The Chemical Company

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

Termidor® Termiticide, Eco-Efficiency Analysis Final Report – November 2011

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1. Purpose and Intent of this Submission

1.1. The purpose of this submission is to provide a written report of the methods and findings of BASF Corporation's "Termidor® Termiticide, 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 Termidor® Termiticide, 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 Submission

2.1. This submission outlines the study goals, procedures, and results for the Termidor® SC Termiticide/Insecticide, Eco-Efficiency Analysis (EEA) study, which was 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 and other project related data (e.g. termiticide labels, efficacy results etc.), 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. 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 functional unit and consider both the environmental and economic impacts of each alternative over their life cycle in order to achieve the specified customer benefit. 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, greenhouse gas emissions (GHG), ozone depletion potential (ODP), acidification potential (AP), photochemical ozone creation potential (POCP), water emissions, solid waste emissions, toxicity potential, risk potential (occupational illnesses and accidents), 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.

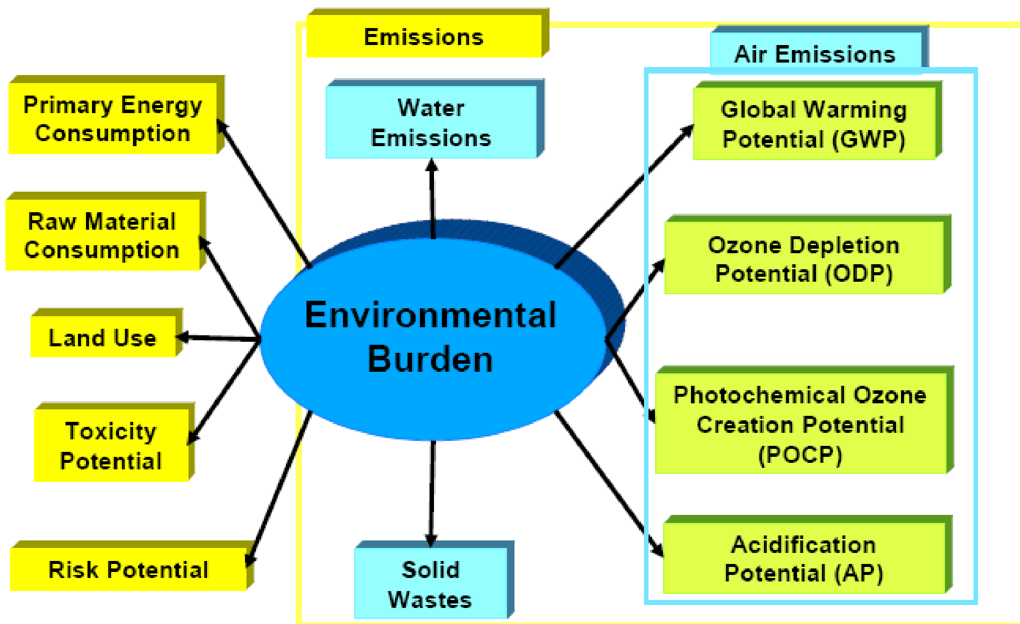

Figure 1. Environmental Impact categories

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, either the sale price paid by the customer or a total cost build-up 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 with appropriate consideration for the time value of money; and
- costs having an ecological aspect, such as the costs involved to treat wastewater generated during a 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.

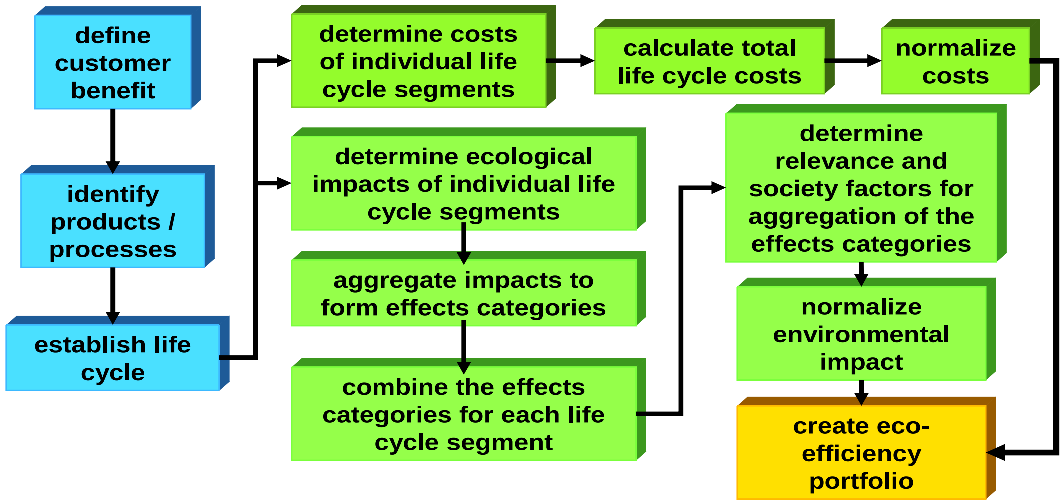

Figure 2: Overall process flow for Termidor® Termiticide EEA study

4. Study Goals, Decision Criteria and Target Audience

4.1. *Study Goals*: The specific goal defined for the Termidor® Termiticide, Eco-Efficiency Analysis was to quantify the differences in life cycle environmental impacts and total life cycle costs of various application technologies (methods) of a termiticide in a post-construction structural treatment of a residential home in the United States delivering 100% structural protection (prevention and/or control) for a period of 20 years. The active ingredient in Termidor® considered in the base case analysis is fipronil. This study will also help identify and quantify the innovative improvements developed over the years in the Termidor® family of termiticide formulations and application methods. The two unique formulations considered are Termidor® SC (suspension concentrate), an aqueous formulation of 9.1% fipronil by weight. This concentrate gets further diluted during application to a finished concentration of active ingredient of 0.06 % by weight. Recently a novel formulation was developed, Temidor® HE (High Efficiency), in order to reduce both trenching requirements at the home and the overall operational time for application without reducing overall protection of the structure. This formulation includes a unique additive which enhances the mobility of the active ingredient in the soil during application thus resulting in less water usage, less trenching requirements and an overall reduction in the operational time required for an application. This enhanced mobility of the active material is temporary and immediate. The active material releases from the HE technology and binds to the soil. This precludes movement away from the treated soil, away from the structure or toward another soil mass. EPA required studies have been completed and show leaching is not a concern with this application technology.

Termidor® HE, is an enhanced aqueous formulation containing 8.73% fipronil by weight in the concentrate form and is labeled for use at a 0.125 % finished dilution.

In addition to comparing the differences in termiticide formulations (SC and HE), the study also looks at the impacts associated with the different application methods as specified by their approved labels. Two different application methods were evaluated for each formulation:

1. A traditional or full conventional treatment to the structure (exterior and interior) as defined by the label; and,
2. An Exterior Perimeter/Localized Interior (EP/LI) method. The approved EP/LI method, also known under the name PerimeterPlus™, establishes a continuous treatment zone along the exterior foundation of the structure (identical to the full conventional treatment) but is only required to treat the interior structure where infestation (termite activity) is already observed.

Proper application of termiticide to a treatment zone to achieve the desired protection can be a very labor and time intensive task and depending on the formulation (SC or High Efficiency) and the application method (conventional or PerimeterPlus™). These differences could result in varying material usage requirements and time allocations. The study will quantify these impacts for each alternative and clearly relate these product or application attributes to the alternatives overall life cycle cost and environmental impact.

The study considered the full life cycle associated with the protection of the structure so the production, transport, application, and end-of-life of the various formulations and associated application methods were evaluated and compared. The study considered protection of various foundation types including monolithic and floating concrete slabs and crawl space designs across the United States as a whole with no specific focus on one region (e.g. Northeast, Southwest), though termite activity is more prevalent in the southern United States.

One of the key performance attributes that clearly differentiates termiticides is their respective efficacy. Termiticides are required to be registered with the U.S. Environmental Protection Agency (EPA) and as such are required to undergo field testing prior to registration approval. Field tests[1] are conducted by the United States Department of Agriculture Forest Service (USDA – FS) and served as the reference for the efficacy for the alternatives considered in this study. The study will examine the effect efficacy has on the life cycle impacts and relative eco-efficiency of a termiticide.

Pesticides are regulated by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). In addition the U.S. EPA requires that the pesticide packaging and label contain a signal word which represents the acute toxicity of the active ingredient. Based on the various defined toxicity classes, signal words can range from danger, warning, caution, or no word at all. While considering the inherent toxicity of the active ingredient this study will also quantify a more comprehensive assessment of the life cycle toxicity potential of each alternative (all achieving the same customer benefit) by looking at the toxicity potential of all the materials utilized during the various activities related to the treatment and on-going protection of a residential structure. Furthermore, additional environmental impacts will be assessed along with each alternative's toxicity potential in order to provide a more holistic environmental impact assessment and thus a more comprehensive picture will unfold with regards to an alternative's environmental or eco-efficient preference.

The study will help quantify in a comprehensive manner some of the key criteria to be evaluated during the decision making process associated with selecting the appropriate kind of termiticide treatment. Some examples of this criteria include the environmental impact associated with the production of the active ingredient, the environmental impact and cost impacts associated with the fuels, utilities and equipment required to transport and apply the active ingredient, the time and cost implications of the various application methods and the impact of product efficacy.

Results will be used to help articulate in an objective and science based manner the relative eco-efficiency or sustainability of various termiticide formulations and application methods over their product life cycle. These results will provide the necessary life cycle environmental and cost data (with supporting details) to key stakeholders in the pesticide value chain (specifically pest management professionals) who are challenged with making decisions related to selecting the more sustainable termiticide treatment.

4.2. *Decision Criteria*: The context of this EEA study compared the life cycle for four unique termiticide treatments in a commercial market at a regional level over the course of an entire life cycle. The study was technology driven and required supplier and customer engagement. The study goals, target audience, and context for decision criteria used in this study are displayed in Figure 3.

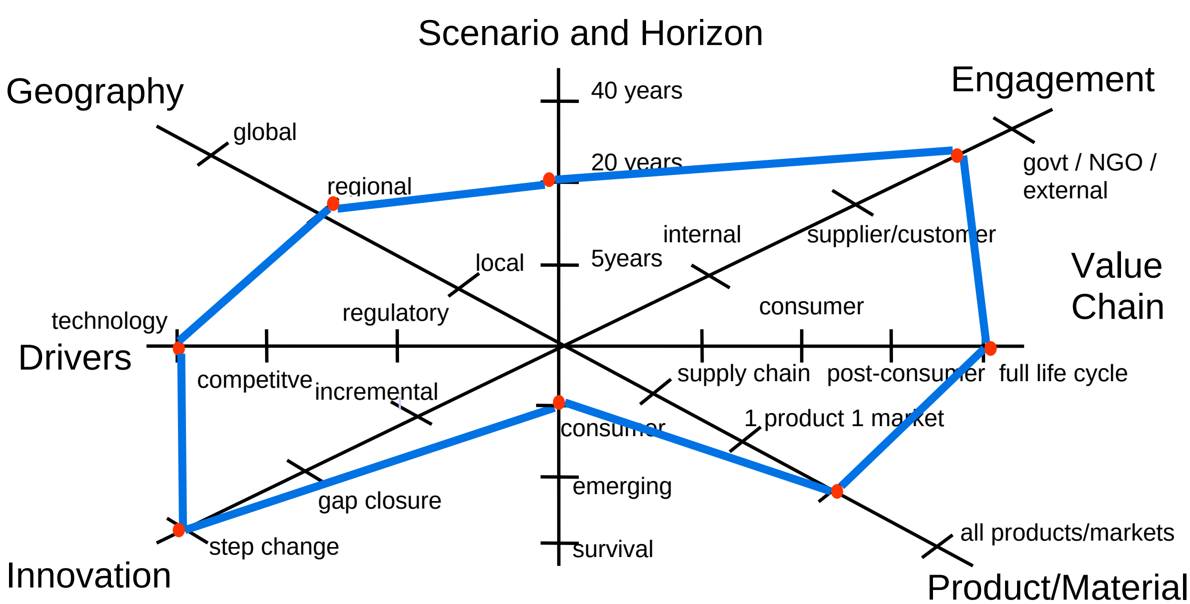

Figure 3. Diagram of study goals, target audience, and context for decision criteria for the Termidor® Termiticide Eco-Efficiency Analysis.

4.3. *Target Audience*: Target audience for the results are federal and state government agencies, pest management professionals (PMPs), universities and homeowners. Results will be shared with key stakeholders in the pest management value chain, published in marketing material and presented at conferences.

5. Customer Benefit, Alternatives and System Boundaries

5.1. *Customer Benefit*: The base case Customer Benefit is defined as the protection (prevention and control) of 1000 residential homes from subterranean termites for a 20 year time frame. The house will have a crawl space foundation with 200 linear feet of exterior perimeter.

Twenty years was a significant enough time period to fully capture the efficacy of the various alternatives and its impact on life cycle costs and environmental impacts. More details on the base case customer benefit can be found in section 6, Input Parameters and Assumptions.

5.2 *Alternatives*: The product alternatives compared in the base case analysis are summarized below. All the termiticide treatments in the base case analysis are manufactured by BASF.

