of creating and delivering the product to the consumer;
- the subsequent costs which may occur in the future (due to tax policy changes, for example) with appropriate consideration for the time value of money; and
- Costs having ecological aspect, such as the costs involved to treat wastewater generated during the manufacturing process.

3.3 Work Flow:

A representative flowchart of the overall process steps and calculations conducted for this eco-efficiency analysis is summarized in Figure 2 below.

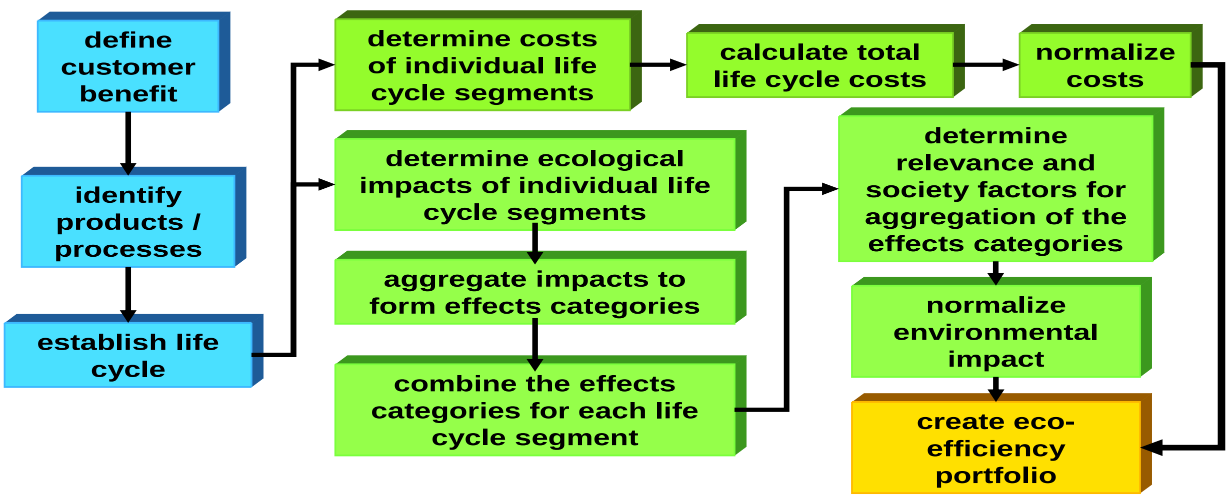

Figure 2: Overall process flow for BASF Almond EEA methodology.

4. Study Goals, Context and Target Audience

4.1. Study Goals:

The specific goal defined for the Almond Eco-Efficiency Analysis was to quantify the differences in life cycle environmental impacts and total life cycle costs of production and processing of Almonds. The comparison of this study is a time difference due to changes made to two operations. The time evaluation is comparing the 2010 operations versus 2007 operations. The data used for the 2010 operations is from 2010, while the data from 2007 is used for 2007 operations or later if data was not available.

The study specifically quantifies the operational changes of the Almond production and processing. This study evaluates the operational changes made at both Braden Farms and Hilltop Ranch, both located in the San Joaquin Valley, California, United States. Braden Farms does the growing, harvesting and nut processing of the Almonds, while Hilltop Ranch does the processing, sizing and packaging of the Almonds.

The major factors influencing the environmental and cost impact of the study will be evaluated and shown in different parts of the operations at both companies. Since both companies work together in delivering Almonds to the consumers, both operations are evaluated together in this study. Table 1 and Table 2 outline the operational changes between 2007 and 2010 that were evaluated in this study. Further tables in the report will present the actual input values for each of the alternatives.

Study results will be used as the basis to promote the operational changes made at both companies and the environmental savings for producing the same amount of Almonds. The results will be shared with others within the industries, such as the California Almond Board, other growers and processors and academic institutions. The information may also be shared with governmental agencies at the federal, state and local levels.

Table 1: Operational changes evaluated at Braden Farms.

Braden Farms	Operational Changes:
Water Usage	Solid set sprinkler to Micro sprinkler
Fertilizer	Vary amounts
Ground Conservation	Disking to Mowing
Shuttle Trucks	3 Carts to 1 Shuttle truck
Pick-up machine	2 Old machines to 1 New machine
Tree limbs processing	Burning vs. Mulching
Processing Equipment	Old machines to 1 New machine
Sticks in feedstock	Burning vs. Mulching
Handling	Totes to Bulk
Transportation	Tote trailers to Bulk trailers

Table 2: Operational changes evaluated at Hilltop Ranch.

Hilltop Ranch	Operational Changes:
Electricity Generation	Grid to Solar
Processing Operation	More efficient
Lights	More efficient lighting
Air Compressors	More efficient compressor
Sorting	Horizontal to Vertical
Cold Storage - Warehouse	Insulation added
Sortex Relocation	Electronic sorting
Cable Bay on rejects	Large to Small motors
Bin Transfer (Propane)	Trailers for bins
New Forklifts (Propane)	More efficient
Sizing Scale (Propane)	Elimination of 1 forklift
Trucks (Diesel)	More efficient
Sales Vehicles (Gas)	More efficient
Sortex Relocation (Propane)	Less handling, More efficient
Tires on Forklift	Tires last over 4.5 longer
Packaging (cardboard)	Bleached white cardboard & colored print to natural & black print
Tires (Magnets on trucks)	30% tire loss without magnets
Scale time	Reduced Labor
Computer Sorting	Reduced Labor
Computerized Bag House	Reduced Labor
Sortex Relocation	Reduced Labor
Dry Ice Blaster	Reduced Labor

4.2 Design Criteria:

The context of this EEA study compares the environmental and cost impacts for production and processing of 1 ton of Almonds. Since we are evaluating the changes made over time, the affect of these changes on yield are not being evaluated to quantify the changes made in the operations. The study design was planned for a 1 year season. The pollination of the almond trees begins around mid to late February and harvest usually is finished by end of October. This study evaluates the processing of Almonds from the growing season, which starts at harvest time in August and usually lasts until June of the following year. The study also evaluates work done at the farm such as tree pruning and selling of hulls and shells. Since Almonds grow on trees, we are assuming in this study that the Almond tree orchard has been established and that the orchard is 5 to 10 years old, which is the beginning of the peak for an Almond tree. Most Almond orchards last roughly 20 to 25 years before they are removed and new trees are planted.

The Almond study will use data that is documented data from both operations or is known information within the industry. Data will also be used from published governmental agencies, university studies, or information within organizational trade groups. The study will also look at transportation and equipment use in each of these areas.

The study is informational driven and goals, target audience and context for decision criteria used in this study are displayed in Figure 3.

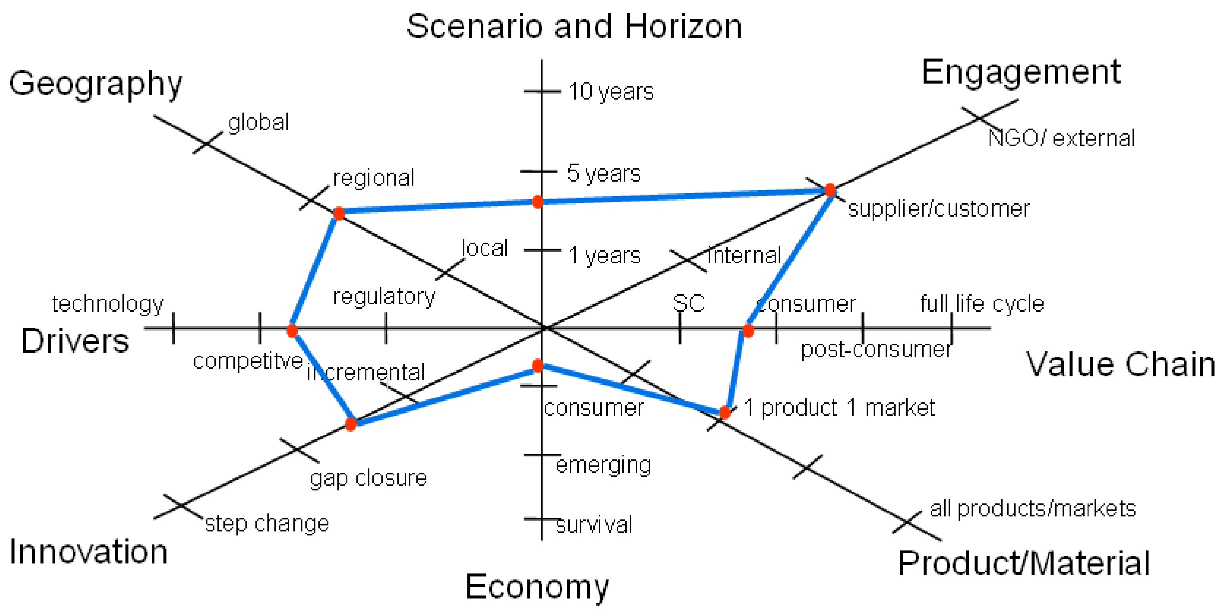

Figure 3. Context of Almond Eco-efficiency Analysis

4.3. *Target Audience*:

The target audience for the study has been defined as all parties involved with the study, as well as other potential Almond operations within the State of California. Future plans may include communication of the study results in marketing materials and at trade conferences.

5. Customer Benefit, Alternatives and System Boundaries

5.1. *Customer Benefit*:

The Customer Benefit (CB) applied to all alternatives for the base case analysis is production and processing of 1 ton of Almonds per year. This study does take into consideration the hulls and shells that are generated in order to get the 1 ton of final Almond nuts.

5.2. *Alternatives*:

The product alternatives compared under this EEA study are (1) production and processing of Almonds 2010 Operations and (2) production and processing of Almonds from 2007 Operations. In each of the alternatives the changes made at both operations were evaluated together and only the changes were assessed in this study. This study is not a complete Life Cycle Analysis (LCA) of almonds since an industry standard LCA has not been established.

5.3. System Boundaries:

The system boundaries define the specific elements of the production and use phases that are considered as part of the analysis. For this study, the system boundary ends at the Use phase (Hilltop Ranch), since subsequent Almond processing, consumption and disposal options remained unchanged from 2007 operations to 2010 operations for the purpose of this study. The system boundaries for the two alternatives are very similar since most of the changes made were for efficiency. The system boundaries for the 2010 operations are shown in Figure 4 and the system boundaries for the 2007 operations are shown in Figure 5. Sections of the production and processing not identified in these figures will not be evaluated in this study.

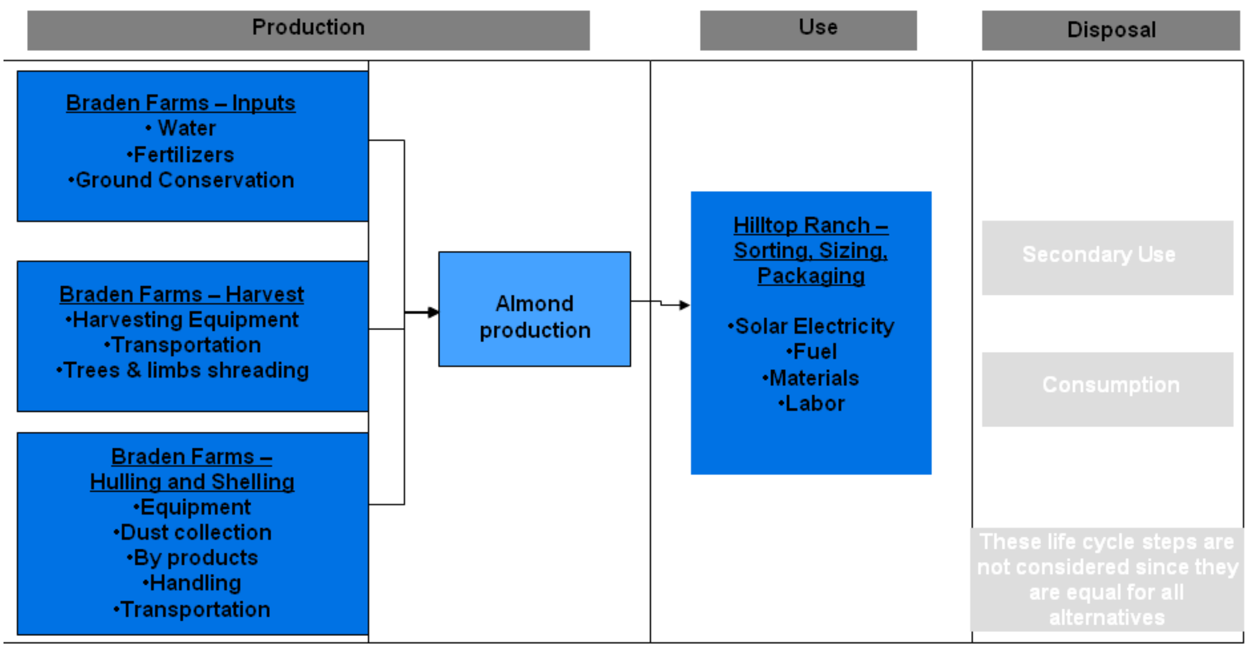

Figure 4. System boundaries for 2010 operations

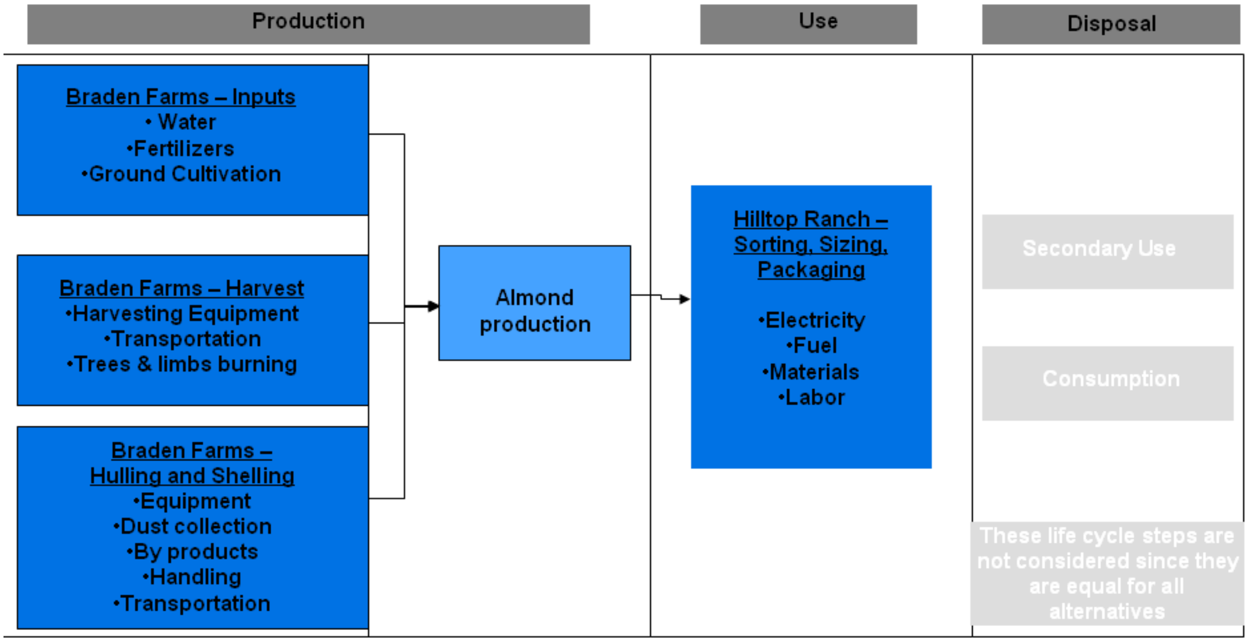

Figure 5. System boundaries for 2007 operations

5.4 Scenario Analyses:

In addition to the base case analysis, additional scenarios will be evaluated to determine the sensitivity of the studies final conclusions and results to key input parameters. Scenario#1 evaluates a 15% yield increase at the field production for the 2010 Operations alternative based on hypothetical technological improvements. Scenario#2 evaluates the impact of reducing the water usage by an additional 15% in the 2010 Operations alternative based on hypothetical operational improvements. Scenario #3 uses the higher fuel cost from March 2011 compared to the fuel costs from 2010. The results of the Scenarios will be discussed in Section 8.4:

5.4.1. Scenario #1: 15% Yield increase in Almond production in 2010 operations.

5.4.2 Scenario #2: 15% Further decrease in water usage in 2010 operations.

5.4.3 Scenario #3: Higher fuel costs in 2010 operations.

6. Input Parameters and Assumptions

6.1. Input Parameters:

A comprehensive list of input parameters were included for this study and considered all relevant material and operational characteristics. The data sources included Braden Farms for Almond production and processing of almonds to remove the hull and shell. The data from Hilltop Ranch is for processing of Almonds by sorting, sizing and packaging. USDA data was used for some of the agricultural costs. The input values for the production and nut processing are absolute values, while the processing at Hilltop Ranch consists of absolute and relative values.

The Almond study evaluates the production and use of the Customer Benefit (CB), which is 1 ton of Almonds. The CB is close to the expected yield from 1 acre of trees (2500 lbs) and is roughly the amount that is held by the totes for processing Almonds. Since there are two operations being evaluated, the CB needed to be correlated between the two operations.

The purpose of the Almond study is to show the environmental and economic benefits of the changes made in the two operations and to evaluate potential improvements that can be made in the future. Since both operations are extremely large compared to most in the industry, any future improvements could have major impacts, especially on these key areas. The plan for the future is to do another analysis 3 years from now to incorporate the future data with the data gathered in this study.

6.1.1. Production Parameters:

The data for the field inputs, field harvesting and almond processing, consisting of nut hulling and shelling, were parameterized for each alternative. The key driver in the farming operation is the reduction of water usage by replacing the solid set sprinklers with micro sprinklers. This reduced the water usage from 5 acre-feet per year down to 3 acre-feet per year. Other key drivers in the farming operation were more efficient pick-up machines, different ground conservation between the trees and mulching of tree limbs instead of burning. Table 3 lists the input amounts and costs for the 2010 operations alternative and Table 4 lists the input amounts and costs for the 2007 operations. The values are based on specific units common to farming operations and these values are then equated to the CB of 1 ton of Almonds. The yield for both alternatives has been established as 2500 lbs of Almonds/acre.

Table 3: Input data and cost for Production and Processing of Almonds 2010 Operations.

	Braden Farms					
	BF Field-Inputs	**Amounts:**	**Units:**	**Costs:**		**Source:**
Farm Operations	Water Usage	977,553.000	gal/acre	$0.00024	US$/gal	Braden Farms
	N Fertilizers	135.000	lbs/acre	$0.22	US$/lbs	Braden & USDA
	P Fertilizers	47.400	lbs/acre	$0.25	US$/lbs	Braden & USDA
	K Fertilizers	147.100	lbs/acre	$0.26	US$/lbs	Braden & USDA
	S Fertilizers	11.600	lbs/acre	$0.16	US$/lbs	Braden & USDA
	Ca Fertilizers	11.800	lbs/acre	$0.02	US$/lbs	Braden & USDA
	Ground Conservation (Fuel use)	2.072	gal/acre	$2.45	US$/gal	Braden Farms
	BF Field-Harvesting					
	Shuttle truck (Fuel use)	0.833	gal/acre	$2.45	US$/gal	Braden Farms
	Pick-up machine (Fuel use)	1.940	gal/acre	$2.45	US$/gal	Braden Farms
	Field Run Trucks (Fuel use)	0.045	gal/acre	$2.45	US$/gal	Braden Farms
	Tree limbs - mulch	1.000	tons/acre	$40.00	US$/ton	Braden Farms
	Tree limbs - burning	0.000	tons/acre	$0.00	US$/ton	Braden Farms
	Labor	17.000	hours/acre	$298.56	US$/acre	Braden Farms
	BF Almond Processing					
Nut Processing	Processing Equipment	0.054	kWh/ton	$0.115	US$/kWh	Braden Farms
	Vacuum Collection (dirt collected)	120.000	lbs/ton	$0.00	US$/lbs	Braden Farms
	Shell Use	1,680.000	lbs/ton	-$0.02	US$/lbs	Braden Farms
	Hull Use	4,160.000	lbs/ton	-$0.06	US$/lbs	Braden Farms
	Sticks in feedstock	40.000	lbs/ton	$0.00	US$/lbs	Braden Farms
	Handling (fuel)	0.039	gal/ton	$2.45	US$/gal	Braden Farms
	Transportation (fuel)	0.111	gal/ton	$2.45	US$/gal	Braden Farms
	Labor	1.400	hours/ton	$17.53	US$/hour	Braden Farms

Table 4: Input data and cost for Production and Processing of Almonds 2007 Operations.

	Braden Farms					
	BF Field	**Amounts:**	**Units:**	**Costs:**		**Source:**
Farm Operations	Water Usage	1,629,255.000	gal/acre	$0.0002	US$/gal	Braden Farms
	N Fertilizers	147.100	lbs/acre	$0.23	US$/lbs	Braden & USDA
	P Fertilizers	59.600	lbs/acre	$0.21	US$/lbs	Braden & USDA
	K Fertilizers	126.900	lbs/acre	$0.14	US$/lbs	Braden & USDA
	S Fertilizers	8.200	lbs/acre	$0.14	US$/lbs	Braden & USDA
	Ca Fertilizers	11.800	lbs/acre	$0.02	US$/lbs	Braden & USDA
	Ground Conservation (Fuel use)	13.580	gal/acre	$2.55	US$/gal	Braden Farms
	BF Field-Harvesting					
	3 tractors shuttle (Fuel Use)	0.777	gal/acre	$2.55	US$/gal	Braden Farms
	Old Pick-up machine	3.880	gal/acre	$2.55	US$/gal	Braden Farms
	Field Run Trucks	0.045	gal/acre	$2.55	US$/gal	Braden Farms
	Tree limbs - mulch	0.000	tons/acre	$0.00	US$/ton	Braden Farms
	Tree limbs - burning	1.000	tons/acre	$75.00	US$/ton	Braden Farms
	Labor	16.800	hours/acre	$282.66	US$/acre	Braden Farms
	BF Almond Processing					
Nut Processing	Processing Equipment(Old	0.051	kWh/ton	$0.10	US$/kWh	Braden Farms
	W/O Vacuum Collection (dirt	120.000	lbs/ton	$0.00	US$/lbs	Braden Farms
	Shell Use	1,680.000	lbs/ton	-$0.01	US$/lbs	Braden Farms
	Hull Use	4,160.000	lbs/ton	-$0.07	US$/lbs	Braden Farms
	Sticks in feedstock	40.000	lbs/ton	$0.01	US$/lbs	Braden Farms
	Handling (fuel)	0.048	gal/ton	$2.55	US$/gal	Braden Farms
	Transportation (fuel)	0.136	gal/ton	$2.55	US$/gal	Braden Farms
	Labor	1.360	hours/ton	$16.83	US$/hour	Braden Farms

6.1.2. Use Parameters:

Inputs for the sorting, sizing and packaging of the Almonds at Hilltop Ranch were parameterized for each alternative. This portion of the process is considered the Use phase since the Almonds have been produced and delivered for processing further and the use of the Almonds in the process is for quality. The major changes in the processing include the installation and use of solar panels to generate electricity, reduction of electricity usage, reduction of fuel and material savings. The cost of solar panels and installation are included in the electricity cost of the solar electricity. The electricity usage was decreased by installation of different lights, replacing the compressor with a more efficient model, installation of insulation in the warehouse for cold storage and changing processing equipment configuration. The cost for these changes are minor over the lifetime use and were not included in the study costs. The reduction of fuel is based on reducing the number of forklifts and buying new efficient forklifts. The addition of the sizing scales and the relocation of the Sortex sorting reduced the movement of the forklifts in processing. The more fuel efficient trucks and sales vehicles also contributed to the fuel reduction. Again, the costs for these changes are minor over the lifetime and were not included. The material savings evaluated was from the reduction in tires needed for the carts and forklifts. More durable forklift tires allowed for longer usage and installation of large magnets on the yard trucks reduced the number of damaged tires on forklifts and carts. The box packaging also reduced raw material usage by replacing a white, colored printed box with a natural cardboard box. Table 5 shows the input amounts and costs for the alternative evaluating the 2010 operations and Table 6 shows the input amounts and costs for the alternative 2007 operations.

Table 5: Input data and cost for Use of the Almonds in the Processing 2010 Operations.

Processing in Plant

Hilltop Ranch

Almond Processing

	Amounts:	Units:	Costs:		Source:
HR Electricity					
Solar Panels - Generation	44.300	kWh/ton	$0.05	US$/kWh	Hilltop Ranch
From Grid - Generation	25.190	kWh/ton	$0.05	US$/kWh	Hilltop Ranch
Processing Operation	40.145	kWh/ton	$0.05	US$/kWh	Hilltop Ranch
Lights	17.281	kWh/ton	$0.14	US$/kWh	Hilltop Ranch
Air Compressors	6.796	kWh/ton	$0.14	US$/kWh	Hilltop Ranch
Sorting	1.416	kWh/ton	$0.14	US$/kWh	Hilltop Ranch
Cold Storage - Warehouse	2.076	kWh/ton	$0.05	US$/kWh	Hilltop Ranch
Sortex Relocation	0.360	kWh/ton	$0.05	US$/kWh	Hilltop Ranch
Cable Bay on rejects	1.416	kWh/ton	$0.05	US$/kWh	Hilltop Ranch
HR Fuel					
Bin Transfer (Propane)	0.000	gal/ton	$0.50	US$/lb	Hilltop Ranch
New Forklifts (Propane)	0.313	gal/ton	$0.50	US$/lb	Hilltop Ranch
Sizing Scale (Propane)	0.000	gal/ton	$0.50	US$/lb	Hilltop Ranch
Trucks (Diesel)	0.357	gal/ton	$2.37	US$/gal	Hilltop Ranch
Sales Vehicles (Gas)	0.036	gal/ton	$2.37	US$/gal	Hilltop Ranch
Sortex Relocation (Propane)	0.000	gal/ton	$0.50	US$/lb	Hilltop Ranch
HR Materials					
Tires on Forklift	14000.000	hrs/tire	$252.09	US$/tire	Hilltop Ranch
Packaging (cardboard)	1.930	lbs/box	$1.09	US$/box	Hilltop Ranch
Tires (Magnets on trucks)	0.015	tires/ton	$252.09	US$/tire	Hilltop Ranch
HR Labor Savings					
Scale time	0.000	hour/ton	$13.02	US$/hour	Hilltop Ranch
Computer Sorting	0.000	hour/ton	$13.02	US$/hour	Hilltop Ranch
Computerized Bag House	0.000	hour/ton	$13.02	US$/hour	Hilltop Ranch
Sortex Relocation	0.000	hour/ton	$13.02	US$/hour	Hilltop Ranch
Dry Ice Blaster	0.001	hour/ton	$13.02	US$/ton	Hilltop Ranch

Table 6: Input data and cost for Use of the Almonds in the Processing 2007 Operations.