1. Termidor® SC: Aqueous termiticide formulation with 9.1% fipronil. Conventional (exterior and interior) treatment of structure required.

2. Termidor® SC PerimeterPlus™: Termidor® SC formulation (9.1% fipronil) delivered to the structure in compliance with the PerimeterPlus™ application label. This application requires a continuous treatment zone along the exterior foundation but is non-invasive to the interior of the structure by only requiring treating interior areas that show termite activity. Application method also known as EP/LI (exterior perimeter / localized interior).

3. Termidor® HE (High Efficiency): A novel, enhanced aqueous formulation containing 8.73% fipronil and designed to be applied using significantly less water (low water alternative) versus the Termidor® SC formulation. An innovative additive ingredient provides enhanced soil mobility and labor savings thus allowing for the same active ingredient coverage as the traditional SC but with almost 50% less water usage. Conventional (exterior and interior) treatment of structure required.

4. Termidor® HE (High Efficiency) PerimeterPlus™: Termidor® HE formulation (8.73% fipronil) delivered to the structure in compliance with the PerimeterPlus™ application label. This application requires a continuous treatment along the exterior foundation but is non-invasive to the interior of the structure by only requiring treating interior areas that show termite activity. Application method also known as EP/LI (exterior perimeter / localized interior).

5.3. *System Boundaries*: The system boundaries define the specific elements of the life cycle (production, use (application), and disposal) that are considered as part of the analysis. The system boundaries for this study are depicted generically in Figure 4.

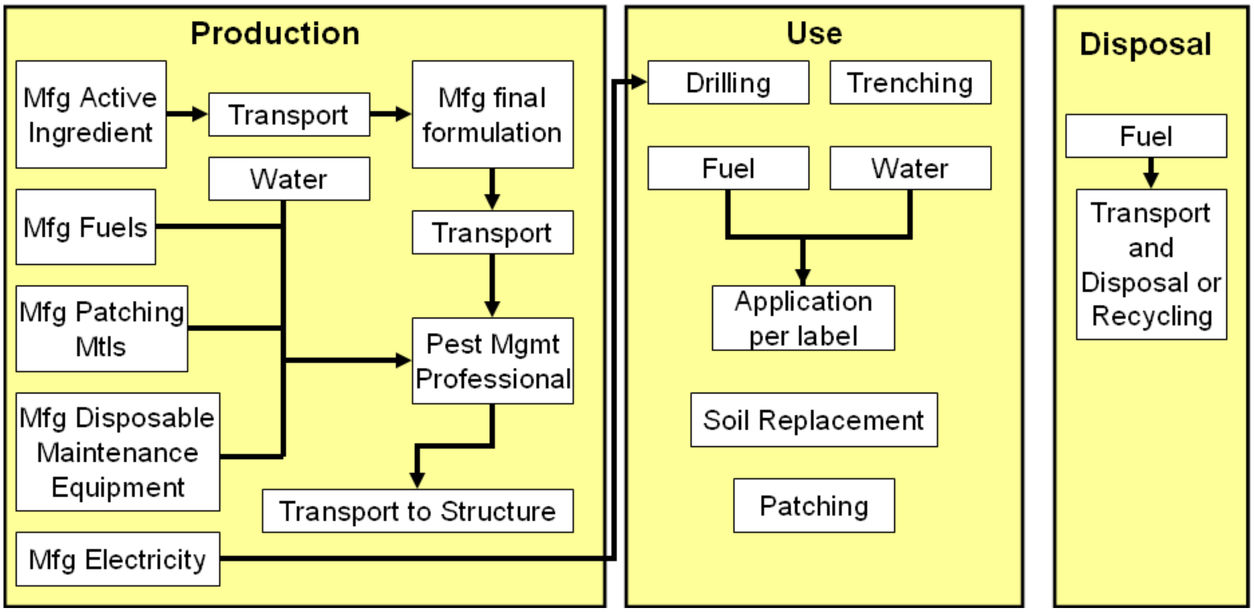

Figure 4. System boundaries for Termidor® Eco-Efficiency Study

5.4. *Scenario Analysis*: In addition to the base case analysis, several additional scenarios were evaluated to determine the sensitivity of the study's final conclusions and results to key input parameters as well as to help focus the interpretation of the study results. Results will be presented and discussed along with the base case in section 8.

5.4.1. *Scenario #1*: Base Case Analysis with depth to footing of 4 feet.

5.4.2. *Scenario #2*: Base Case Analysis with depth to footing of 1 foot.

5.4.3. Scenario #3: Conventional Termiticide with 5 year efficacy

5.4.4. *Scenario #4*: Monolithic Foundation

5.4.5. Scenario #5: Floating Foundation

5.4.6. *Scenario #6*: Termidor HE® Pricing

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 for each alternative. General data sources included BASF manufacturing and internal data, pest management professional field data, BASF time and motion studies and government agency data. Input parameters utilized in the analysis were absolute values and not relative values.

6.1.1. Termiticide Compositions

The material compositional data for the concentrate termiticide formulations (SC or HE) were obtained from company confidential formulation manufacturing manuals[2,3,4]. In addition, site surveys were collected from the relevant manufacturing plants to determine the input/output data required to develop precise eco-profiles for the active ingredients, additives and final formulations. Specific product compositions and site manufacturing data, though company confidential, were made available to NSF International for the purposes of this verification.

The water based suspension concentrate of both the SC and HE formulations gets further diluted at the application site to achieve its desired final concentration. The specific composition of the SC or HE formulation is disclosed in the E.P.A. labels[5,6] for each alternative. The label also provides guidance on the mixing instructions to be followed in order to dilute the Termidor® SC or Termidor® HE formulation to its final application concentration. For Termidor® SC the fipronil concentration is 9.1% with a finished dilution concentration (what is applied on the structure) of 0.06%. For Termidor® HE the fipronil concentration is 8.73% and labeled to be used at a finished dilution concentration of 0.125%.

6.1.2. Structure:

The base case analysis considered the protection of 1000 standard residential homes with an enclosed crawl space foundation with hollow block foundation walls and piers for a period of 20 years. Other pertinent construction details include:

- 200 foot exterior perimeter allocated 70% to soil and 30% to hardened surface (patios, porches, sidewalks etc.). Thus 140 feet requires trenching and 60 feet requires drilling. A typical schematic is provided below in Figure 5.
- A standard concrete masonry unit (CMU) assumed for foundation wall and yields an approximate interior perimeter of 192 feet. Trenching required in the interior and drilling and treating of each void in the hollow block foundation wall is required.
- 15 Piers of hollow block construction with 2 feet per side.
- 2.5 feet depth from grade to footing.
- Other penetrations requiring treatment: 0 bath trap; 3 toilet; 2 plumbing / utility.

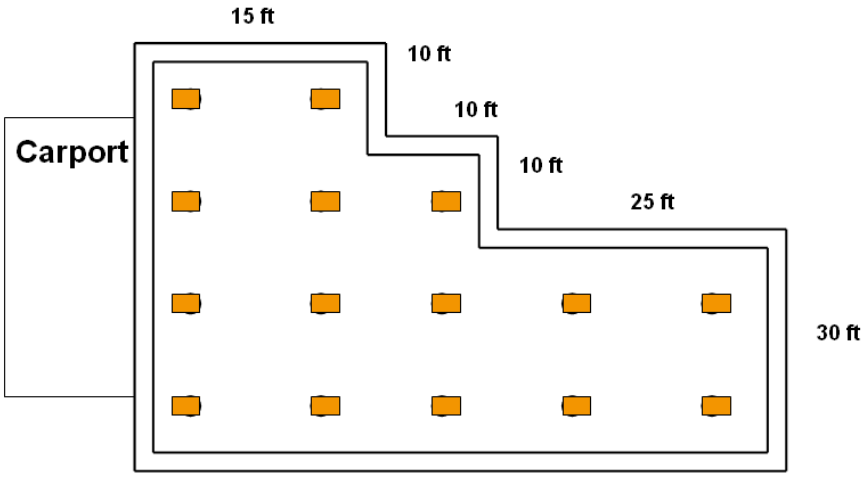

Figure 5. System boundaries for Termidor® Eco-Efficiency Study (base case)

6.1.3. Material Usage (termiticide)

The label for each termiticide provided specific details on the permissible mixing amounts (concentrate + water = finished dilution), application quantities and coverage required for each termiticide application. Based on these required amounts and the construction details provided in Section 6.1.2 the application amounts were calculated for each alternative and are shown in Figure 6.

In general HE application rates (#gal/linear feet/footing depth) are 50% less than conventional treatments. However, in practice, slightly more is applied per hole than what would be expected due to the increased center to center spacing required between holes (18” for HE and 12” for conventional).

Material Usage (per home)					
Alternative		Termidor® SC	Termidor® SC PerimeterPLUS	Termidor® High Efficiency (HE)	Termidor® HE PerimeterPLUS
Location					
Exterior Trench / non Drilling					
	ft	140	140	140	140
	gal/10 linear ft / ft	4	4	2	2
	Depth to footing (ft)	2.5	2.5	2	2
Total	gal (solution)	140	140	56	56
Exterior Drilling					
	ft	60	60	60	60
	gal/10 linear ft / ft	4	4	2	2
	Depth to footing (ft)	2.5	2.5	2	2
Total	gal (solution)	60	60	24	24
Interior Drilling / Trenching					
	ft	192		192	
	gal/10 linear ft / ft	4		2	
	Depth to footing (ft)	2.5		2	
Total	gal (solution)	77		38	
Foundation Wall (hollow block)	ft	200		200	
	gal/10 linear ft	2		1	
Total	gal (solution)	40		20	
Piers (inside trenching)	Perimeter (ft)	8			
(closed crawl)	Depth to footing (ft)	2.5		2	
	gal/10 linear ft / ft	4	4	2	2
Total	gal (solution)	120	120	48	48
Piers (void area)	ft/void	2			
(closed crawl)	gal/10 linear ft	2		1	
Total	gal (solution)	6		3	
Bath & Utility	quantity	5	5	5	5
	gal / location	1.5		1	1
Total	gal (solution)	8	0	5	0
Total (entire home)					
	gal (solution)	450	320	194	128

Figure 6. Termiticide Application amounts

6.1.4. On-site Utility and Fuel Consumption

Utilities are used on-site to support various activities during the termiticide application process. Gasoline or Diesel is used to run the pumps and motors required to mix and apply the termiticide solution while electricity is used mainly for running the drill to make holes in hardened surfaces (pads, walls, piers). Field data was utilized to calculate specific fuel and electricity requirements based on the use of standard industry equipment. Based on the scope of work necessary for each alternative and the overall usage of the equipment, on-site utility consumption requirements were calculated and are shown below in Figure 7.

	Alternative:	Termidor® SC	Termidor® SC PerimeterPLUS	Termidor® High Efficiency (HE)	Termidor® HE PerimeterPLUS
On-site Fuel consumption	(gasoline)				
consumption	gal/hour	0.6	0.6	0.6	0.6
time required	hour	8.8	3.8	6.3	2.0
consumption	gal/home	5.3	2.3	3.8	1.2
	gal/CB	10604	4600	7518	2458
	MJ/CB	1336104	579600	947268	309708
On-site Electricity consumption					
consumption	kw	0.83	0.83	0.83	0.83
time	hr	4.0	0.7	3.9	0.6
	MJ/home	12.0	2.1	11.5	1.7
	MJ/CB	23904	4183	23067	3347

Figure 7. On-site Fuel and Utility Consumption - Termidor® Eco-Efficiency Study

6.1.5. Application & Maintenance Equipment – Disposables

Pest management professionals (PMP) require a significant amount of equipment in order prepare the structure for treatment (e.g. shovels, picks, drills etc.) and during application (e.g. rods, nozzles, hoses, motors, tanks etc.). Many of these items can be viewed as capital equipment or durable goods (e.g. truck, mixing tank, motors, drills etc.). Analogous to their exclusion from the impacts in the manufacturing of the raw materials, capital equipment utilized during the Use phase (application) of this study will not be considered in the analysis. In the majority of these cases their impacts would have negligible impact when properly allocated over the customer benefit. In addition their impacts would have been equivalent for each alternative so their exclusion should not have any significant impact on the (relative) final results. However, PMPs do use various non-durable equipment and materials that require inclusion in the analysis. Some of these items will have varying durability depending upon the alternative considered. For example, since the HE alternative requires smaller trenches to be dug, trenching tools should generally last longer for HE applications than they would for SC applications. Similarly, equipment following the PerimeterPlus™ label should generally last longer than those involved in full conventional treatments as their usage is minimized since the interior treatment of the residence is reduced to only infested areas. Considering this information, PMP professionals and BASF experts estimated the respective durability for these key non-durable items and they are reflected in Figure 8 below:

Item	Drill Bits	Trenching Tools and Rods
Alternatives		
Termidor® SC	20 homes	19 homes
Termidor® SC PerimeterPLUS	40 homes	38 homes
Termidor® High Efficiency (HE)	25 homes	25 homes
Termidor® HE PerimeterPLUS	50 homes	47 homes

Figure 8. Life expectancy for key non-durable application items

Finally, materials required in patching the various drill holes were included in the analysis. Specifically, in order to leave a professional final appearance all drill holes were initially filled with a 3/8" triple seal plastic plug and then capped with ½" of liquid concrete hole filler.