Processing in Plant

Hilltop Ranch

Almond Processing

	Amounts:	Units:	Costs:		Source:
HR Electricity					
Solar Panels - Generation	0.000	kWh/ton	$0.00	US$/kWh	Hilltop Ranch
From Grid - Generation	138.630	kWh/ton	$0.12	US$/kWh	Hilltop Ranch
Processing Operation	62.638	kWh/ton	$0.12	US$/kWh	Hilltop Ranch
Lights	38.107	kWh/ton	$0.12	US$/kWh	Hilltop Ranch
Air Compressors	24.245	kWh/ton	$0.12	US$/kWh	Hilltop Ranch
Horizontal? Sorting	4.041	kWh/ton	$0.12	US$/kWh	Hilltop Ranch
Cold Storage - Non insulated warehouse	2.962	kWh/ton	$0.12	US$/kWh	Hilltop Ranch
Sortex Relocation	2.596	kWh/ton	$0.12	US$/kWh	Hilltop Ranch
W/O Cable Bay on rejects	4.041	kWh/ton	$0.12	US$/kWh	Hilltop Ranch
HR Fuel					
Old Bin Transfer (Propane)	0.405	gal/ton	$0.45	US$/lb	Hilltop Ranch
Old Forklifts (Propane)	0.447	gal/ton	$0.45	US$/lb	Hilltop Ranch
Sizing Scale (Propane)	0.179	gal/ton	$0.45	US$/lb	Hilltop Ranch
Trucks (Diesel)	0.669	gal/ton	$2.44	US$/gal	Hilltop Ranch
Sales Vehicles (Gas)	0.096	gal/ton	$2.32	US$/gal	Hilltop Ranch
Sortex Relocation	0.243	gal/ton	$0.45	US$/lb	Hilltop Ranch
HR Materials					
Tires on Forklift	3000.000	hrs/tire	$319.10	US$/tire	Hilltop Ranch
Packaging (dyed cardboard)	1.930	lbs/box	$1.18	US$/box	Hilltop Ranch
Tires (W/O Magnets on trucks)	0.031	tires/ton	$319.10	US$/tire	Hilltop Ranch
HR Labor Savings					
W/O Scale time	16.000	hour/ton	$13.02	US$/hour	Hilltop Ranch
W/O Computer Sorting	1.905	hour/ton	$13.02	US$/hour	Hilltop Ranch
W/O Computerized Bag House	0.500	hour/ton	$13.02	US$/hour	Hilltop Ranch
Sortex Relocation	0.195	hour/ton	$13.02	US$/hour	Hilltop Ranch
Dry Ice Blaster	0.011	hour/ton	$13.02	US$/ton	Hilltop Ranch

6.2. Costs

6.2.1. User Costs

User costs were evaluated for each alternative. User costs were entered based on the CB of 1 ton of Almonds being produced and processed. The cost parameters were summarized for each operation in the two processes. The final costs of each of the parameters can be seen in Table 7. The Almond processing credit at Braden Farms is based on Almond hulls and shells being sold for animal feed and bedding.

Table 7: General Input data costs based on production and processing of 1 ton of Almonds.

Parameters	2010 Operations	2007 Operations
BF Field-Inputs	$323.25	$395.80
BF Field-Harvesting	$276.37	$295.72
BF Almond Processing	-$229.81	-$285.13
HR Electricity	$9.24	$33.27
HR Fuel	$1.59	$12.89
HR Materials	$43.61	$47.40
HR Labor Savings	$0.01	$242.31
Total cost/CB	$424.27	$742.26

7. Data Sources

7.1. Environmental:

The environmental impacts for this study were calculated from eco-profiles (a.k.a. life cycle inventories) for the individual components and for fuel usage. Life cycle inventory data for these eco-profiles were from several data sources, including BASF, specific manufacturing data and customer supplied data. Overall, the quality of the data was considered medium. None of the eco-profile data was considered to be of low data quality. A summary of the eco-profiles is provided in Table 8.

Table 8: Summary of eco-profiles used in the Almond EEA

Eco-Profile	Source, Year	Comments
Almond EEA		
Water	BASF well data, 1995	Boustead database[1]
Urea Fertilizer	Agrium, 2005	Boustead database[1]
DAP Fertilizer	Univ. of Minnesota., 2002	
K-Fertilizer	DE Avg., 1997	Boustead database[1]
S-Fertilizer	GB Avg., 1997	Boustead database[1]
Ca-Fertilizer	DE Avg., 1997	Boustead database[1]
Diesel Use - US	US Avg., 1996	Boustead database[1]
Wood chip	DE Avg., 2003	Boustead database[1]
Wood combustion	CH Avg., 2003	Boustead database[1]
Electricity - US	US Avg. 2004	Boustead database[1]
Solar Electricity- US	US Avg., 1999	Boustead database[1]
Propane – US	US Avg., 1999	Boustead database[1]
Gasoline - US	US Avg., 1999	Boustead database[1]
Tires	BASF, 2008	Boustead database[1]
Packaging	BASF, 2000	Boustead database[1]
BASF data sources are internal data, while the others are external to BASF. Internal data is confidential to BASF; however, full disclosure can be provided to NSF International for verification purposes.		

7.2. Amounts and Costs:

The data sources for the amounts and costs of the individual components were mainly obtained from the two operations, Braden Farms and Hilltop Ranch. Some of the fertilizers costs were from the USDA data. A summary of the source of this data is provided in Table 9. The reference materials for this information can be found in Appendix A.

Table 9: Summary of data sources for amounts and costs

Braden Farms	Input Source	Costs source
Production		
BF Field-Inputs	Braden Farms	Braden Farms & USDA
BF Field-Harvesting	Braden Farms	Braden Farms
BF Almond Processing	Braden Farms	Braden Farms
Hilltop Ranch		
Almond Processing		
HR Electricity	Hilltop Ranch	Hilltop Ranch
HR Fuel	Hilltop Ranch	Hilltop Ranch
HR Water	Hilltop Ranch	Hilltop Ranch
HR Materials	Hilltop Ranch	Hilltop Ranch
HR Labor Savings	Hilltop Ranch	Hilltop Ranch

8. Eco-efficiency Analysis Results and Discussion

8.1. Environmental Impact Results: The environmental impact results for the Almond EEA are generated as defined in Section 6 of the BASF EEA methodology. The results discussed in Section 8.1.1 through 8.3 (depicted in Figures 5 through 21) are for the Base Case only and do not represent any of the Scenarios.

The major factor in the farming operation is the reduction of water usage by replacing the solid set sprinklers with micro sprinklers. The solid set sprinklers would irrigate a large round area and would usually cover about 3 trees per acre. This would use much more water to get the right amount over most of the tree. The micro sprinklers would each cover 1 tree and would monitor water amounts in the soil 3 to 4 feet deep. This would reduce the amount of water needed and supply water when levels in the soil were below the established amounts need by each tree. The replacement of the solid set sprinkler with micro sprinklers reduced the water usage from 5 acre-feet per year down to 3 acre-feet per year.

8.1.1. Primary energy consumption: From Figure 6, the key driver for energy consumption is the Braden Farms field inputs. This is dominated by the use of water for irrigation in the production of Almonds, which is due to the pumping of the water to the fields. The energy consumption takes into account the resources needed to produce this energy. The reduction of energy at Hilltop Ranch is due to reduction in electricity usage in the processing and the resource reduction switching to solar energy. The main affect of the water reduction overshadows the changes made in the processing. Between the two operations, there was an energy reduction of about 36% between 2010 operations and 2007 operations.

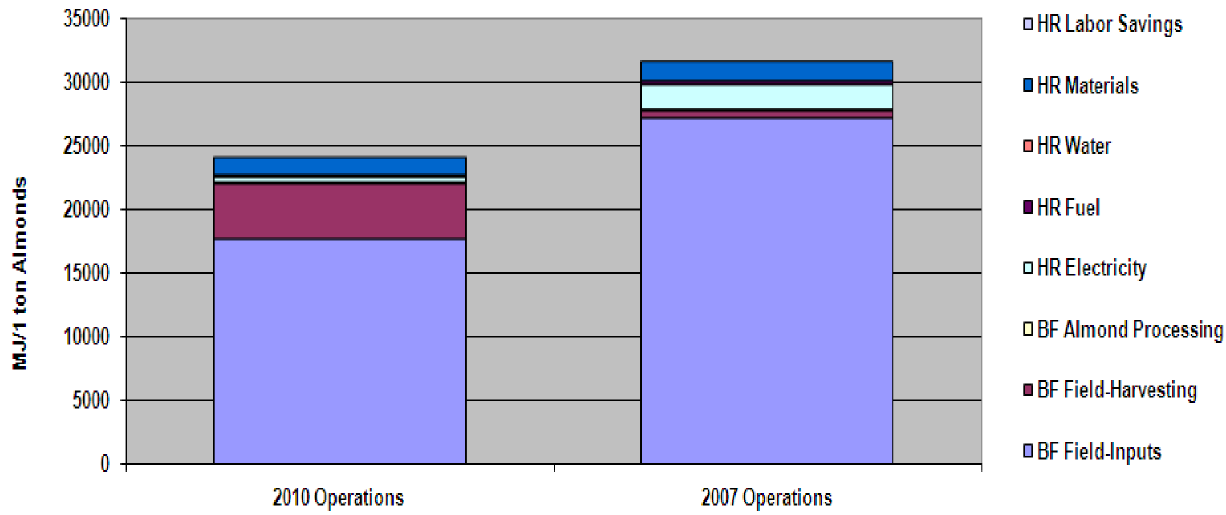

Figure 6. Primary energy consumption.

8.1.2. Raw material consumption: Figure 7 shows that the key driver for the raw material or resource consumption is dominated by the materials needed for Braden Farms field input. Resource consumption is dominated by the use of water for irrigation of Almonds in the field operations. The reduction of the water use between the alternatives is from replacing the solid set sprinklers with micro sprinklers as discussed in the beginning of this section.

Natural gas is the resource needed most due to the water used for irrigation and for the generation of fertilizers. Per the BASF EEA Methodology, individual raw materials are weighted according to their available reserves and current consumption profile. These weighting factors are appropriate considering the context of this study. The oil, coal, lignite and phosphorus are consumed mainly in the electricity, fuel, and fertilizer generation and a minor reduction of these can be seen from 2007 operations to the 2010 operations. Figure 8 shows the overall use of individual raw materials for the different alternatives.

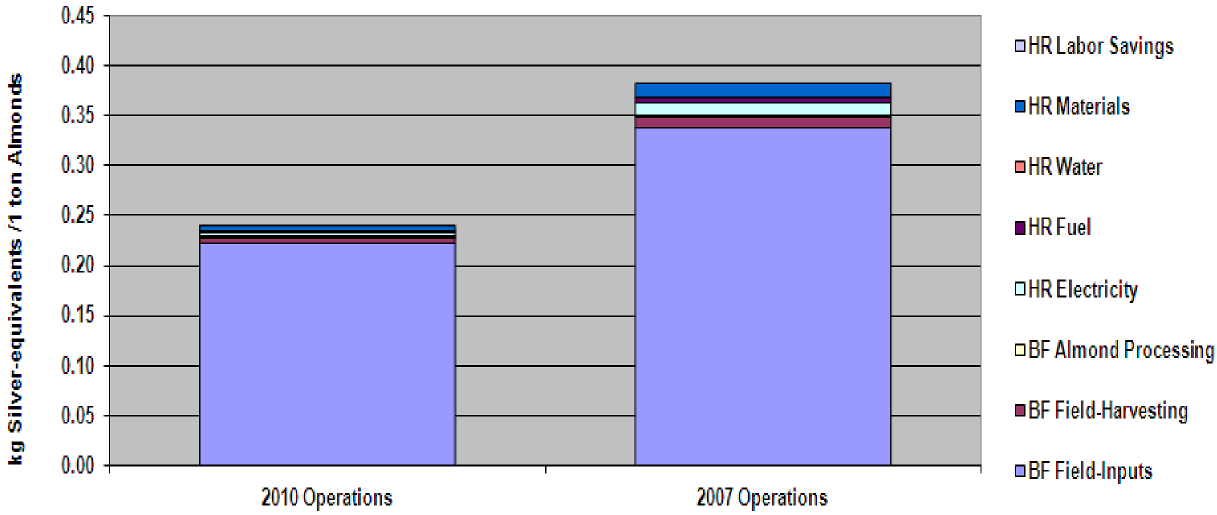

Figure 7. Raw Material consumption by Module.