6.1.6. Soil Trenching

Because of the improved penetration and mobility of the solution in the soil, the HE alternatives do not require as extensive trenching in order to provide the required coverage. Per its label, an application with Termidor® SC requires trenches that are a minimum of 6" deep and no wider than 6". The Termidor® HE label only requires trenches that are a minimum of 2" deep and no wider than 4". Benefits from these smaller trenches include: (1) less time and resulting cost for trenching (2) less material to be excavated and eventually replaced (reduced risk of injuries to the trench diggers) (3) increased life extensions for the non-durable items (e.g. tools); and (4) reduction in the risk of damaging any underground utilities or cables (peripheral damage).

Quantity of soil removed for each alternative was based on a Termidor® HE Time study[7].

6.1.7 Time Allocations (Application)

Various time studies were referenced[7,8,9] in order to compile a comprehensive summary of the time required to complete the application of termiticide for each alternative. These studies were based on actual field applications which included various foundation types and application methods. Though these numbers could vary slightly depending on each homes unique situation and the abilities/experience of the application crew, the project team felt they were representative of typical times and should be the basis for the time comparisons. The itemized time take-offs for each alternative is shown below in Figure 9.

Time Allocations (per home)					
Alternative		Termidor® SC	Termidor® SC PerimeterPLUS	Termidor® High Efficiency (HE)	Termidor® HE PerimeterPLUS
Activity	Time				
Set-up					
Wash & Fill Tank	min				
required amount of liquid	gal	450	320	194	128
fill rate	gpm	5			
time to fill	min/home	90	64	39	26
Remove Obstacles	min/home	20	20	20	20
Verify Graph	min/home	20	20	20	20
sub-total	**min/home**	**136**	**110**	**85**	**72**
Exterior Trenching					
Dig Trench	min/10 ft	5		1.1	1.1
Transition to Trench Treatment	min	10	10	10	10
Treat and Backfill	min/10 ft	7		4.2	4.2
	min/home	98	98	44	44
sub-total	**min/home**	**178**	**178**	**70**	**70**
Exterior Drilling					
Drill Holes	min/ 10 ft	7		6	
	min/home	42	42	34	34
Treat with insecticide	min/ 10 ft	7		3.7	
Transition to Patching	min	10	10	10	10
Patch Holes	min/ 10 ft	5		4	
	min/home	30	30	24	24
sub-total	**min/home**	**134**	**134**	**100**	**100**
Transition to Drilling	min	0		0	
Drill Holes	min/10 ft	0		0	
	min/home	0		0	
	min/home	0		0	
Transition to Patching	min	0		0	
Patch Holes	min/10 ft	0		0	
Interior Trenching - Piers	(crawl space only)				
Dig Trench	min/10 ft	5	5	1	1
	min/home	60	60	13	13
Transition to Trench Treatment	min	10	10	10	10
Treat and Backfill	min/10 ft	7	7	4.2	4.2
	min/home	84	84	50.4	50.4
sub-total	**min/home**	**154**	**154**	**74**	**74**

Time Allocations (per home)					
Alternative		Termidor® SC	Termidor® SC PerimeterPLUS	Termidor® High Efficiency (HE)	Termidor® HE PerimeterPLUS
Interior Trenching - Foundation Wall	(crawl space only)				
Dig Trench	min/10 ft	5		1	
	min/home	96		21	
Treat and Backfill	min/10 ft	8		8	
	min/home	154		154	
sub-total	**min/home**	**250**		**175**	
Interior Drilling - Piers	(crawl space only)				
Drill Holes	min/10 ft	0.5			
	min/home	6		6	
Treat with insecticide	min/10 ft	7		5	
	min/home	84		56	
Transition to Patching	min	0			
Patch Holes	min/10 ft	5		4	
	min/home	60		48	
sub-total	**min/home**	**150**		**110**	
Interior Drilling - Foundation Walls					
Transition to Drilling	min	10		10	
Drill Holes	min/10 ft	10		10	
	min/home	192		192	
Treat with insecticide	min/10 ft	3		2	
	min/home	58		38	
Transition to Patching	min	10		10	
Patch Holes	min/10 ft	5		5	
	min/home	96		96	
sub-total	**min/home**	**356**		**336**	
Bath and Utility	included				
Access	min/location	8	excluded		
		40	0	40	0
Treat with insecticide	min	1			
		5	0	5	0
Transition to Patching	min	10	0	10	0
Patch Holes	min/location	5			
	min/home	25	0	25	0
sub-total	**min/home**	**80**	**0**	**80**	**0**
Clean-up / Mtg with Homeowner					
	min/home	15	15	15	15
Total	min/home	1462	591	1055	330

Figure 9. Application Times for Termiticide Applications

6.2. Costs

The economic analysis for the Termidor® EEA considered costs from the PMP's perspective rather than the purchase price of the treatment paid by the homeowner. This will provide a more detailed breakdown of the total cost build-up for each alternative and thus clearly highlight the cost advantages and weaknesses of each alternative. Specifically the analysis took into account material costs, labor costs associated with the application, utility costs, equipment and maintenance costs, costs related to any retreatment of structures (infestation/damage during warranty period) and costs associated with peripheral damage to the home infrastructure that could occur during various site activities (e.g. trenching) and application. Where applicable a constant dollars approach was applied to future costs.

The life-cycle cost data was acquired from numerous sources. Specifically, the various Termidor® costs were supplied by BASF. Pricing for Termidor® can vary depending on specific program discounts and incentives but the base price considered for this analysis was $1.70 per finished gallon. This assumes a 78 oz. container of suspension concentrate and a 0.06% finished solution. As it has yet to be launched into the marketplace, the pricing for Termidor® HE will vary over time as well as with the specific purchase program that is offered to the PMP. For the base case analysis, Termidor® HE was positioned at a 10% price premium over Termidor® SC.

Equipment and patching material costs were obtained from either PMP professionals or directly from on-line pesticide equipment retailers. Specific suppliers and contacts were supplied to NSF International. Based on field experience an allocation of $300 per year was applied to each alternative to cover various incidentals as well as costs related to equipment maintenance and repair. A labor rate of $15 per hour was assumed for time dependant activities. The gas/diesel price was assumed to be $4 per gallon.

Field data shows that retreatment of structures may be required earlier than should be expected (i.e. when the warranty runs out). This can be caused by many factors (e.g. poor initial application, overall effectiveness of active ingredient etc.), but the reality is the PMP will incur additional costs to correct the situation. Costs to the PMP will be mostly time related but also material costs for the spot treatment of the break/infestation. Based on experience, the project team felt a retreatment cost of $200 per event was reasonable. Based on field data and expert opinions, a retreatment rate for all Termidor® treatments was assigned a value of 0.75%, which compares favorably to the average retreatment rate of around 5% for other generally less effective termiticides.

Finally, peripheral damage to the home, exterior landscaping and/or underground utilities (e.g. water irrigation systems, cable/phone lines etc.) could occur during the treatment process. The probability of peripheral damage increases proportionately with the extent and depth of trenching and drilling activities required, the amount of material that needs to be applied and to some degree the lack of experience among the PMP team. The project team felt that the key differentiator among the alternatives is with regards to the PerimeterPlus™ application method and to a lesser degree the decreased trench depth required for the HE applications. Depending on the structure to be treated, this method could significantly reduce the amount of labor related activities and thus proportionately reduce the likelihood of peripheral damage. The project team talked with external experts and determined that a reasonable approach would be to assign a percentage of the PMP's treatment and annual renewal revenues towards peripheral damage. Based on historical data, the project team agreed that values of 5% for full conventional treatments (range of 3 – 6%), 3% for High Efficiency and 1% for PerimeterPlus™ were reasonable.

6.3. Study Assumptions

6.3.1. Transportation

Logistical impacts for the production of the various Termidor® formulations were considered. Transportation impacts from the active ingredient (fipronil) manufacturing facility in France to the manufacturing and packaging facility in the Southeastern US was considered. Subsequent shipment of the suspension concentrate form of the SC and HE formulations to the pest management professional was estimated at 500 km.

During its application, the suspension concentrate is diluted significantly with water in order to achieve the finished dilution concentration. The dilution ratio on a weight basis to the final concentration is 152:1 for SC and 70:1 for HE. In some cases this dilution occurs at the site of the PMP and is then transported to the residence for application. However in other cases, the formulation is diluted on site at the residential home. Thus, for this study, it was assumed that 50% of the times the finished solution is premixed off-site and transported to the residence. Distance from the PMP to the residential home was estimated at 50 km.

Where applicable, distance to landfill was assumed to be 100 km.

6.3.2. Efficacy

As mentioned previously, all termiticides that are registered with E.P.A. must be evaluated in field tests conducted by the USDA – Forest Service. Standardized test methods and guidelines are used to determine the efficacy of termiticides. According to these federal guidelines, termiticides remain effective during the period they prevent termites from penetrating the soil in the test plots. Citing the 2010 published results[1], a basis of 10 years was established for fipronil. It should be noted that testing on Termidor® SC only began in 1999 so test data only exists for 11 years and in many test locations no break throughs have been observed, thus the team felt a 10 year efficacy was reasonable but conservative.

6.3.3. Application: Concentrations, Amount, Time allotments

The registered labels for the termiticide detail the allowable application of the material. In some cases, the label allows ranges of applications depending on many variables. The assumptions applied for this analysis were:

- Termidor® SC is labeled for use at 0.06%, 0.09% or 0.125% finished dilution. The basis for this study was 0.06% as this is the recommended finished dilution for typical control situations.

- All mixed solution was assumed to be fully utilized and thus no solution remained that required disposal. Any rinse water used on the site was not considered in the analysis.

- Depth to the footing which is supporting the foundation wall can vary. Depths can range from 1 foot – 4 feet. For this analysis an average depth to footing of 2.5 feet was assumed for the base case analysis but sensitivity of the results to variations in footing depths will be presented and discussed in section 8.4, scenario analyses.

- Drill holes and rod holes are required to be spaced in order to provide a continuous treatment zone. A spacing of 12" (maximum allowed) was used for Termidor® SC applications.

- No above ground or interior infestation exists at the house at the time of initial treatment.

- Treatment amounts for bath traps, shower trains, piping penetrations can range from 1 - 4 gal/ft^2. Based on expert opinion, the team agreed to use an average Termidor® SC treatment amount of 1.5 gal/ft^2.

6.3.4. Termidor® High Efficiency (HE)

Termidor® High Efficiency (HE) was developed specifically to improve upon the economic and environmental position of the SC formulation. Specifically, the new formulation and application method reduces trenching and drilling requirements (very labor intensive operations), reduces overall water consumption, and in general has a significant impact in reducing the overall cycle time for applications relative to the SC formulation. Specific to the HE label and relative to the assumptions for SC which are defined in Section 6.3.3 and remain the same, the following assumptions were agreed upon:

- Consistent with the label, a 0.125 weight % finished dilution of solution was applied to the structure.

- HE is only required to be applied to a minimum depth of 2 feet even if the depth to footing exceeds 2 feet. Thus, for footing depths exceeding 2 feet, say 4 feet, HE would only require application to 2 feet, where the current SC formulation would require treatment to 4 feet.

- Excluding bath & utility applications, it was assumed that 50% less finished solution was applied to the structure. Considering that the HE formulation is twice as concentrated with active ingredient as the SC formulation, this still results in the application of an equivalent amount of active ingredient. In the case of bath and utility penetrations, it was assumed that 1 gal/ft^2 was applied. A 50% reduction from the SC application rate of 1.5 gal/ft^2 would have exceeded the minimum requirement specified on the label.

- Spacing of drill and rod holes was based on 18” between centers. Where SC solution would be applied at around 0.4 gal/hole based on 12” spacing, HE would thus require 0.3 gal/hole at 18” spacing.

- Times to dig and treat trenched areas were based on the SC time studies[8] and were scaled from the quantity of soil that required removal.

6.3.5. Migration of Termiticide

Significant research and field data exists to support that under proper adherence to the application methods provided in the registered labels that leaching of the active ingredient is not an issue for any of the alternatives and thus not considered in the scope of this analysis.

6.3.6. Occupational Injuries and Illnesses

As trenching and the replacement of the soil back into the trench are labor intensive operations and the probability of injuries to the PMP are quite high during these activities, the differences in the amount of soil removed and replaced for an HE trench and an SC trench was determined[7]. Data related to accidents / injuries and diseases for construction activities similar to trenching/digging are compiled by the US Department of Labor Bureau of Labor statistics[11] and were utilized in the study in the Occupational Illnesses and Accidents impact category.

As the finished solution of termiticide applied to the structure is almost entirely water, the risk data for the applied solution was adjusted to reflect only the risk related metrics associated with the non-water components (e.g. fipronil, additive etc.).

6.3.7. Patching

It was assumed that all holes drilled through hardened surfaces would be repaired in a professional manner which includes the placement of a plastic plug in the hole followed by a treatment of up to 1/2” with a hole filler material, normally concrete.

7. Data Sources

7.1. The environmental impacts for the production, use (application), and disposal of the four termiticide alternatives were calculated from eco-profiles (a.k.a. life cycle inventories) for the individual components, as well as the utilities consumed (fuel and electricity) and the impacts from logistics. Life cycle inventory data for these eco-profiles were developed from several data sources, including BASF specific production sites, and the quality of this data was considered high. None of the eco-profile data for the base case analysis was considered to be of low data quality. A summary of the eco-profiles is provided in Table 1.

Table 1: Summary of eco-profiles used in the Termidor® EEA.

Eco-Profile	Source, Year	Comments
Fipronil (a.i)	France, 2011	BASF manufacturing data; plant survey (confidential)
Disulfur	France, 2011	BASF manufacturing data; plant survey (confidential)
High Efficiency Additive	Germany, 2011	BASF Internal Data (confidential)
Termidor® SC Formulation	U.S., 2011	BASF manufacturing data; plant survey (confidential)
Termidor® HE Formulation	U.S., 2011	BASF Internal Data (confidential)
Working Accidents	2010	US Dept of Labor Bureau of Labor Statistics
Liquid Cement	U.S. Avg., 1996	DAP MSDS, Most reliable profile available; Boustead database[10]
Stainless Steel	Industry Avg., 1999	ETH Zurich Study
LDPE	U.S. Avg., 1996	Most reliable profile available; Boustead database[10]
Well Water	Germany, 2011	BASF Internal Data
Conventional Termiticide with 5 year Efficacy	U.S. Avg. 2011	Most reliable profile available (patents); Boustead database[9]
Sea Transport	Great Britain, Avg. 1996	Most reliable profile available; Boustead database[10]
Truck Transport	U.S. Avg., 1996	Most reliable profile available; Boustead database[10]
Electricity	U.S. Avg., 1996	Most reliable profile available; Boustead database[10]
Gasoline Usage - US	U.S. Avg., 1996	Most reliable profile available; Boustead database[10]
Diesel Use – US	U.S. Avg., 1996	Most reliable profile available; Boustead database[10]
Solid Waste to Landfill	U.S. Avg., 1996	Most reliable profile available; Boustead database[10]
BASF data sources are internal data, while the others are external to BASF. Internal data is confidential to BASF; however, full disclosure was provided to NSF International for verification purposes.		

8. Eco-Efficiency Analysis Results and Discussion

8.1. *Environmental Impact Results*: The environmental impact results for the Termidor® Termiticide EEA reflecting the base case scenario only are generated as defined in Section 6 of the BASF EEA methodology and presented below.

8.1.1. *Primary energy consumption*: Energy consumption, measured over the entire life cycle, shows that Termidor® HE (High Efficiency) PerimeterPlus™ had the lowest energy consumption followed closely by Termidor® SC PerimeterPlus™ (~8% difference). A major contributor to energy consumption is the on-site fuel and utility consumption during application. In fact it is equivalent to the energy consumption for the active solution. Eliminating the need of application of termiticide in the interior, saves between 60-70% of the on-site utility consumption for the PerimeterPlus™ alternatives relative to the full conventional treatment. The High Efficiency alternatives use less energy than SC alternatives, mostly due to the reduction in material usage (application only required to a 2 feet depth rather than 2.5 feet), less utility consumption on site and lower logistical impacts. However, the Termidor® HE alternatives do have an additional energy impact related to the production of the additive, which contributes between 20 – 30% of the total energy consumption for the alternative and about 70% of the energy required to produce the active ingredient solution.

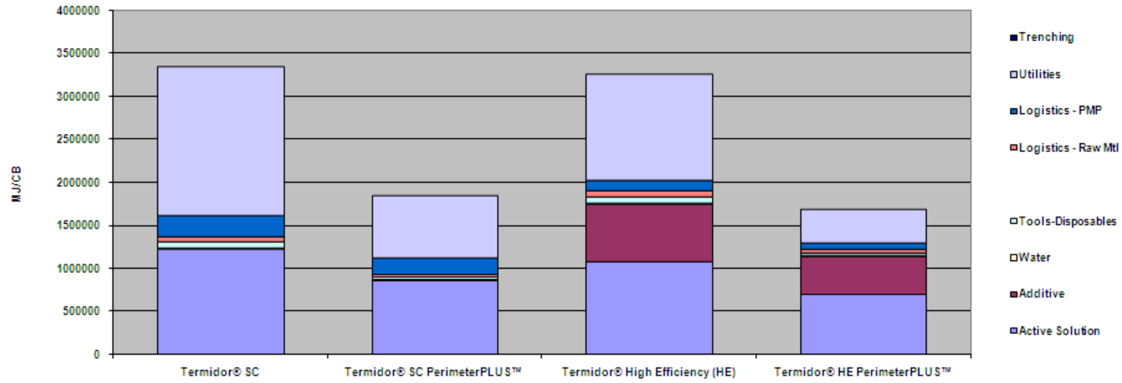

Figure 10. Primary energy consumption

8.1.2. *Raw material consumption*: As to be expected, and depicted on Figures 11 and 12 the resource consumption for each alternative parallels the energy consumption graph. On-site utilities and the active ingredient solution are the two largest contributors to this impact category. The PerimeterPlus™ alternatives have the lowest impact due to their usage of less active solution (around 30% less) and the resulting reduction in utility usage. The manufacture of the additive for the High Efficiency alternatives still contributes significantly to the overall resource consumption. Specific to the basic resources used, the majority of the raw materials and utilities are fossil fuel based, so oil and natural gas are the predominant resources consumed. Though not used in large quantities, copper used in the pre-chain manufacturing of fipronil, is given significant weighting in resource consumption because of its relative scarcity when compared to more abundant resources like oil and natural gas. Resource consumption is the second most significant impact category for the study.

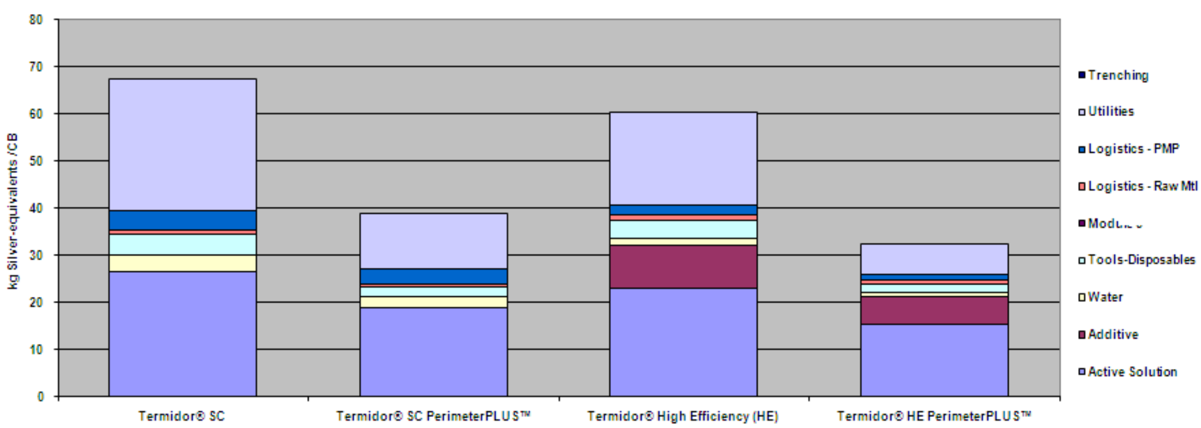

Figure 11. Resource Consumption: Modules

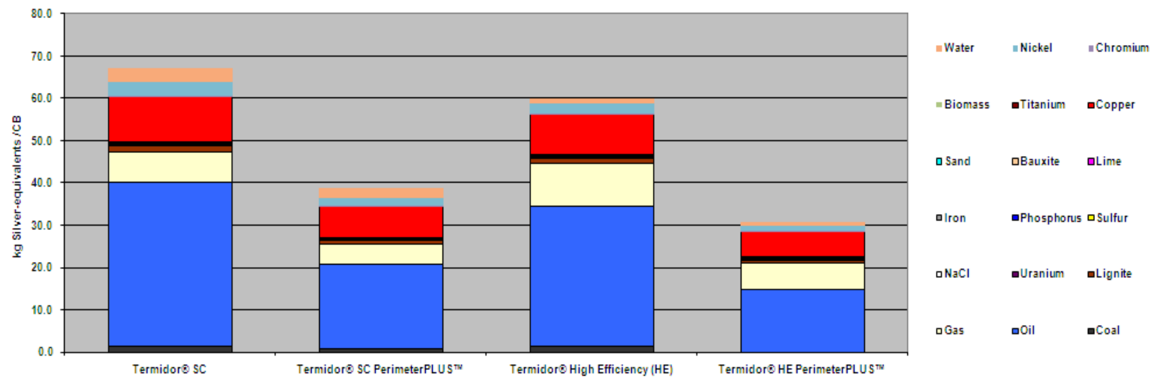

Figure 12. Resource consumption: Materials

8.1.3. *Air Emissions*:

8.1.3.1. *Greenhouse Gases (GHG)*: Results for greenhouse gas emissions (Figure 13) parallel those for energy consumption (Figure 10). GHG emissions related to the utility consumption on site shares a slightly higher percentage of the impact as it did in energy consumption. Thus, alternatives which demonstrate reduction in on-site utility consumptions relative to their alternatives will benefit slightly more in this category. Thus, PerimeterPlus™ alternatives will benefit the most. Overall, the PerimeterPlus™ alternatives have a significantly lower carbon footprint than full conventional treatments and the HE (High Efficiency) alternatives have lower carbon footprints relative to the SC applications. Specifically, the HE alternatives have around a 13% - 20% lower carbon footprint than SC applications.

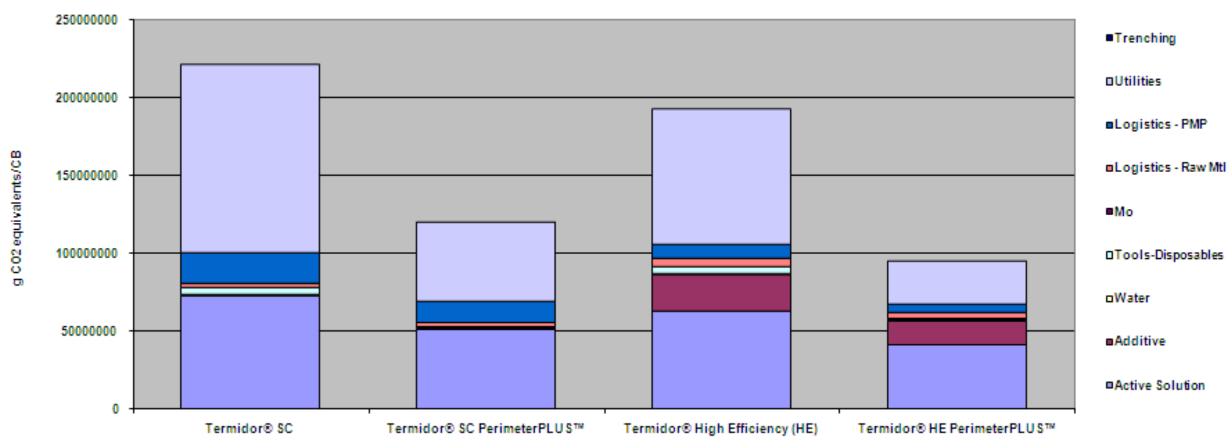

Figure 13. Greenhouse Gas (GHG) emissions

8.1.3.2. *Photochemical ozone creation potential (smog)*: The lowest emissions for ground level ozone formation potential (POCP) occurs in the Termidor® HE PerimeterPlus™ alternative. Figure 14 indicates that the active solution, on-site utility consumption and transportation activities are the largest contributors for all alternatives. POCP (summer smog) is mostly attributed to the hydrocarbon and VOC emissions related to the use of diesel fuel and gasoline. Alternatives that require larger amounts of materials to be produced and transported will have corresponding higher impacts.

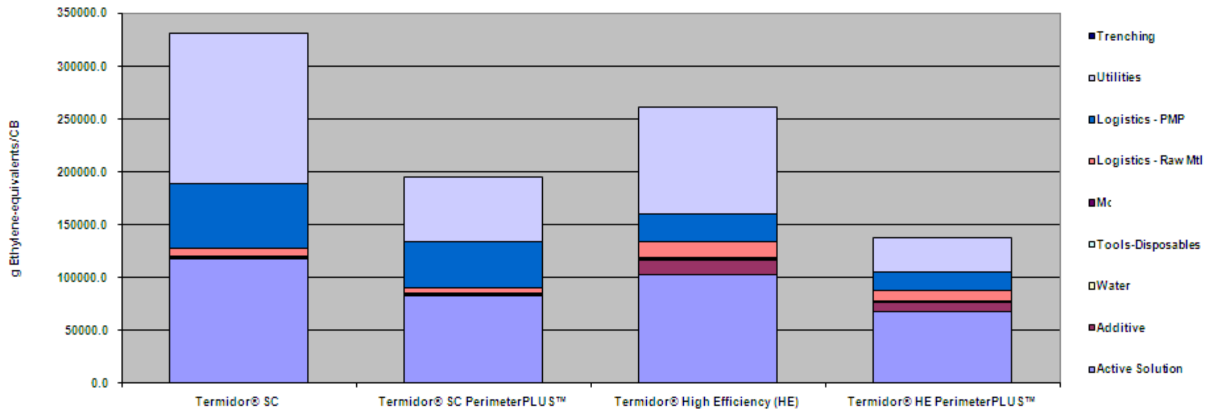

Figure 14. Photochemical ozone creation potential

8.1.3.3. *Ozone depletion potential (ODP)*: As depicted in Figure 15, all of the alternatives result in an ODP, measured at between 1 – 1.8 kg CFC equivalents per customer benefit. The majority of the impact comes from the pre-chain chemistries and emissions related to the manufacture of the active ingredient, fipronil. Put into context with the other environmental impacts being measured, ODP is the least relevant impact category and contributes only around 2% to the total environmental impact.