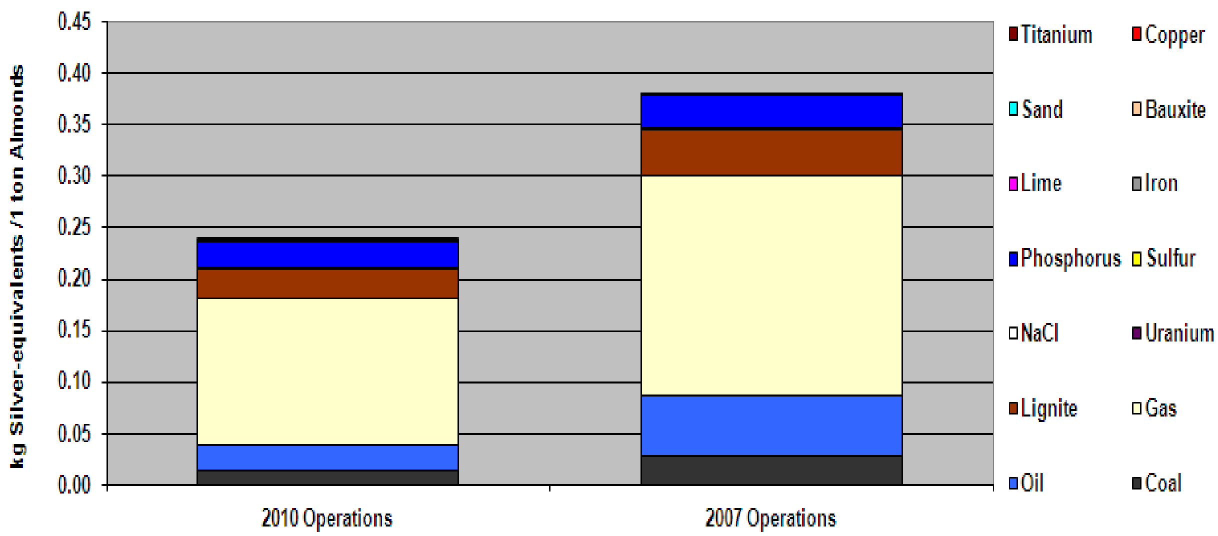

Figure 8. Raw Material consumption by Type.

8.1.3. Air Emissions:

8.1.3.1. Green House Gases (GHG): Green House Gases is equivalent to and also known as the Global Warming Potential (GWP), GHG is the cause and GWP is the affect. Figure 9 shows the overall GHG emission for each of the alternatives. GHG emissions are dominated by the use of water for irrigation and there is about a 30% reduction from the 2007 operations to the 2010 operations. There is also a tremendous amount of GHG that is emitted in the process of producing fertilizers. With the reduction of fertilizer usage, there is a reduction of GHG emissions in the 2010 operations. For the processing of the Almonds, the electricity reductions and the switch to solar energy at Hilltop Ranch showed an 80% reduction is GHG in the 2010 operations compared to 2007 operations. Emissions in fertilizer production are mainly due to the use of fossil energy.

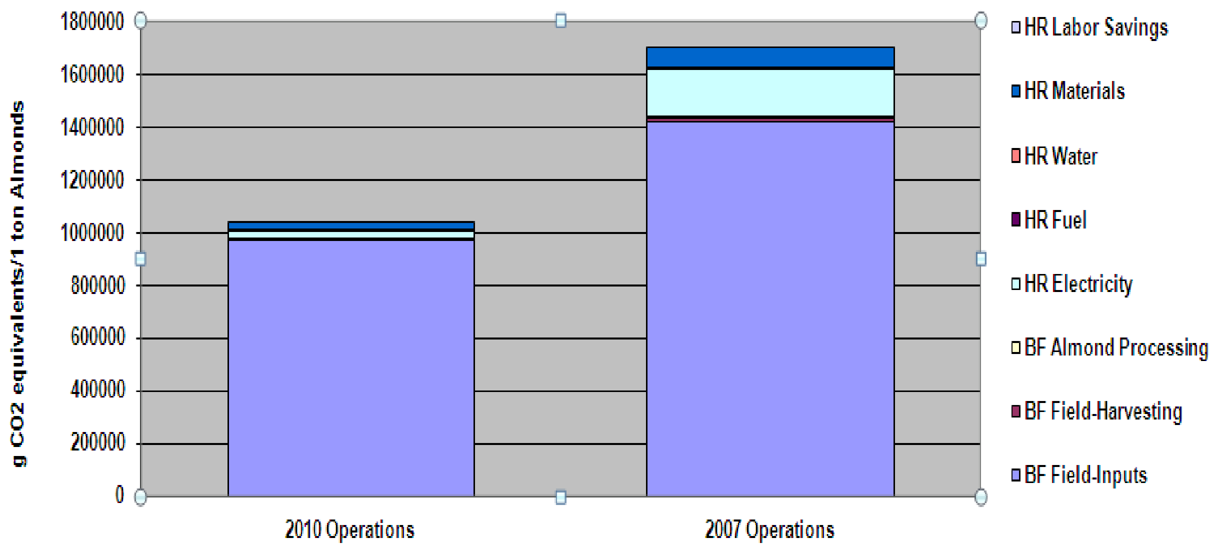

Figure 9. Green House Gas Emissions.

8.1.3.2. Photochemical ozone creation potential (POCP, smog): Emissions with Photochemical Ozone Creation Potential are dominated by the use of water for irrigation and the reduction of fuel and energy at Hilltop Ranch. The environmental affect of the POCP is very minor in this study and the results of each alternative are shown in Figure 10.

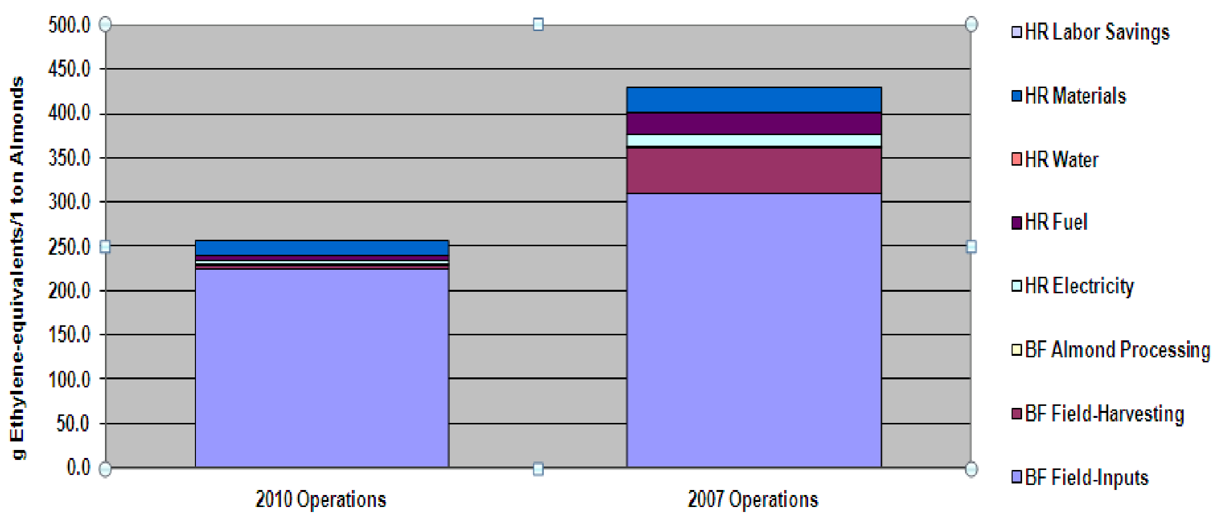

Figure 10. Photochemical ozone creation potential.

8.1.3.3. Ozone depletion potential (ODP): Overall, the ODP emissions are very small in both comparisons and the only difference is mainly the water usage and the materials reduction at Hilltop, such as packaging and tires on the forklifts. This environmental category has a very minor influence also and the results are shown in Figure 11.

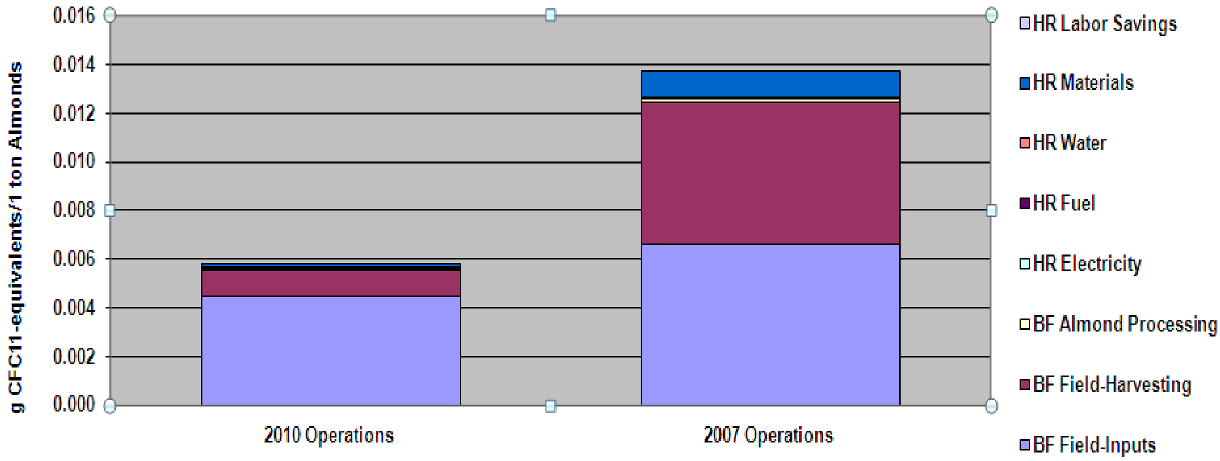

Figure 11. Ozone depletion potential.

8.1.3.4. Acidification potential (AP): It can be seen in Figure 12 that largest impact areas come from the field harvesting and the reduction of electricity in the processing. The reduction in the field is due to the almond tree limbs from pruning being shredded to mulch instead of being burned and contaminating the air. The other major AP factor is at Hilltop ranch were the electricity reductions reduced the AP amounts and the solar electricity generation reduced the AP from the generation of electricity from fossil fuels . The affect on AP from the water for irrigation and is only reduced by 20% between the alternatives.

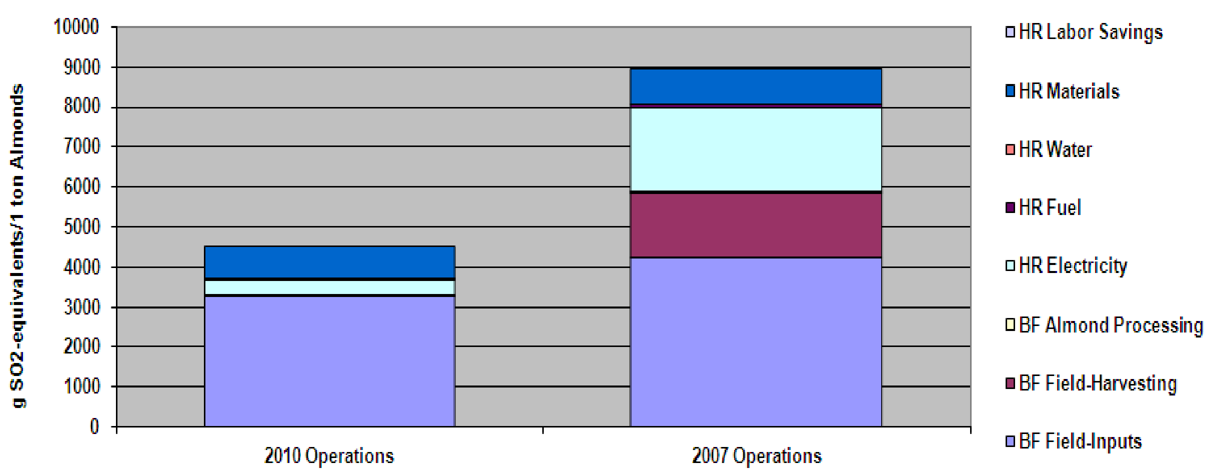

Figure 12. Acidification potential.

Figure 13 below, shows the relative impacts of the four air emissions: GHG, AP, POCP and ODP. These values are normalized and weighted based on the calculation factors (see Figure 28 for the calculation factor percentage). The calculation factor is a calculation of the relative environmental factors and the social weighting factors.

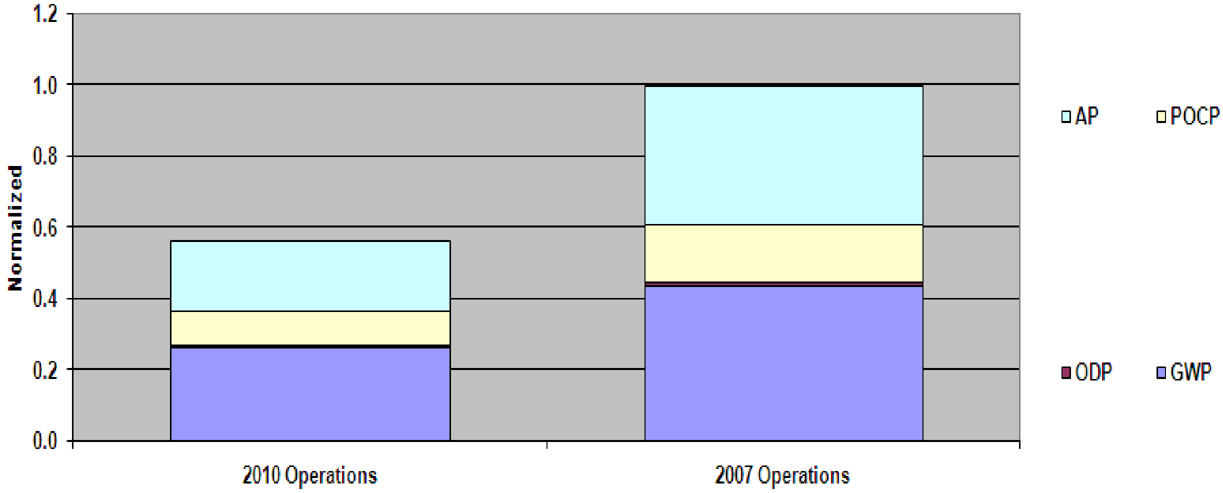

Figure 13. Overall Air Emissions

8.1.4. Water emissions:

This environmental category has a minimal affect on the overall results. The impact from water emissions (Grey water) is calculated using a critical volume approach to the ecotoxicity of the materials. Figure 14 displays that water emissions are dominated by the materials use at Hilltop Ranch and the field inputs and Braden Farms. In the processing at Hilltop Ranch, the largest contribution to water emissions was from the reduction and changes in raw materials; predominately involving the changes in packaging from a white & colored print cardboard to a natural & black print cardboard. At Braden farms, the water emissions mainly are reduced between the two alternatives due to less water and fertilizer use. The shredding of trees and limbs increased the water emissions between the two alternatives due to the mulch being placed back on the ground. This increase is due to the Chemical Oxygen Demand and Biological Oxygen Demand from the wood in the decomposition process, instead of the burning of the trees and limbs.