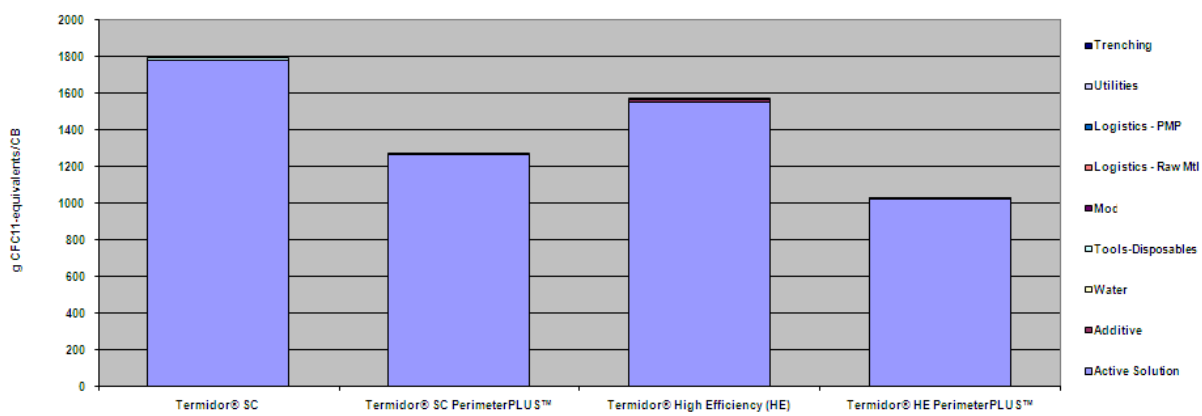

Figure 15. Ozone depletion potential

8.1.3.4. *Acidification potential (AP)*: It can be seen from Figure 16 that overall, the major contributors to AP are the consumption of fossil fuels (utilities) and the production of the active solution. Logistics also contributes proportionately for alternatives which need to transport more materials from the distributors to the PMPs and from the PMPs to the residential home.

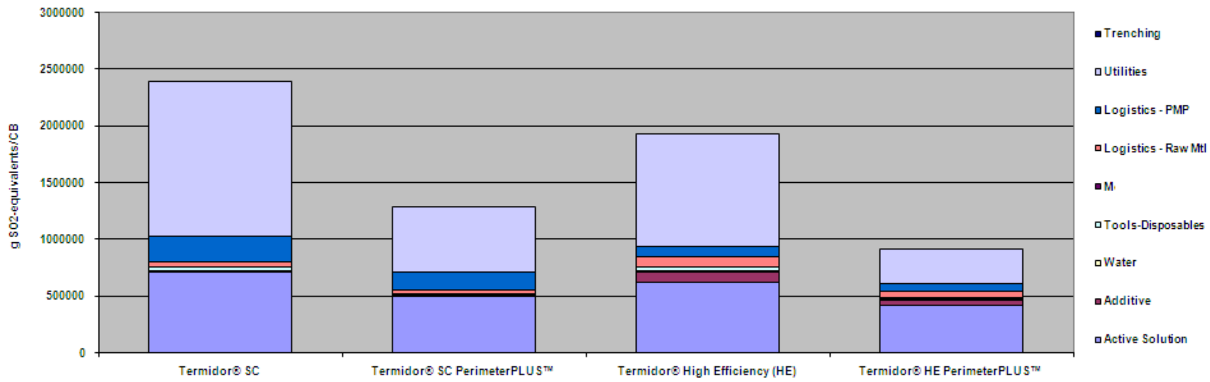

Figure 16. Acidification potential

Utilizing the calculation factors shown in Figure 38, Figure 17 shows the normalized and weighted impacts for the four air emissions categories (GWP, AP, POCP and ODP) for each alternative. Air emissions have similar relevance to the studies with GWP being the most relevant (around 3.3%) and ODP the least (2%).

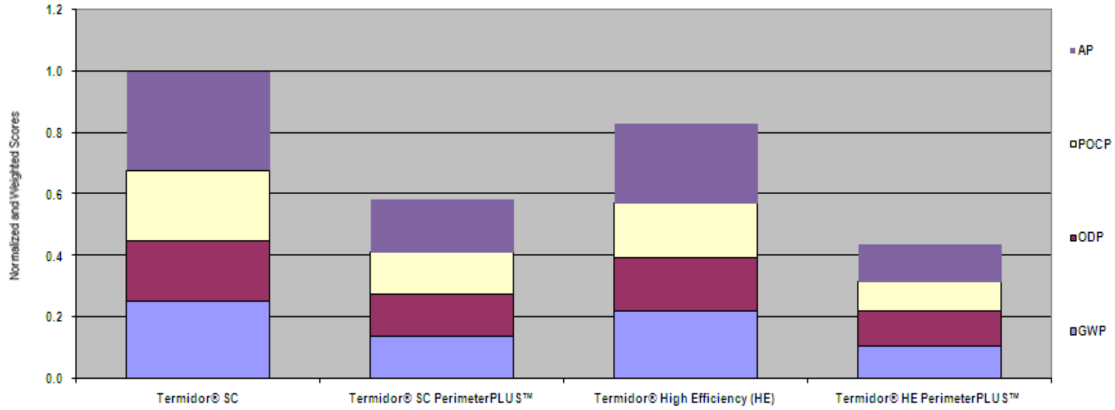

Figure 17. Overall Air Emissions

8.1.4. *Water emissions*: Figure 18 shows the main contributor to the water emissions for the termiticide alternatives are emissions from the pre-chain chemistries, specifically the active ingredient, fipronil. Considering the impacts from the manufacturing of the additive for the High Efficiency alternative, the overall water emissions for the SC and HE alternatives are relatively equivalent. PerimeterPlus™ reduces water emissions by over 30% relative to a full conventional treatment. Overall, relative to the other environmental impact categories, water emissions contribute around 9% to the overall environmental impact.

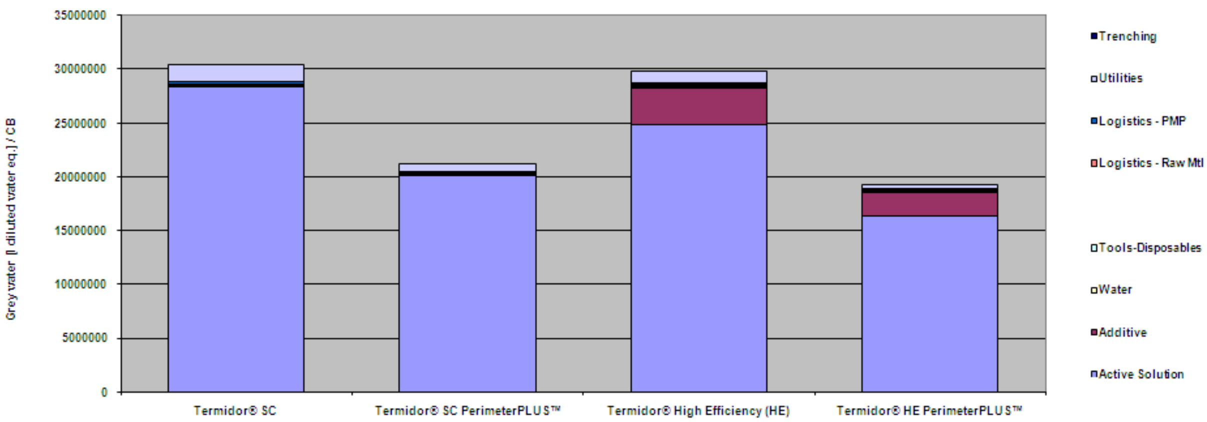

Figure 18. Water emissions

8.1.5. *Solid waste generation*: As depicted in Figure 19, the Termidor® HE PerimeterPlus™ alternative generates the least amount of waste due to its minimization in the amounts of active solution required and less impacts from logistics. The PerimeterPlus™ alternatives also benefit from longer durability of the tools and less disposable items utilized.

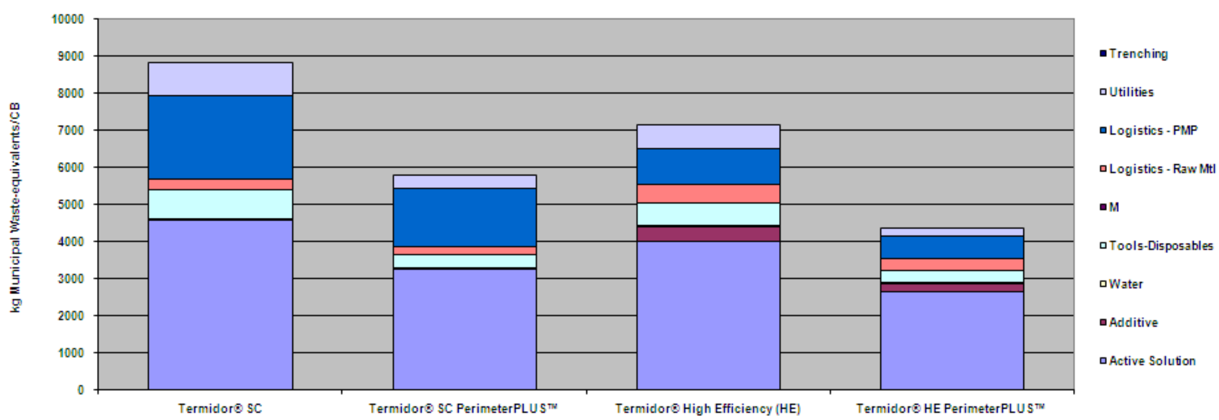

Figure 19. Solid waste generation

Utilizing the calculation factors shown in Figure 38, a composite of the cumulative impact of the three main emission areas of air, water and solid waste is derived. Figure 20 below shows the relative weighted impacts for the three main emissions categories for each of the alternatives considered. Termidor® HE PerimeterPlus™ has the lowest overall life cycle emissions of all the alternatives considered. PerimeterPlus™ has an overall reduction in emissions of around 40% relative to full conventional treatments and Termidor® HE achieves a reduction of around 10% relative to Termidor® SC applications.

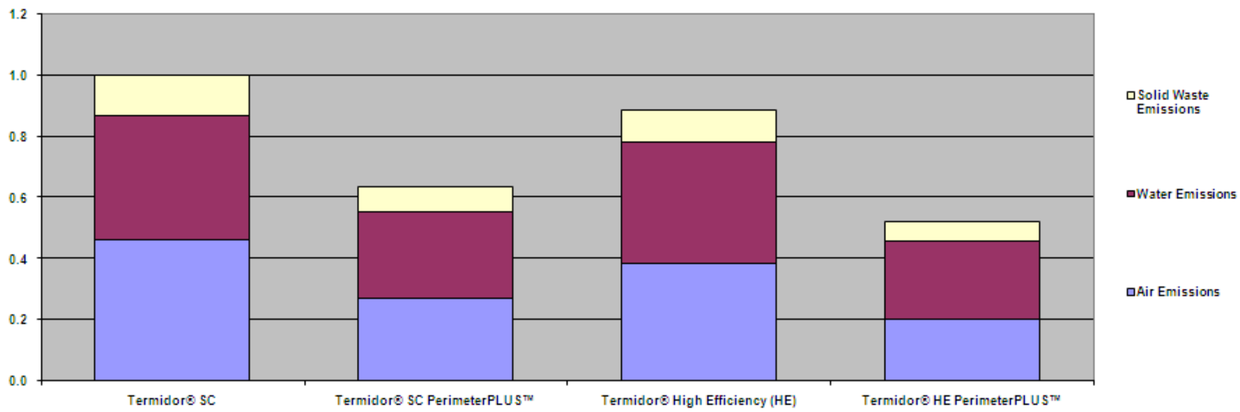

Figure 20. Overall Emissions.

8.1.6. *Land use*: As displayed in Figure 21, the PerimeterPlus™ alternatives, specifically HE, have the lowest impact on land use. Fuel and electricity use during the application process is the single largest contributor. Logistical impacts of shipping active ingredients and finished solution are the next largest contributor.