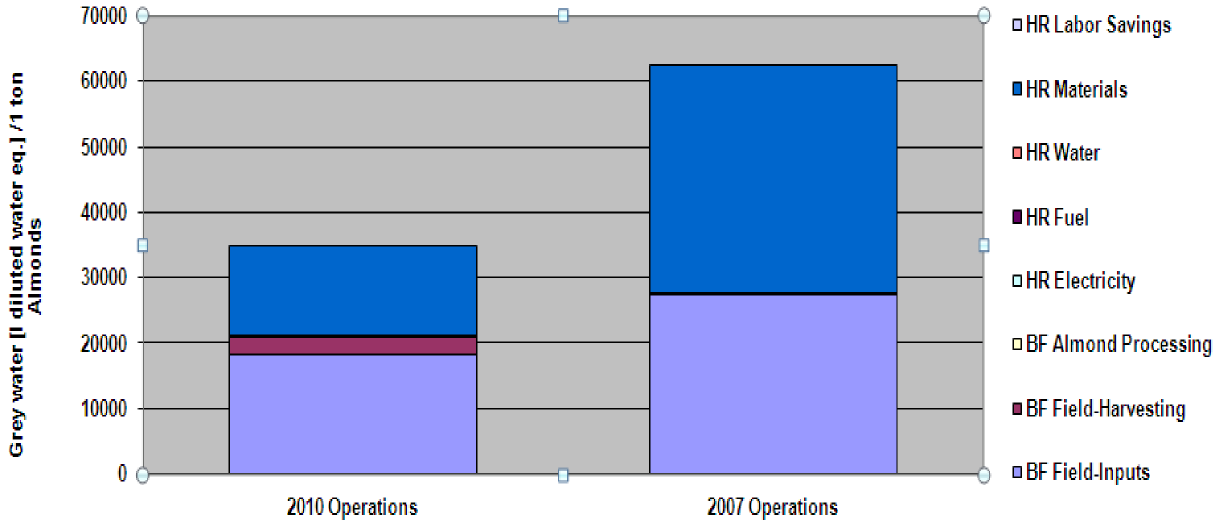

Figure 14. Water emissions.

8.1.5 Solid waste generation:

Solid waste emissions have minor influence on the overall result. The impact from solid wastes (materials) is dominated by the water and fertilizers used in the field operations. Due to the large amount of water used in the farm operations, there is some solid waste generated from the pumping and use of the water. In the production of fertilizers there is some waste generated as impurities in the fertilizer. The other operation where waste is reduced slightly is from the reduction of the electricity in the processing. Figure 15 displays the solid waste emissions for the two alternatives.

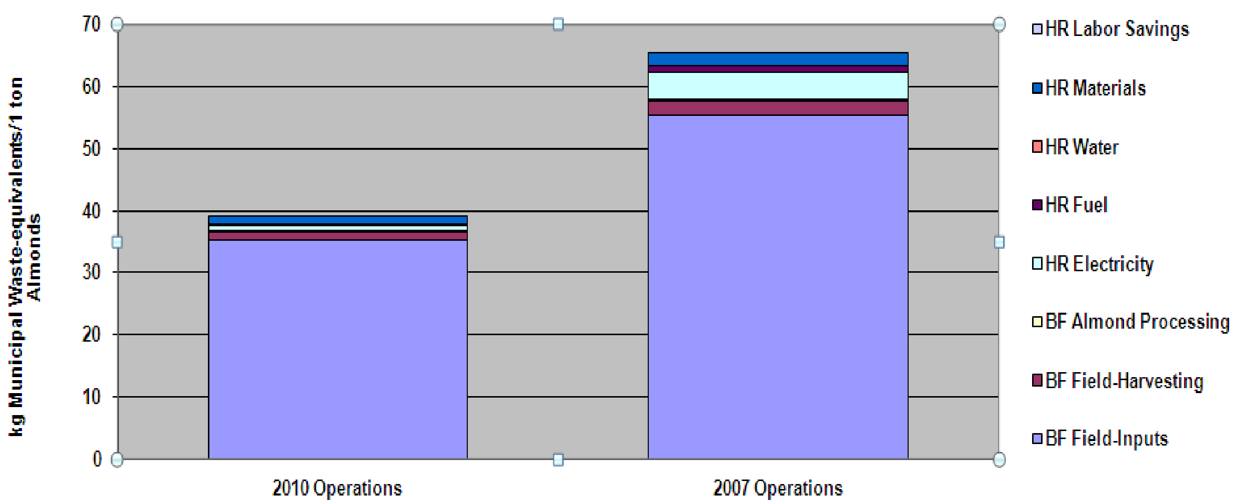

Figure 15. Solid waste generation.

8.1.6 Land use:

As displayed in Figure 16, land use is assessed for each alternative. Land use is one of the most important environmental categories for agricultural processes assessed with eco-efficiency analysis. The land use impact assessment takes into account an Ecosystem Damage Potential[2,3] (EDP), with damage functions and generic characterization factors for quantifying damages to ecosystems from land occupation and land transformation. EDP is based on an assessment of the impacts of land use on species diversity. The land use is of significance (15%) with the majority of the land use from the field inputs due to the use of water for irrigation. Land use is affected due to the water being pumped from local wells, reservoirs and waterways. The water used for the almond trees could have an affect on other vegetation or eco-systems in the area. The use of land for the production of fertilizers is negligible. The units for this metric are square meter years/1 ton of Almonds

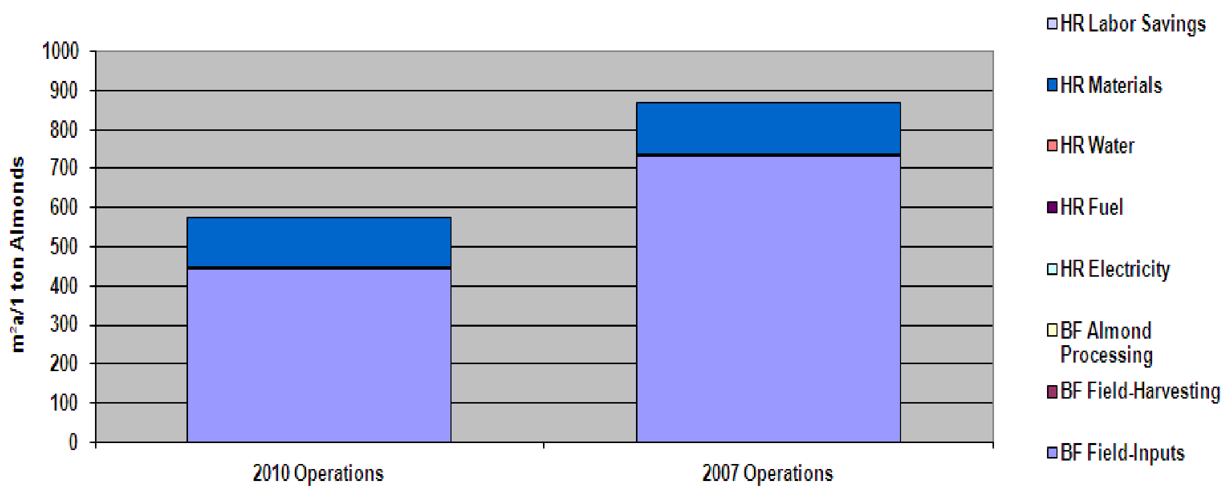

Figure 16. Land use – EDP assessment.

8.1.7 Toxicity potential:

The toxicity potential for the Almond study is shown in Figure 17 for each of the modules. The main driver in toxicity is the reduction of fuel in processing at Hilltop Ranch. Figure 18, shows the human toxicity potential at the life cycle phases for both the Production and Use phase for each alternative. The values have been normalized and weighted. Human toxicity potential is decreased from 2010 operations as compared to 2007 operations, since it is strongly influenced by the amount of fuel used. As seen by the chart, the alternatives have similar toxicity potential in the Production phase, while in the Use phase, the toxicity potential drastically is decreased in the 2010 operations. The field operations had a slight decrease due to less fertilizer being used and a slight decrease in the materials used in processing.

Ecotoxicity was not evaluated for the use phase since the study was not evaluating the affects of the application of fertilizers or chemicals on the soil.

The use of nanoparticles were not evaluated in the chemical inputs for any of the alternatives, therefore the toxicity of nanoparticles was not evaluated in the study results.

Consistent with the methodology's approach for assessing the human health impact of these materials (ref. Section 6.8 of Part A submittal), a detailed scoring table was developed for each alternative broken down per life cycle stage. This scoring table with all relevant material quantities considered as well as their R-phrase and pre-chain toxicity potential scores[4] were provided to NSF International as part of the EEA model which was submitted as part of this verification.

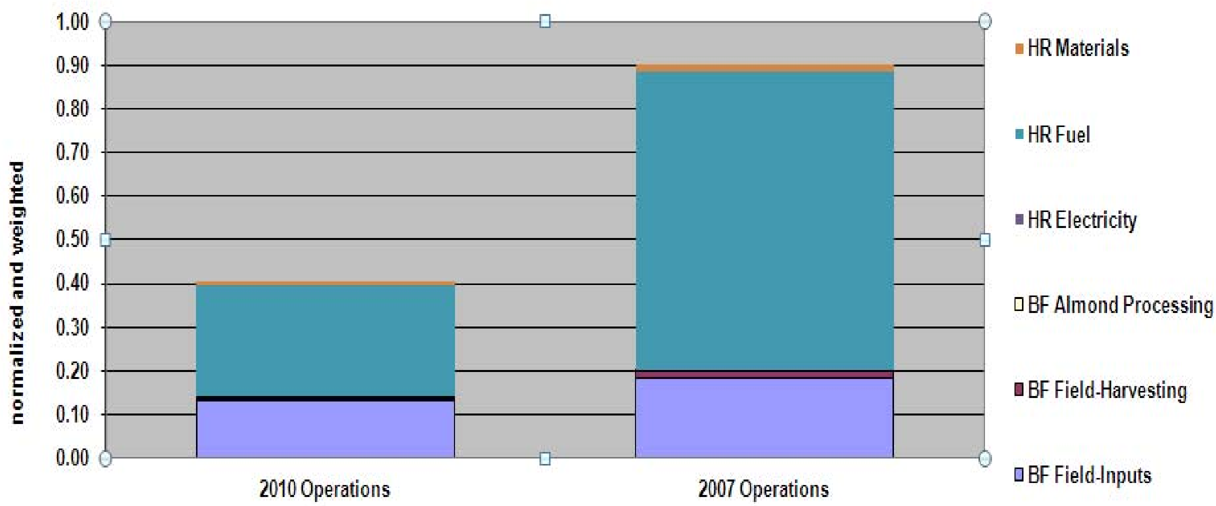

Figure 17. Toxicity potential by Module

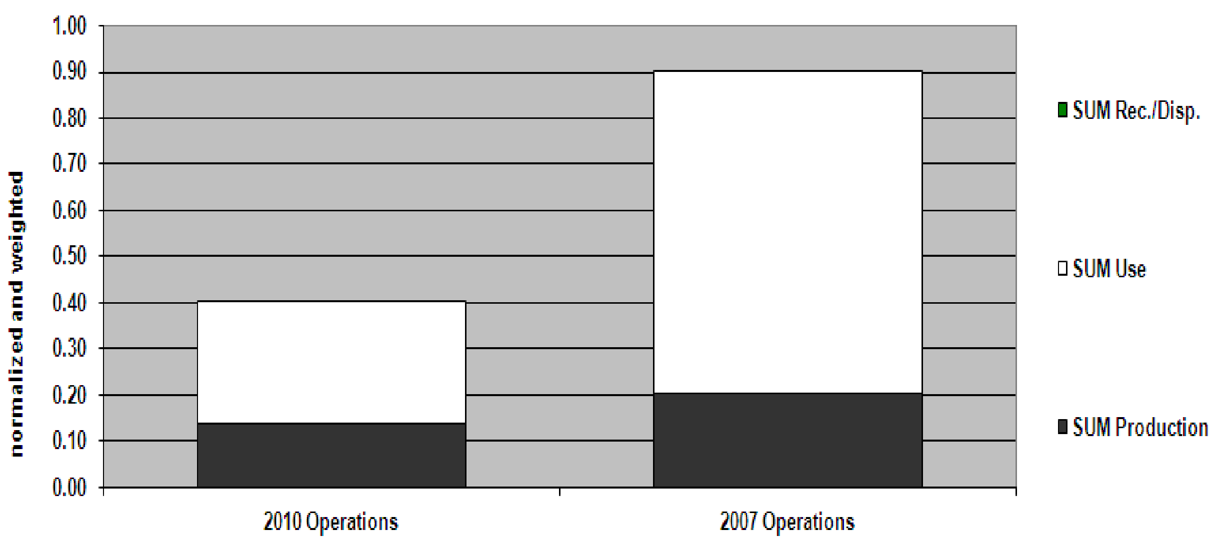

Figure 18. Toxicity by life-cycle process

8.1.8 Risk potential (Occupational Diseases and Accidents potential):

All the materials and activities accounted for in the various life cycle stages were assigned specific NACE codes. NACE (Nomenclature des Activities Economiques) is a European nomenclature which is very similar to the NAICS codes in North America. The NACE codes are utilized in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the business economy and is broken down by specific industries. Specific to this impact category, the NACE codes track, among other metrics, the number of working accidents, fatalities and illnesses and diseases associated with certain industries (e.g. chemical manufacturing, petroleum refinery, inorganics etc.) per defined unit of output. By applying these incident rates to the amount of materials required for each alternative, a quantitative assessment of risk is achieved.

In Figure 19, the greatest Occupational Illnesses and Working Accidents potential occurs in the field input operations. These risks are mainly due to the farming operations using water and fertilizer. The occupational diseases are mainly from the fertilizer production and use due to chemicals used to produce the fertilizers. The occupational diseases associated with the water use are due to diseases associated with irrigation such as bacteria and fungi. The impact from occupational diseases clearly outweighs the impact from working accidents as shown in Figure 20. The toxicity for both alternatives are weighted and normalized to the worst case, which is established as a value of 1.0.

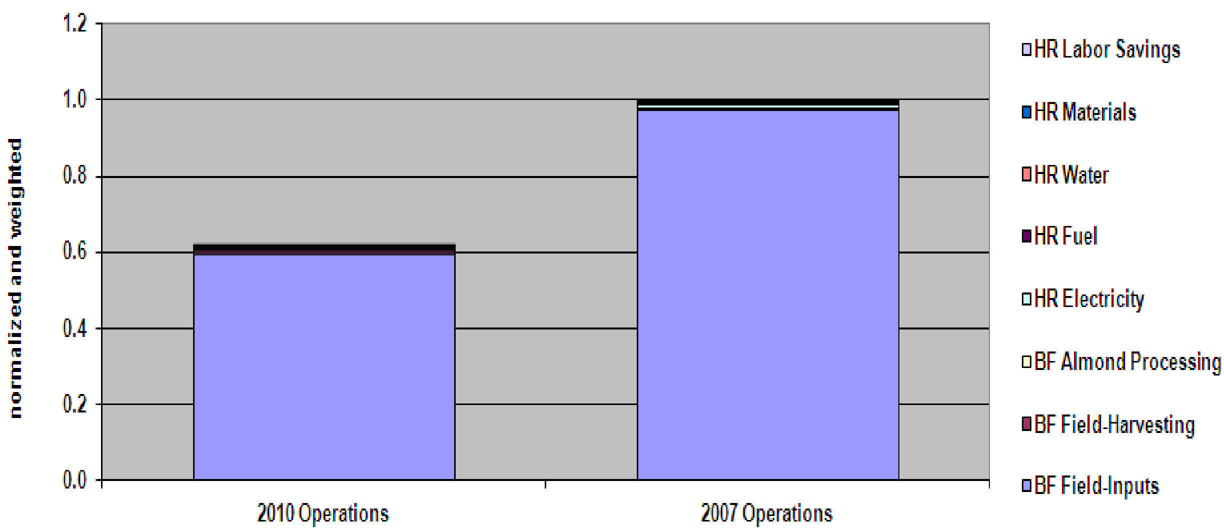

Figure 19. Occupational Illnesses and Accidents by modules

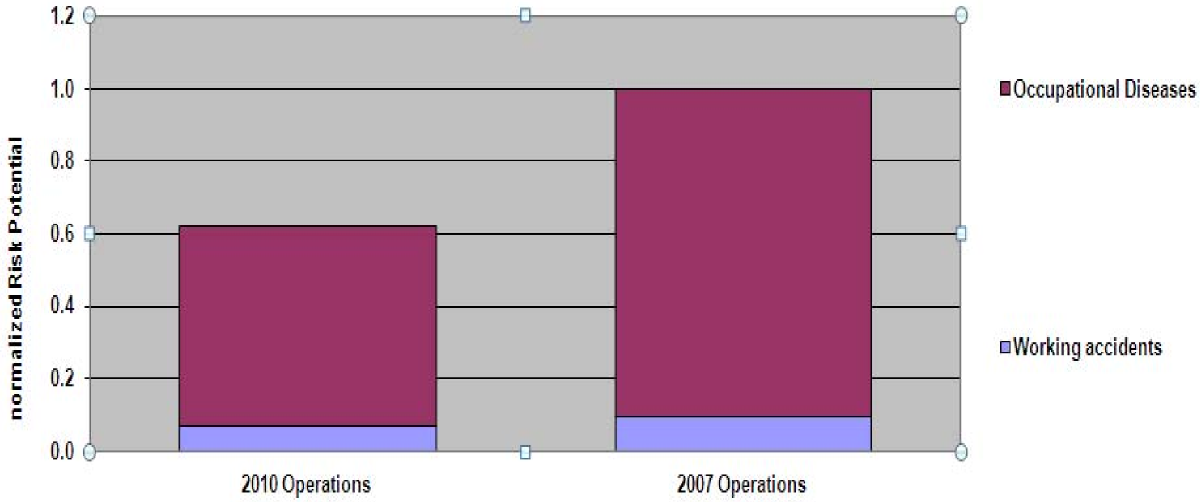

Figure 20. Overall Occupational Diseases and Working Accidents

8.1.9 Environmental Fingerprint:

Following different environmental impact categories in a normalized style and normalized and weighted with regards to emissions. The relative impact for all six of the environmental categories in each alternative is shown in the Environmental Fingerprint, Figure 21. A value of 1 represents the alternative with the highest impact in the concerning category, all other alternatives are normalized in relation to 1.

As seen in the Environmental fingerprint, the 2007 operations alternative is worse than the 2010 operations alternative in all the categories, since this is established as 1. The environmental advantages of the 2010 operations are in all 6 categories:

- Energy Consumption
- Emissions
- Toxicity Potential
- Occupational illnesses and working accidents
- Resource Consumption
- Land Use

The greatest change in the environmental impact of the 2010 operations over the operations from 2007, as seen in figure 21, is the toxicity potential. This is mainly due to less fuel being used in both production and processing.

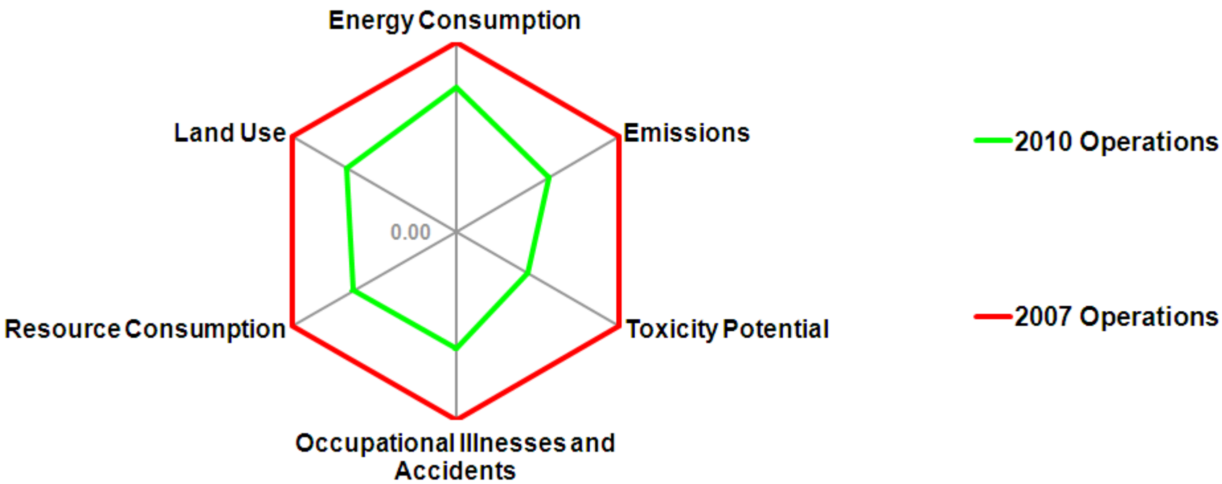

Figure 21. Environmental Fingerprint.

8.2 Economic Cost Results:

The life cycle cost data for Almond EEA are generated as defined in Section 7 of the BASF EEA methodology and described in section 6.2 above. The results of the life cycle cost analysis found that in the operations, the field input and the field harvesting are the driving factors for costs. Figure 22 represents the graph of the costs for each of the alternatives based on the individual components. There is a credit for costs in the Almond processing at Braden Farms due to the selling of the hull and shell, which are both by-products of the Almond. There was a decrease in the selling price for hulls from 2007 to 2010 and this is reflected in the graph as a larger credit in 2007.

The cost analysis is based on data from a "point in time" mainly from data supplied for 2007 and 2010. Although this cost data may vary throughout the year, the input data costs are average fixed amounts for each year.

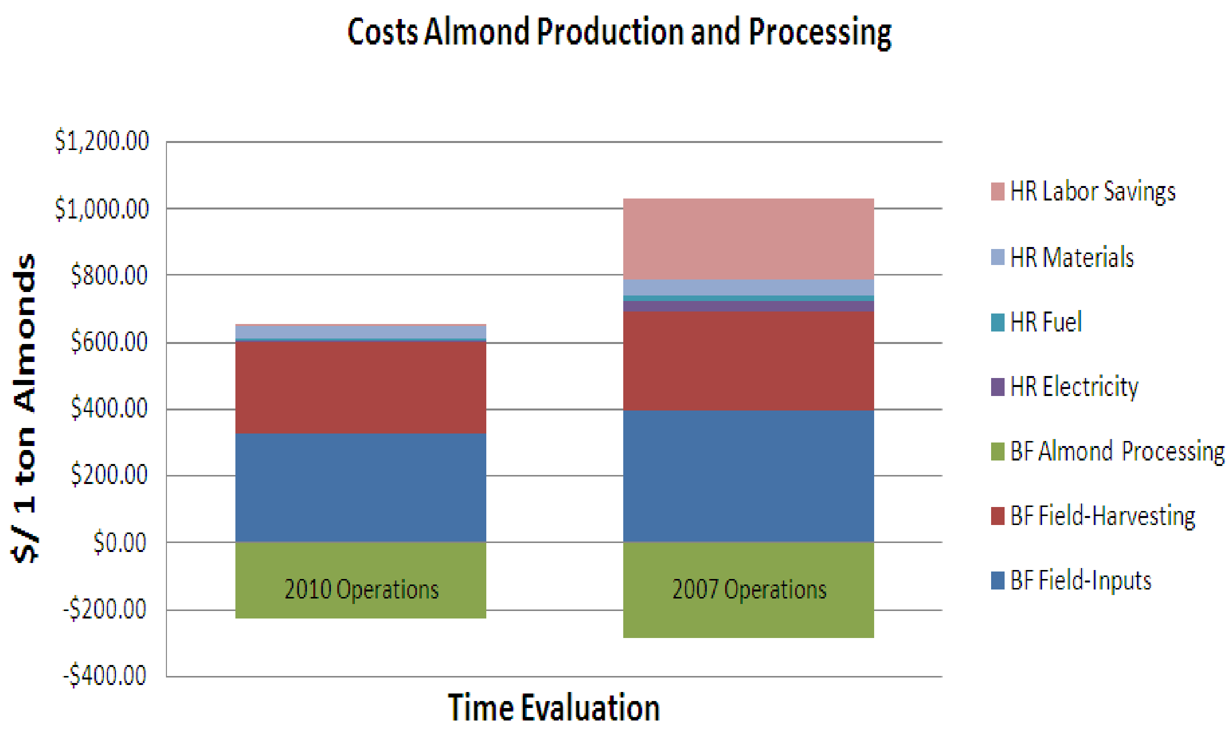

Figure 22. Life cycle costs – modules

8.3 Eco-Efficiency Analysis Portfolio:

The Eco-efficiency analysis portfolio for the Almond EEA has been generated as defined in Section 9.5 of the BASF EEA methodology. Utilizing relevance and calculation factors, the relative importance of each of the individual environmental impact categories are used to determine and translate the fingerprint results to the position on the environmental axis for each alternative shown. For a clearer understanding of how weighting and normalization is determined and applied please reference Section 8 of BASF's Part A submittal to P-352. Specific to this study, the worksheets "Relevance" and "Evaluation" in the EEA model provided to NSF as part of this verification process should be consulted to see the specific values utilized and how they were applied to determine the appropriate calculation factors. Specific to the choice of environmental relevance factors and social weighting factors applied to this study, factors for the USA (national average) were utilized. The environmental relevance values utilized were last reviewed in 2007 and the social weighting factors were recently updated in 2009 by an external, qualified 3rd party.

Figure 23 displays the Base Case (BC) eco-efficiency portfolio, which shows the results when all six individual environmental categories are combined into a single relative environmental impact and combined with the life cycle cost impact. Because environmental impact and cost are equally important, the most eco-efficient alterative is the one with the largest perpendicular distance above the diagonal line. The results from this study find that the 2010 operations is the most eco-efficient alternative due to its combination of lower environmental burden and having the lowest life cycle cost.