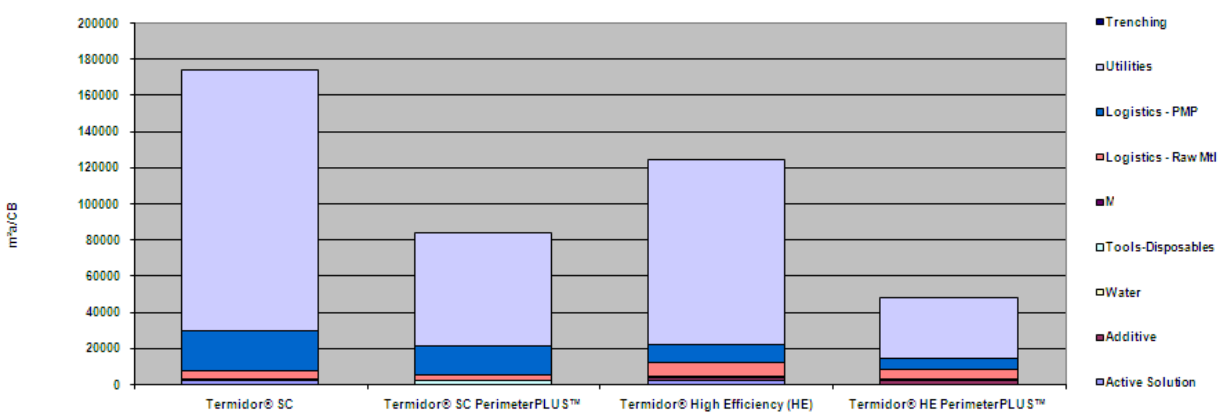

Figure 21. Land use.

8.1.7 *Toxicity potential*: The toxicity potential of the individual components utilized during the production, application and disposal phases of the various termiticide applications during their respective life cycles were considered. For the production phase, not only was the active ingredient (fipronil) and final products considered but the entire pre-chain of chemicals required to manufacture the various materials was considered as well. Human health impact potential in the use (application) phase consisted mainly of the activities surrounding the application of the active solution and the handling and combustion of the fuels at the residence.

Inventories of all relevant materials were quantified for the three life cycle stages (production, use and disposal). Consistent with our 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 were provided to NSF International as part of the EEA model which was submitted as part of this verification. Figure 22 shows how each module contributed to the overall toxicity potential score for each alternative. The values have been normalized and weighted. The toxicity potential weightings for the individual life cycle phases were production (20%), use (70%) and disposal (10%). These standard values were not modified for this study from our standard weightings.

Interestingly, the toxicity potential of the fuels used during application is much more significant than the toxicity potential of the active solution. This is related to the fact that the amount of active ingredient actually applied versus the amount of fuel consumed is significantly lower. The production phase impacts come predominately from the production of fipronil and the HE additive. Though the inherent toxicity of the additive is not as high as fipronil, the additive has a higher pre-chain score, thus resulting in a higher overall contribution than the active ingredient as both are used in the same concentration in the HE formulation.

Figure 23 shows how the scoring is distributed across the life cycle stages. As higher weighting is given to the use phase activities due to the potential to expose workers and/or consumers, the use phase impacts are the most significant, followed by the production phase. A high safety standard was assumed for the manufacturing processes for the raw materials. For the use phase, an allowance was made to take into consideration the open nature of the application process.

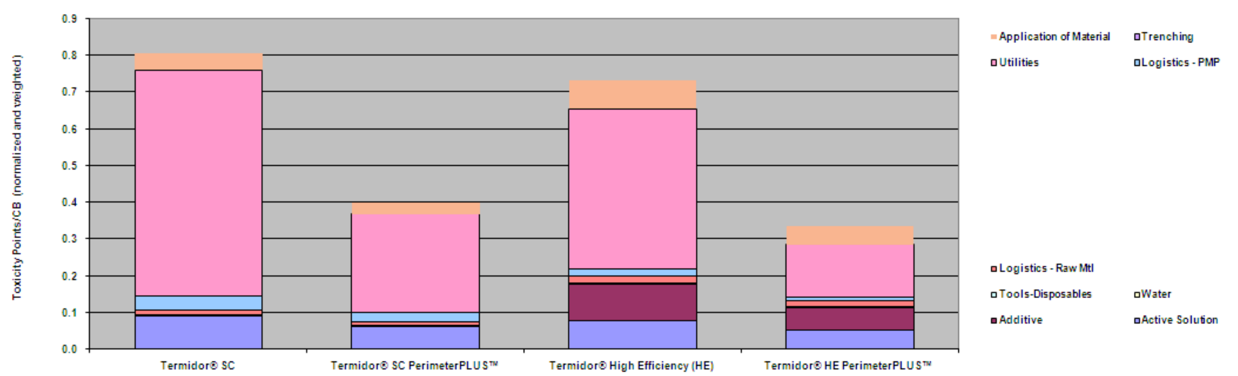

Figure 22. Toxicity Potential by Impact Category

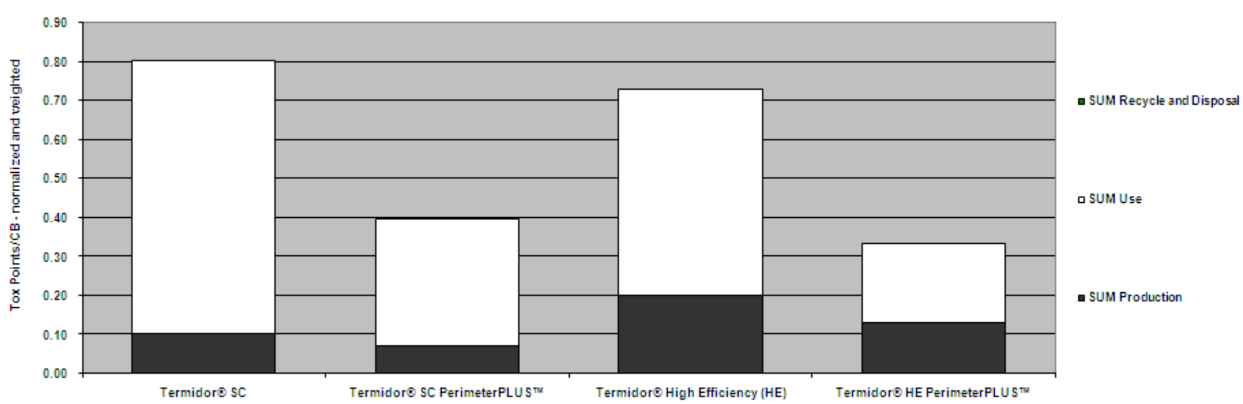

Figure 23. Toxicity Potential by Life Cycle Stage

8.1.8. *Risk potential (Occupational Illnesses and Working 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 24, the greatest Occupational Illnesses and Accident potential occurs for the Termidor® SC full conventional treatment. Not surprisingly, the activity (module) which contributes to the highest risk potential for occupational illnesses and accidents is the manual trenching activity. Closely behind, the next significant risk would be those associated with the production and use of the utilities and finally the risks associated with the manufacturing activities for steel, which is component of the tools required for trenching and rodding. Specifically, for the crawl space design where interior trenching is required for the conventional treatment and not for PerimeterPlus™, the PerimeterPlus™ alternatives show over a 50% reduction in overall risk reduction. Additionally, since the reduced trenching activities result in a corresponding life extension to the trenching and rodding tools, the PerimeterPlus™ alternatives show a significant reduction in the risks associate in the tools-disposable materials module. Finally, the Termidor® HE alternatives show a significantly lower impact in the risks associated with trenching activities due to the requirements that smaller trenches are required for application relative to the SC applications. Very low risks of occupational illnesses and injuries exist for the production of the active solutions and additives.

This study put a 20% weighting on additional risk categories specific to the materials, activities and issues considered by this study. These three categories covered (1) leakage of material (active solution) (2) damage to underground items such as piping, cables etc. and (3) injury to workers (from activities other than those already covered in the trenching module.

Leakage of material is impacted by two key, related factors: (1) the quantity of material that is pre-mixed off-site by the PMP and transported to the residence and (2) how much material is required to be applied by the label. The base assumption for each alternative was that 50% of the required active solution was prepared off site and then transported to the residence. Similarly, due to its better soil mobility and penetration attributes, the HE alternatives require about 50% less material to be handled and applied than the SC alternatives. Thus for this risk category the Termidor® SC full conventional treatment scored the highest and Termidor® HE PerimeterPlus™ scored the lowest. The major influencing factor in the second additional risk category (underground damage) was the extensive nature of the trenching activities, specifically the required depth and required amount. Since the likelihood of damage is highest at the exterior of the residence, the benefit of the HE alternatives requiring shallower and overall smaller trenches was the major influencer in them demonstrating less risk in this category. Finally, the risk of injury to the PMP from activities other than trenching (e.g. drilling and patching, rodding etc.) was deemed highest for the full conventional treatment and lowest for Termidor® HE PerimeterPlus™.

Figure 25 shows that the highest risk type is occupational illnesses as determined from the manufacturing and transport activities supporting the production and use of the various materials.

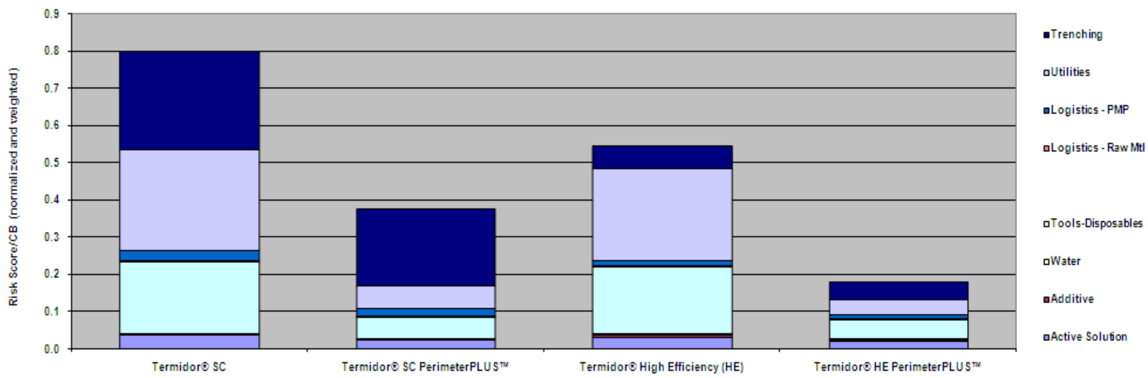

Figure 24. Occupational Illnesses and Working Accidents by Module

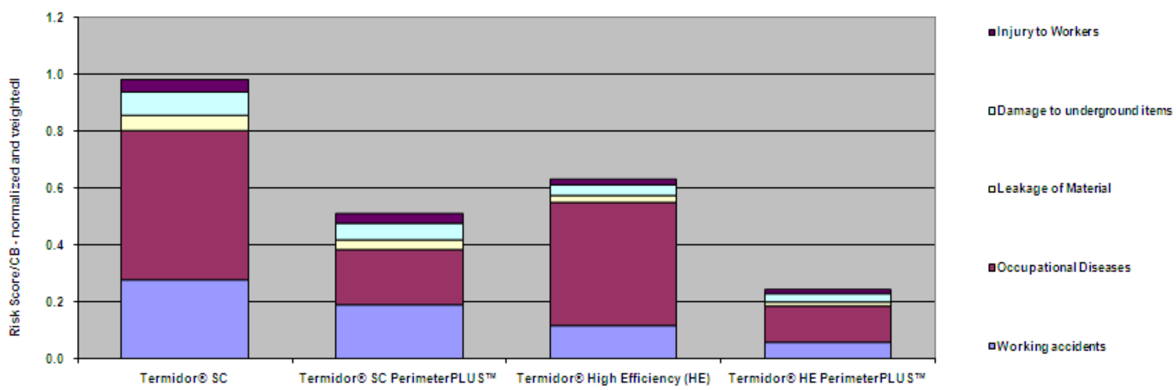

Figure 25. Risk Potential by Type

8.1.9. *Environmental fingerprint*: Following normalization, or normalization and weighting with regards to emissions, the relative impact for all six of the environmental categories for each alternative is depicted in the environmental fingerprint (Figure 26). This figure clearly shows how the advancements in application methods (PerimeterPlus™) or novel re-formulations of the active ingredient (HE, High Efficiency) has significantly improved upon the environmental profile of the Termidor® SC full conventional treatment. The environmental improvements in the High Efficiency formulation relative to SC are derived from having to apply less overall material and require less trenching. Termidor® HE has improved in all impact areas relative to SC with significant improvements in

Occupational Illnesses and Accidents (mostly related to the minimized trenching and drilling activities) and Land Use (mostly related to the reduction in on-site utility usage). Improvements in Toxicity Potential, Emissions and Resource consumption are proportional to the reduction in required material usage. Only in Energy Consumption is the benefit minimized due to the increased energy required during the manufacturing of the HE additive. Specifically, the environmental fingerprint of Termidor® HE is an improvement of around 14% relative to Termidor® SC and when applied with the PerimeterPlus™ label, it achieves an improvement of around 21% relative to Termidor® SC PerimeterPlus™.

Considering the base case structure of a crawl space, the PerimeterPlus™ alternative shows a significant improvement over the full conventional treatments in all impact categories, by not requiring the treatment of all interior structures. Overall, the environmental impact of the PerimeterPlus™ alternatives is improved by around 50% relative to the full conventional alternatives.