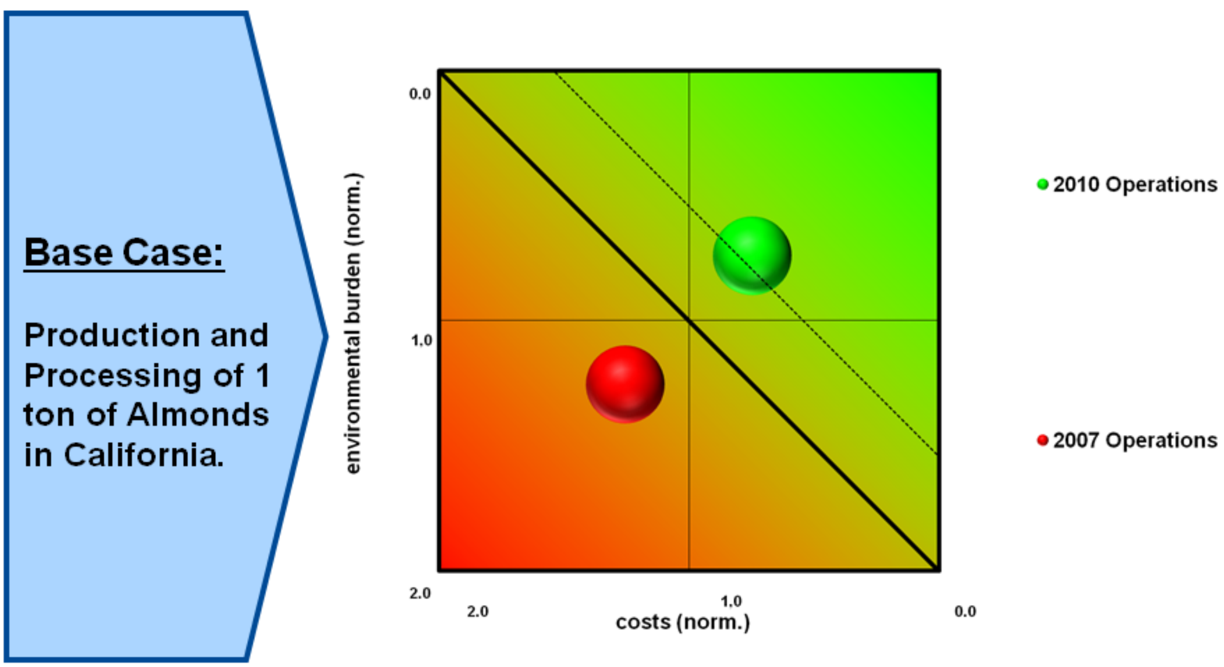

Figure 23 Eco-Efficiency Portfolio Base Case – Almond

8.4 Scenario Analysis:

In addition to the base case analysis, additional scenarios were evaluated to determine the sensitivity of the studies final conclusions and results to key input parameters. These scenarios are hypothetical technological or operational improvements.

8.4.1. Scenario #1: 15% Yield increase in Almond production in 2010 operations.

In this scenario analysis, the yield for the 2010 operations increased by 15% due to better field processes. From this analysis the 2010 operations would have an even more advantage over the 2007 operations. This is due to the fact that yield has a major impact on the analysis since the CB is a fixed amount and any increase would decrease the environmental and cost burden. Figure 24 shows the Eco-efficiency Portfolio results of Scenario #1 and Figure 25 shows the Environmental Fingerprint of Scenario #1.

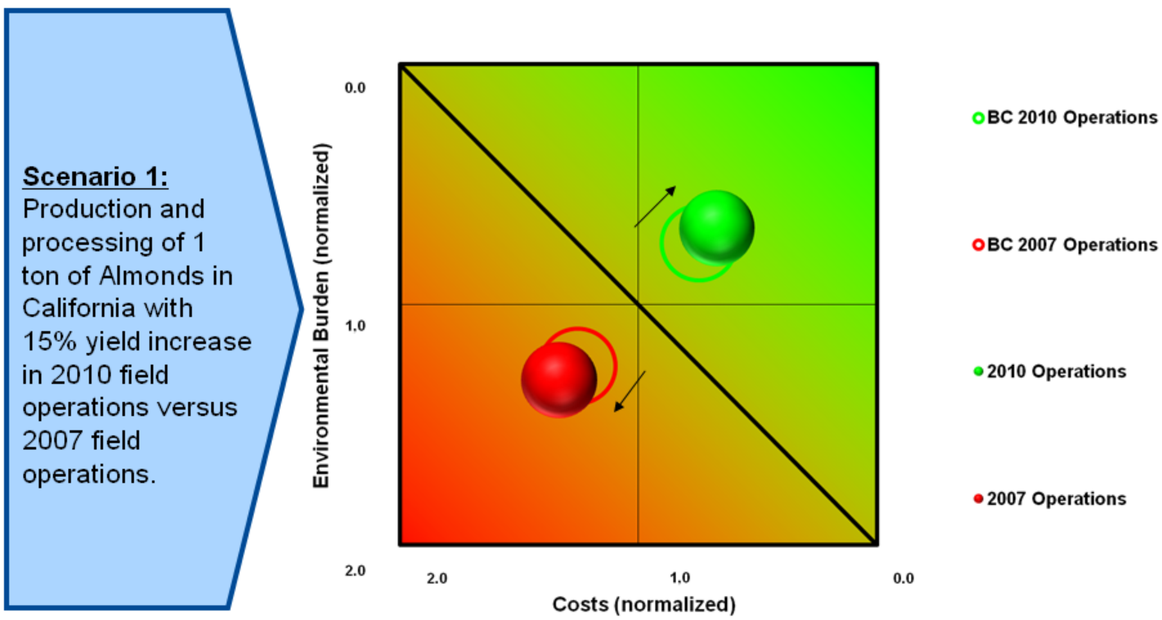

Figure 24. Scenario #1: 15% Increased Yield for Almond production

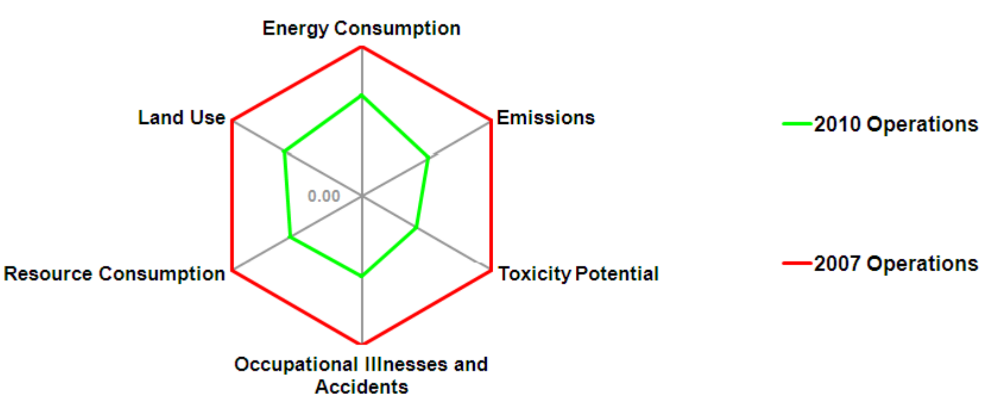

Figure 25. Environmental Fingerprint of Scenario #1.

8.4.2. Scenario #2: 15% Further decrease in water usage in 2010 operations.

For this scenario analysis, decreasing the amount of water used for irrigation improves the environmental output of the 2010 operation. Water used for irrigation was the major factor in this study and this scenario shows the impact of reducing water usage further by 15%. This scenario also helps to show the benefit both environmentally and economically if conservation methods can be implemented. The use of water is a very important issue for the growers in California for Almond production, but also due to water shortages in California. Figure 26 shows the Eco-efficiency Portfolio results of Scenario #2 and Figure 27 shows the Environmental Fingerprint of Scenario #2.

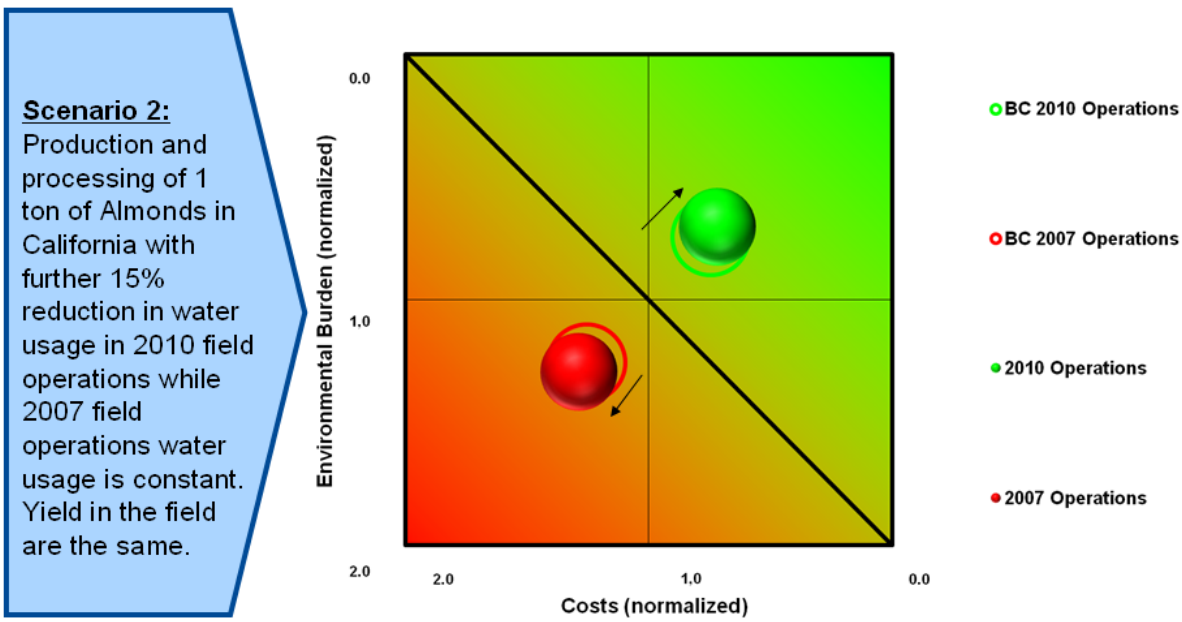

Figure 26. Scenario #2: 15% Further decrease in water usage for Almonds

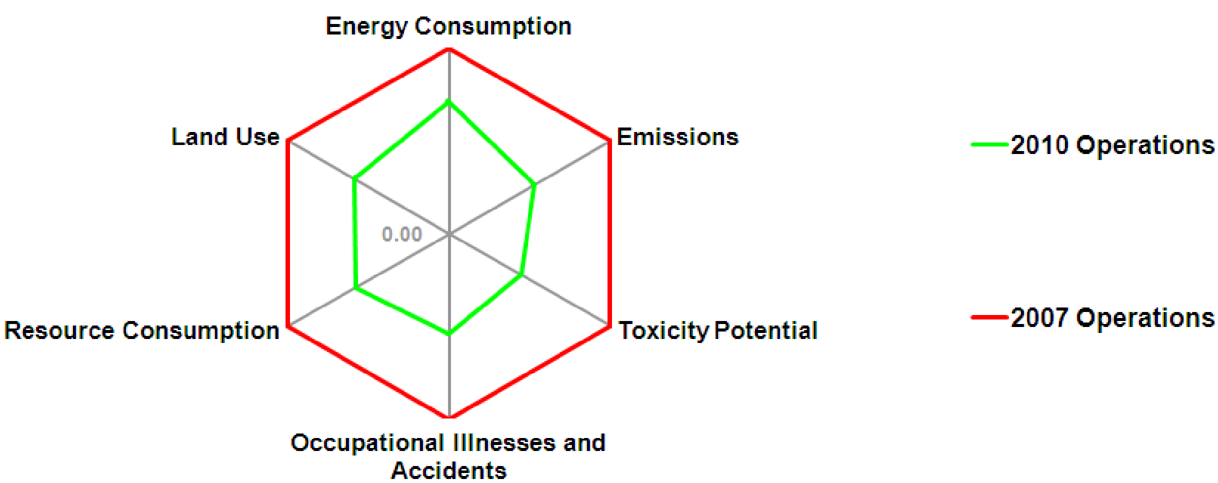

Figure 27. Environmental Fingerprint of Scenario #2.

8.4.3. *Scenario #3:* Higher fuel costs in 2010 operations.

For this scenario analysis, higher fuel cost for the 2010 operation were used to model the increase in fuel prices in 2011. The fuel costs used in the 2010 operation were $4.30/gal. for diesel, $.68/lb for propane and $4.00/gal. for gasoline. This scenario shows that the fuel usage is minor in the production and processing of Almonds and that increases in price has a minor influence on the Eco-efficiency results. Figure 28 shows the Eco-efficiency Portfolio results of Scenario #3.

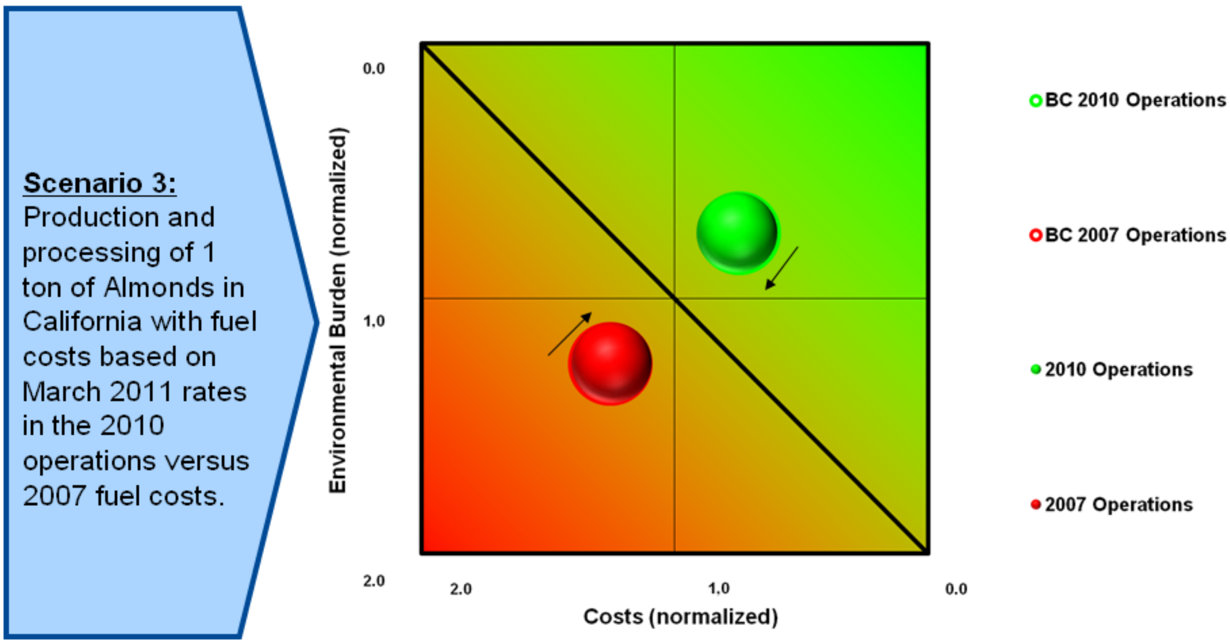

Figure 28. Scenario #3: Higher fuel costs in 2010 operation.

9. Data Quality Assessment

9.1. Data Quality Statement: The data used for parameterization of the EEA was sufficient with most parameters of moderate to high data quality. Moderate data is where industry average values or assumptions pre-dominate the value. No critical uncertainties were identified within the parameters and assumptions that could have a significant effect on the results and conclusions. The data is from the Almond production and processing at Braden Farms and Hilltop Ranch. The data used in this study are from 2007 (2008 when no data for 2007), and 2010, see Appendix A for data sources and years. Table 10 provides a summary of the data quality for the EEA.

Table 10: Data quality evaluation for EEA parameters.

Data	Source	Quality
Life Cycle Inventories	Boustead V. 5.0.12 Published public data	Med-High
Compositional data	Braden Farms Hilltop Ranch USDA	High
Data for Alternatives	Braden Farms Hilltop Ranch USDA	Med-High
Production and application impacts	Braden Farms Hilltop Ranch	Med-High
Life Cycle Costing	Braden Farms Hilltop Ranch Industry rates	Med-High
Toxicity Potential	Toxipo data files	Med-High
Risk Data	NACE Codes	Med

10. Sensitivity and Uncertainty Analysis

10.1. Sensitivity and Uncertainty Considerations:

A sensitivity analysis of the final results indicates that the environmental and economic impacts are equally comparable in this study. Both have an influential or relevant affect in determining the final relative eco-efficiency positions of the alternatives. This conclusion is supported by reviewing the BIP Relevance (or GDP-Relevance) factor calculated for the study. The BIP Relevance indicates for each individual study whether the environmental impacts or the economic impacts were more influential in determining the final results of the study. For this study, the BIP Relevance indicated that the environmental and economic impacts were similar because the BIP value was very close to 1 (reference the "Evaluation" worksheet in the Excel model for the BIP Relevance calculation).

As the data quality related to these main contributors were of medium to high and scenario variations were run related to them (see section 8.4), this strengthened the confidence in the final conclusions indicated by the study. A closer look at the analysis (see Figure 29) indicates that Energy is the environmental impact category that has the most relevance for this study, followed by toxicity, land use and resources. Within the emissions category, air emission was the most relevance. In air emissions, AP and GHG are considered the two most relevant factors.

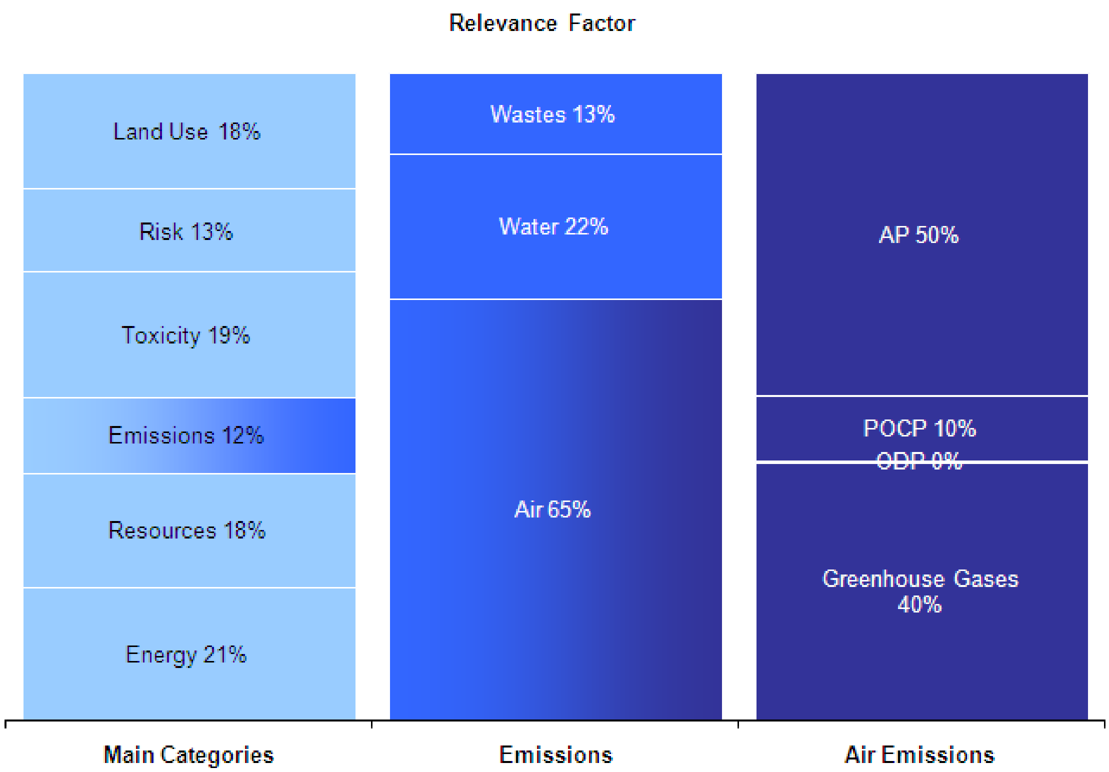

Figure 29. Environmental Relevance factors that are used in the sensitivity and uncertainty analysis.

The calculation factors (Figure 30), which considers both the social weighting factors and the environmental relevance factors, indicate which environmental impact categories has the largest affect on the final outcome. Calculation factors are utilized in converting the environmental fingerprint results (Figure 20) into the final, single environmental score as reflected in our portfolio (Figure 22). The impacts with the highest calculation factors were similar to the environmental relevance factors, with regards to the six main impact categories. Energy and toxicity potential are the environmental impact categories that have the most influence on the final eco-efficiency, followed by resources and emissions. Within the emissions category, air is the highest followed by water. In air emissions, GHG and AP are considered the most significant. The social weighting factors considered for this study did influence some minor reprioritization of the impact categories represented in the energy, land used and emissions, with further changes with the air emissions sub-categories.

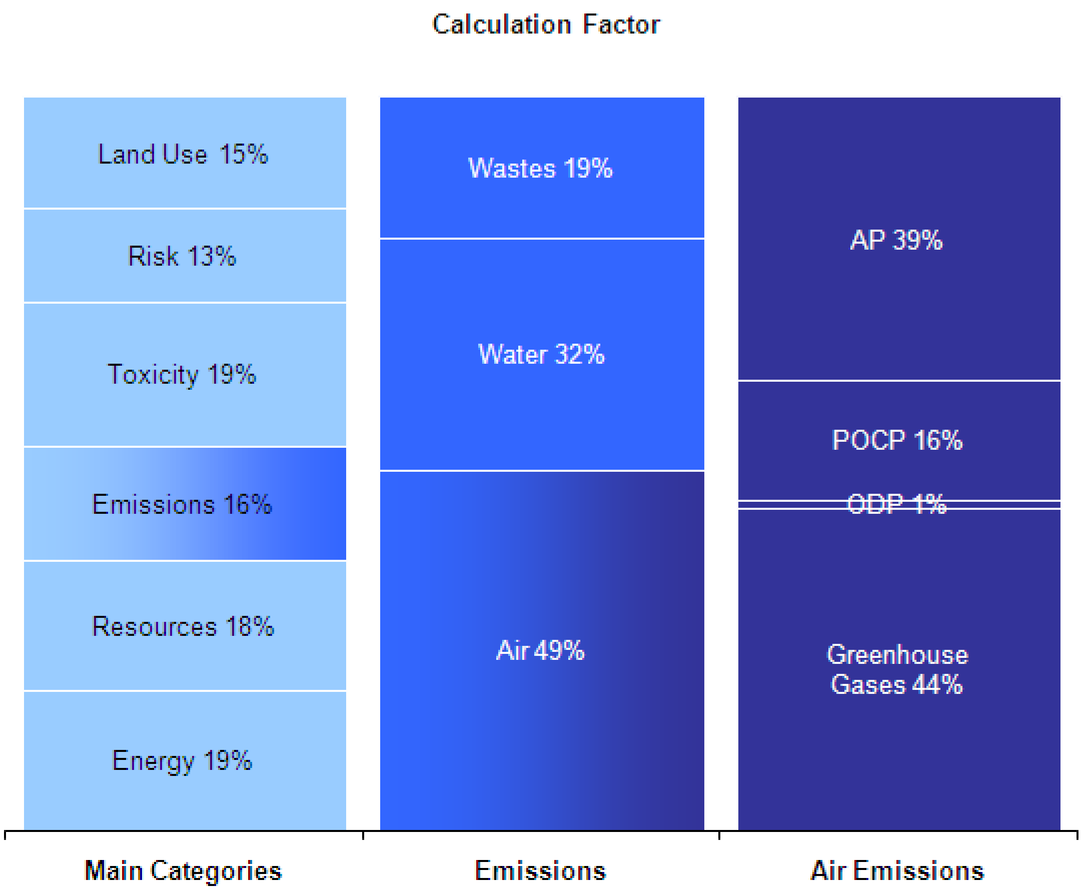

Figure 30. Calculation factors that are used in the sensitivity and uncertainty analysis.

10.2. Critical Uncertainties:

There were no significant critical uncertainties from this study that would limit the findings or interpretations of this study. The data quality, relevance and sensitivity of the study support the use of the input parameters and assumptions as appropriate and justified.

11 Limitations of EEA Study Results

11.1. Limitations:

These Eco-efficiency analysis results and its conclusions are based on the specific comparison of the production, for the described customer benefit, alternatives and system boundaries. Transfer of these results and conclusions to other production methods or products is expressly prohibited. In particular, partial results may not be communicated so as to alter the meaning, nor may arbitrary generalizations be made regarding the results and conclusions.

12. References

1. Boustead Consulting Ltd UK, The Boustead Model 5.1.2600.2180 LCA database.

2. Koellner, T., and Scholz, R., *Assessment of Land Use Impacts on the Natural Environment, Part 1: An Analytical Framework for Pure Land Occupation and Land Use Change*, International Journal LCA 12(1) 16-23, 2007.

3. Koellner, T., and Scholz, R., *Assessment of Land Use Impacts on the Natural Environment, Part 2: Generic Characterization Factors for Local Species Diversity in Central Europe*, International Journal LCA 2006.

4. Landsiedel R, Saling P: Assessment of toxicological Risks for Life Cycle Assessment and Eco-Efficiency Analysis, Int J LCA 7(5) 262-268, 2002.

Appendix A:

<u>Data Sources used for input data:</u>

- Braden Farms Data from 2/22/2010 to 2/22/2011 from Pure Sense irrigation event table file.
- Braden Farms Data 3-4-2011 spreadsheet, 2011.
- Braden Farms Huller labor data from 2010 and 2008.
- Braden Farms Labor Cost, email from Manny Dias, March 21, 2011.
- Braden Farms Shell sales and mulching costs, email from Manny Dias, March 25, 2011.
- Braden Farms Water Cost, email from Manny Dias, April 6, 2011.
- United States Department of Agriculture (USDA) Economic Research Service Website – http://www.ers.usda.gov/Data/FertilizerUse/ERS/USDS data, *U.S. Fertilizer Use and Price,* Tables 7, 8, 10, 12, 14, (Feb. 2010)
- Hilltop Ranch Cost efficiency spreadsheet for forklift from 2008 to 2010.
- Hilltop Ranch diesel fuel purchase spreadsheet from 2007 & 2010.
- Hilltop Ranch Solar energy production, email from Fernando Gomez, March 23, 2011.
- Hilltop Ranch energy Savings for Lights, email from Fernando Gomez, December 22, 2010.
- Hilltop Ranch PG&E Project spreadsheet, 2011
- Hilltop Ranch Sortex Relocation spreadsheet, August 2010.
- Hilltop Ranch Dry Ice blaster analysis spreadsheet, January 2011.
- Hilltop Ranch Sortex labor savings spreadsheet, December 2010.
- Hilltop Ranch W/O scale time – Sizing plant spreadsheet, January 2011.
- Hilltop Ranch Sustainability Calculations spreadsheet, 2011
- Hilltop Ranch Sustainability Calculations-2 spreadsheet, 2011
- International Paper price list, June 2010.