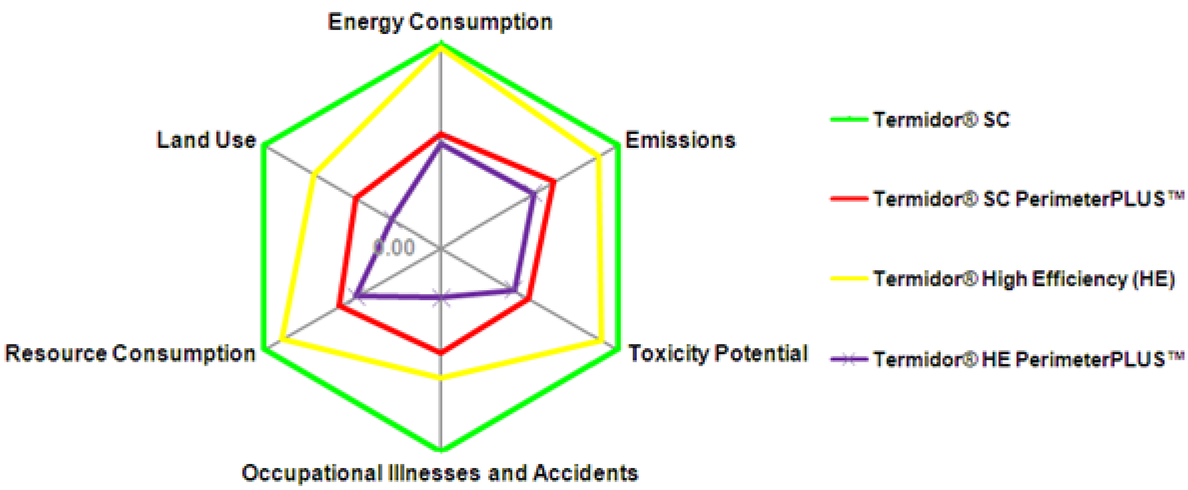

Figure 26. Environmental fingerprint - Termidor® EEA – base case

8.2. *Economic Cost Results*: The life cycle cost data for the Termidor® Termiticide, Eco-Efficiency Analysis are generated as defined in Section 7 of the BASF EEA methodology. The results of the life cycle cost analysis are itemized in Table 2 and presented graphically in Figure 27.

Life Cycle Costs		Termidor® SC	Termidor® SC PerimeterPLUS™	Termidor® High Efficiency (HE)	Termidor® HE PerimeterPLUS™
Material					
Active Ingredient ($/finished gal)		$1.70		$3.74	
Quantity of Material (gal/CB)		900,600	640,000	388,800	256,000
	Cost ($/CB)	$1,531,020	$1,088,000	$1,454,112	$957,440
Labor					
	Rate	$15			
	Manhours (hr/CB)	48742	19700	35153	11000
	Costs ($/CB)	$731,130	$295,500	$527,301	$164,994
Fuel					
	Cost ($/gal)	$4.00			
	On-site usage ($/CB)	$42,416	$18,400	$30,072	$9,832
	Transportation ($/CB)	$5,952	$4,230	$2,569	$73
	Total ($/CB)	$48,368	$22,630	$32,641	$9,905
Equipment					
Trenching Tools		$3,088	$1,544	$2,316	$1,235
Treating Rods	($/CB)	$2,539	$1,269	$1,904	$1,015
Hole Filler	($/CB)	$1,884	$423	$1,799	$339
Hole Plugs	($/CB)	$36,205	$8,136	$34,578	$6,509
Drill Bits	($/CB)	$2,800	$1,400	$2,240	$896
Maintenance / Incidentals	($/CB)	$12,000	$6,000	$9,600	$6,000
Equipment Total	($/CB)	$58,516	$18,773	$52,437	$15,994
Retreatment	Rate (% homes)	0.75%	0.75%	0.75%	0.75%
Cost to PMP	($/visit)	$3,000	$3,000	$3,000	$3,000
Peripheral Damage %		5%	1%	3%	1%
Peripheral Damage	($/CB)	$75,400	$13,405	$50,267	$16,756
Total		$2,447,434	$1,441,307	$2,119,759	$1,168,089

Table 2: Life cycle costs for Termidor® EEA – base case

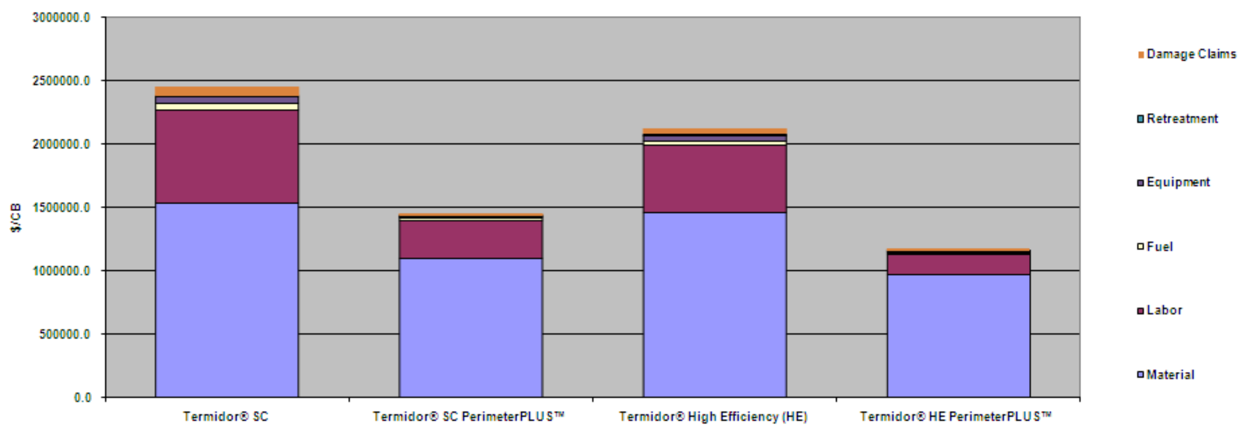

Figure 27. Life cycle costs - Termidor® EEA – base case.

As depicted in Table 2, the material costs are the most significant life cycle cost, accounting for between 60% - 80% of the total depending on the alternative. Though Termidor® High Efficiency is sold at a slight premium over its respective SC alternatives, its total material costs for the base case analysis are the lowest due to the material savings by requiring only treatment to a depth of 2 feet (vs. 2.5 feet for SC). Specifically, this amounts to a 5% savings for Termidor® HE vs. Termidor® SC and a 12% reduction for Termidor® HE PerimeterPlus™ relative to Termidor® SC PerimeterPlus™. The next significant cost is the labor component. Both the High Efficiency and the PerimeterPlus™ alternatives deliver significant labor savings relative to the SC full conventional treatment. High Efficiency benefits of less trenching and drilling requirements as well as labor savings related to requiring significantly less material to be applied leads to a labor savings of around 25% relative to SC. PerimeterPlus™ alternatives benefit from a significant reduction in the area required to be treated leading to labor savings of over 60% when compared against full conventional treatments.

Fuel costs consist of costs related to both transportation fuel as well as on-site utility consumption. Analogous to the savings realized in material and labor costs, alternatives that require less material to be shipped and applied will show the lowest impact in this category. Termidor® HE PerimeterPlus™ leads the way by achieving about an 80% reduction in fuel costs relative to the SC full conventional treatment.

High Efficiency and PerimeterPlus™ alternatives benefit in the equipment and maintenance impact categories due to the less wear and tear on the equipment afforded by less trenching and drilling requirements. The largest cost contributor to the full conventional treatments is the hole plugs while for the PerimeterPlus™ alternatives the plastic hole plugs and the maintenance / incidental costs were the most significant.

There were no cost advantages to any of the alternatives with regards to retreatment costs as the retreatment rate for all Termidor® applications were the same at less than 1%. As described earlier in Section 6.2, costs associated with peripheral damage mostly related from accidents from trenching activities and work inside the structure, where linked to a percentage of the PMP's treatment and annual renewal revenues. To estimate revenues, it was estimated that the general charge to the home owner for the base case structure for the various alternatives would be around $1000 except for the Termidor® SC PerimeterPlus™ method which was estimated at $800. Annual inspection and renewal charges were estimated at $170/home. A net present value of all revenues was determined by using a discount rate of 4%. As expected, peripheral damage costs were highest for the full conventional treatments and accounted for around 2% - 3% of the total life cycle costs.

Overall, the Termidor® SC full conventional treatment had the highest life cycle cost. Breaking the analysis down to additional costs (or conversely additional savings to the PMP) per home rather than as a total for the customer benefit, Table 3 shows significant savings can be realized by the PMP through the PerimeterPlus™ application method and to a less degree through the application of Termidor® HE. Over the life cycle defined for this study, the PMP would incur $640/home additional costs relative to the lowest cost alternative, Termidor® HE PerimeterPlus™. Relative to Termidor® SC full conventional treatment, Termidor® HE would save the PMP around $160/home while Termidor® SC PerimeterPlus™ would save the PMP around $500/home.

	Termidor® SC	Termidor® SC PerimeterPLUS™	Termidor® High Efficiency (HE)	Termidor® HE PerimeterPLUS™
Costs ($/CB)	$2,447,434	$1,441,307	$2,119,759	$1,168,089
Costs ($/home)	$1,224	$721	$1,060	$584
delta Costs ($/CB)	$1,316,087	$309,960	$988,412	$36,742
extra cost / application ($)	$640	$137	$476	$0

Table 3: Life cycle cost savings for Termidor® EEA – base case

8.3. *Eco-Efficiency Analysis Portfolio*: The eco-efficiency portfolio for the Termidor® Termiticide, Eco-Efficiency Analysis has been generated as defined in Section 9.5 of the BASF EEA methodology. Utilizing regionally specific relevance factors and calculation factors, the relative importance of each of the individual environmental impact categories are used to determine and translate the fingerprint results (Figure 26) to the position on the environmental axis for each alternative shown. Figure 28 displays the 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. A significance line of 5% is included in the graph so a relative significance can be observed between the spacing of the alternatives on the portfolio. Considering only the four base case termiticide treatments, the results from this study find that Termidor® HE PerimeterPlus™ is the most eco-efficient alternative and the Termidor® SC full conventional treatment is the least eco-efficient. Specific to one of the goals of the study, the combined environmental and life cycle cost advantages of Termidor® product innovations over time have been quantified and are reflected in the final portfolio. Specific to the High Efficiency formulation an overall eco-efficiency improvement of around 25% was realized versus the next best alternative. This was mostly driven by the life cycle cost advantages of between 13% - 19% (depending on extent of treatment required) and an environmental advantage of between 14% - 21%, again depending on whether a full conventional treatment is required or whether an exterior perimeter / limited interior treatment is used. Contrasting the PerimeterPlus™ treatment vs. a full conventional application an eco-efficiency improvement of around 80% is achieved. This is driven by both a significant environmental footprint improvement as well as a significant reduced life cycle cost. Comparing the average of all environmental relevance factors to the economic relevance factor yields a value much less than one. This indicates that the economic impacts are influencing the relative eco-efficiency of the alternatives more significantly than the environmental impacts.

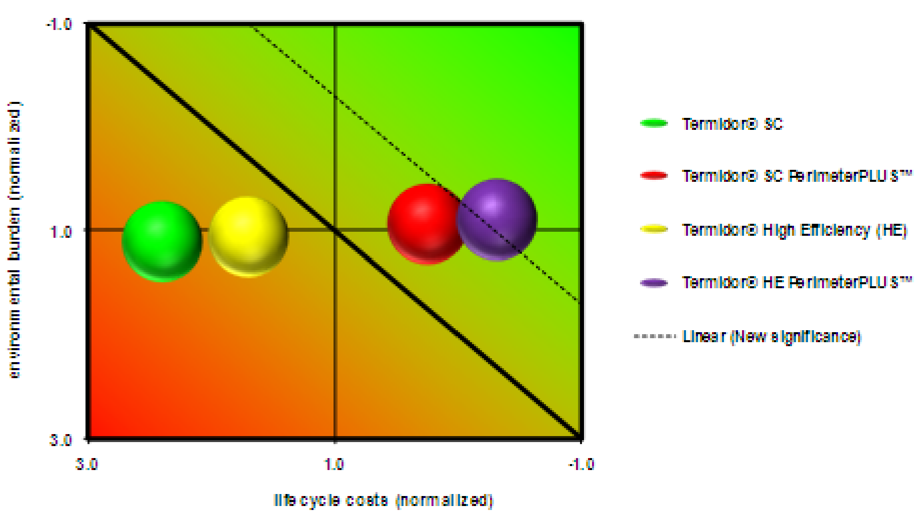

Figure 28. Eco-Efficiency Portfolio, Termidor® Termiticide EEA (base case analysis)

8.4. *Scenario Analyses*

8.4.1. Scenario #1: Base case assumption with depth to footing of 4 feet.

As depicted in Figure 29, for footing depths more than the average of 2.5 feet, which was modeled in the base case analysis, the economic and environmental advantages of the High Efficiency formulation is magnified. At a maximum footing depth of four feet, and relative to the Termidor® SC conventional treatment which requires 642 gallons of finished solution, the High Efficiency alternatives requires 20% less material and the Termidor® HE PerimeterPlus™ requires 80% less material. This reduction in material usage has both a significant economic and environmental advantage. Based on its improved economic and environmental position, the Termidor® HE alternative becomes as eco-efficient as Termidor® SC PerimeterPlus™.

Table 4 shows that the total cost per home is almost equivalent between Termidor® SC PerimeterPlus™ and Termidor® HE. Termidor® SC with full conventional treatment will cost the PMP approximately $1000 more / home in extra costs relative to the least expensive option.

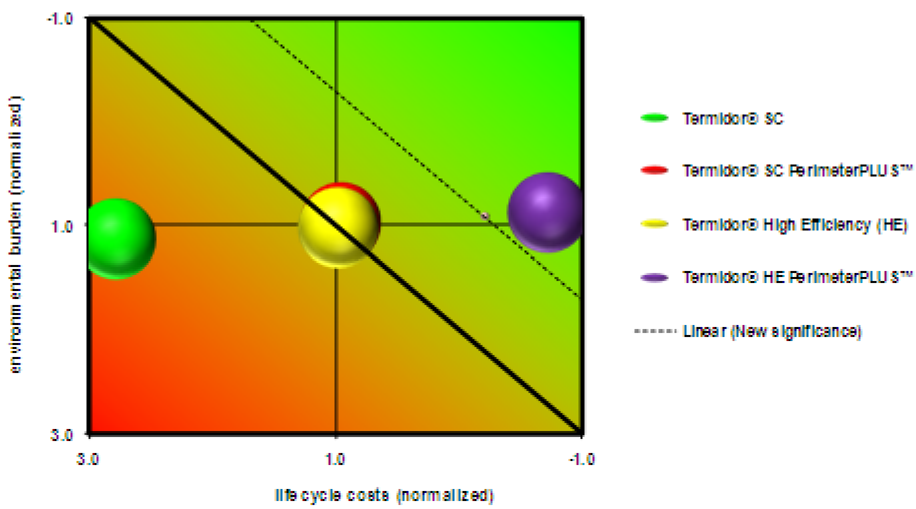

Figure 29. Scenario Analysis #1: Eco-Efficiency Portfolio, Termidor® Termiticide EEA

	Termidor® SC	Termidor® SC PerimeterPLUS™	Termidor® High Efficiency (HE)	Termidor® HE PerimeterPLUS™
Costs ($/CB)	$3,121,972	$2,115,845	$2,119,759	$1,168,120
Costs ($/home)	$1,561	$1,058	$1,060	$584
delta Costs ($/CB)	$1,988,087	$981,960	$985,874	$34,235
extra cost / application ($)	$977	$474	$476	$0

Table 4: Scenario Analysis #1: Life cycle cost savings for Termidor® EEA

8.4.2. Scenario #2: Base case assumption with depth to footing of 1 feet

With the footing depth decreased to the minimum depth of 1 foot, the advantages of the High Efficiency formulation are minimized as it is required to now treat to the same depth as the SC formulation. Relative to the base case analysis portfolio depicted in Figure 28, the HE formulations eco-efficient positions are drawn closer their corresponding SC alternatives. For this application, and shown in Figure 30, there still remains a distinct eco-efficient advantage for both PerimeterPlus™ alternatives.

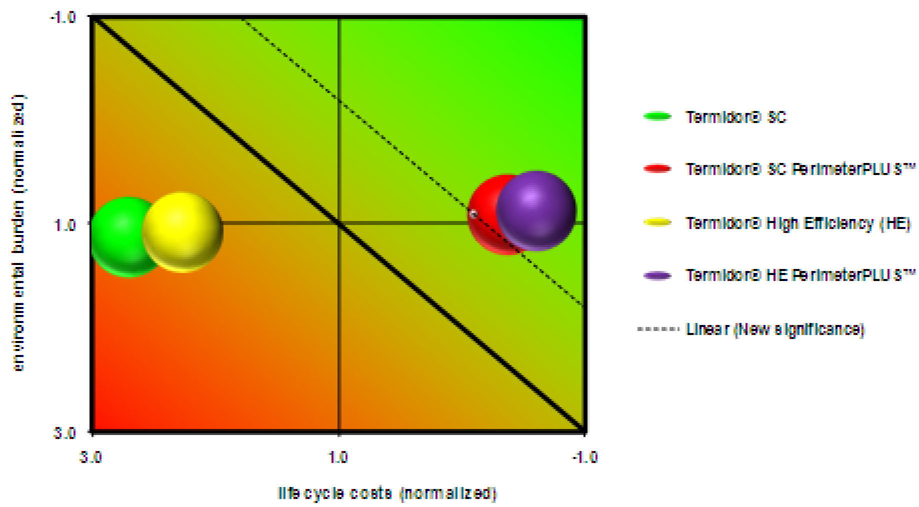

Figure 30. Scenario Analysis #2: Eco-Efficiency Portfolio, Termidor® Termiticide EEA

8.4.3. Scenario #3: Base case assumption with addition of conventional termiticide with 5 year efficacy (vs. 10 years for Termidor®)

All the alternatives in the base case analysis had an efficacy of 10 years, based on the application of BASF's active ingredient, fipronil. However, not all termiticides on the market have efficacies of 10 year. Shorter efficacies will require additional treatments by the PMP over the 20 year life cycle, and thus incur higher costs and through additional material usage a higher environmental impact. Upon review of the USDA-FA report, the team selected an efficacy of 5 years to represent other competitive, lower efficacy termiticides that are in the market. Assumptions relative to these conventional termiticides include:

- Full conventional treatment required, thus material quantities and time allocations are identical to SC conventional treatment.
- Pricing would be at a $1.45/ finished gallon, representing around a 15% price discount to Termidor® SC.
- A price to homeowner of around $800 per treatment.

Based on these assumptions, the eco-efficiencies of the alternatives is reflected in Figure 31. A scale change relative to that presented in the base case assumption was required in order to accommodate this additional alternative in the portfolio. As to be expected, requiring two additional full treatments (4 total) relative to only the two treatments required by the various Termidor® alternatives positions the alternative with shorter efficacy at a distinct cost and environmental disadvantage. The relative position of the Termidor® alternatives to one another did not change from the base case.

As shown in Table 5, the life cycle cost for the competitive alternative with shorter efficacy is over 75% higher than the Termidor® SC full conventional treatment and the environmental impact is also increased by over 20%. It should be noted that the extra cost per application and the overall costs/home figures for the alternative having a shorter efficacy are incurred every 5 years so they would need to be doubled in order to be comparative to the Termidor® values which reflect a 10 year efficacy.

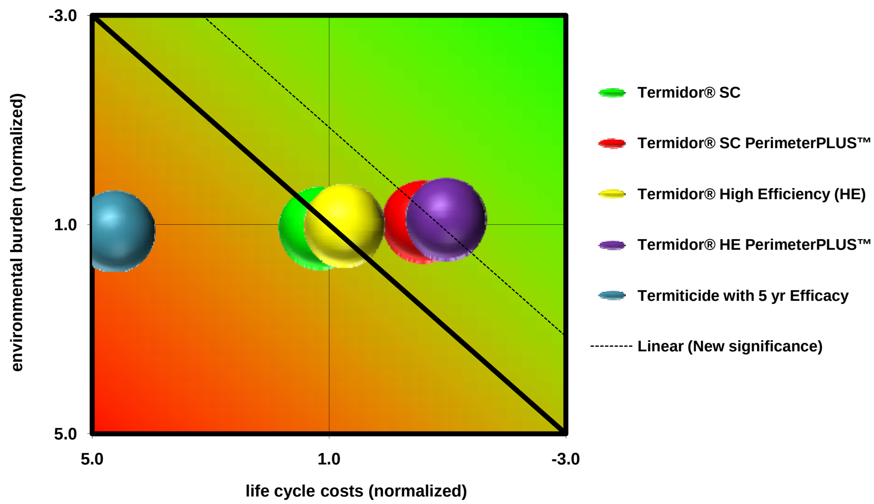

Figure 31. Scenario Analysis #3: Eco-Efficiency Portfolio, Termidor® Termiticide EEA

	Termidor® SC	Termidor® SC PerimeterPLUS™	Termidor® High Efficiency (HE)	Termidor® HE PerimeterPLUS™	Alt with 5 year Efficacy
Costs ($/CB)	$2,447,434	$1,441,307	$2,119,759	$1,168,089	$4,379,346
Costs ($/home)	$1,224	$721	$1,060	$584	$1,095
delta Costs ($/CB)	$1,316,087	$309,960	$988,412	$36,742	$3,247,999
extra cost / application ($)	$640	$137	$476	$0	$511

Table 5: Scenario Analysis #3: Life cycle cost savings for Termidor® Termiticide EEA

8.4.4. Scenario #4: Monolithic Foundation (with base case assumptions)

Figure 32 shows the revised portfolio reflecting the change from a crawl space foundation to a monolithic foundation. The PerimeterPlus™ label treatment is less advantageous for monolithic structures as compared to alternative foundation types such as crawl space and floating. The reason for the less advantageous position is due to fact that the interior foundation does not require treatment for any of the alternatives and there are no piers to treat. An advantage for PerimeterPlus™ comes with not requiring treatment of the bath and utility penetrations and the hollow block wall foundation. Figure 32 shows that the full conventional treatments increase there relative eco-efficiency when compared to PerimeterPlus™. The Termidor® HE PerimeterPlus™ and Termidor® SC PerimeterPlus™ have equivalent eco-efficiencies.

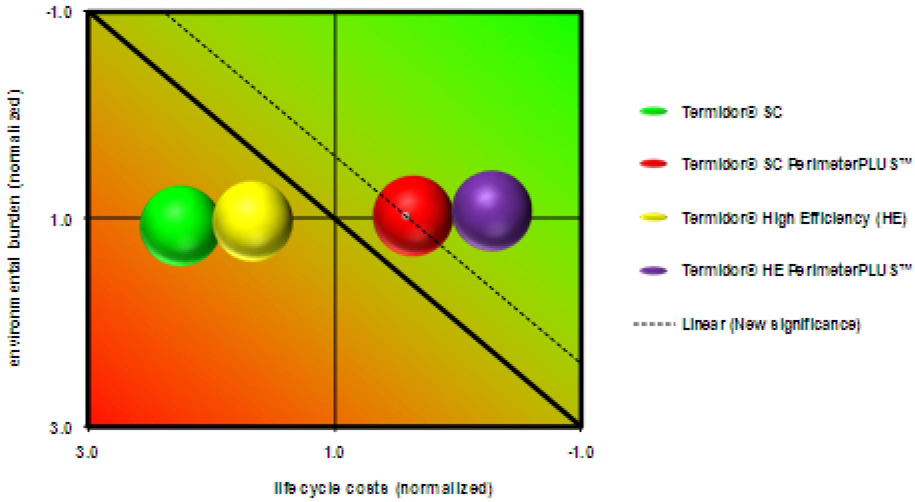

Figure 32. Scenario Analysis #4: Eco-Efficiency Portfolio, Termidor® Termiticide EEA

8.4.5. Scenario #5: Floating Foundation (with base case assumptions)

Figure 33 shows the revised portfolio reflecting the change from a crawl space foundation to a floating foundation. Unlike the previous scenario for a monolithic foundation, a full conventional treatment for the floating foundation requires treatment of the interior foundation wall as well as the voids in the hollow block foundation wall. This requires extensive interior drilling activities which will benefit the PerimeterPlus™ alternatives as well as the HE alternatives which achieves advantages by requiring less foundation soil treatment, less drilling and application time (reduced labor costs) and less disposable material usage (plastic plugs, concrete filler etc.). Because of these advantages, the HE alternatives improve slightly over the SC alternatives relative to their base case positioning. Drilling is minimized due to fact that the interior foundation does not require treatment for any of the alternatives. The only advantage for PerimeterPlus™ comes with not requiring treatment of the bath and utility penetrations and the hollow block foundation. Similar to the monolithic structure the Termidor® HE PerimeterPlus™ and Termidor® SC PerimeterPlus™ are the most eco-efficient alternatives.

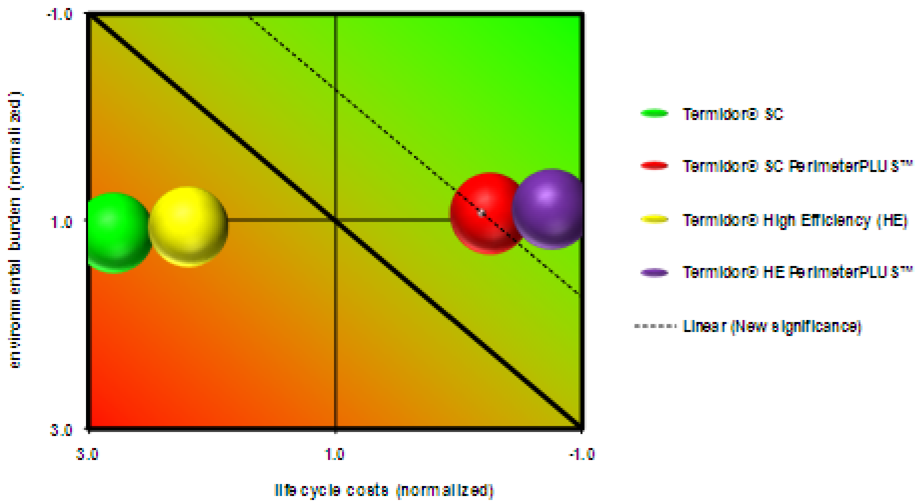

Figure 33. Scenario Analysis #5: Eco-Efficiency Portfolio, Termidor® Termiticide EEA

8.4.6. Scenario #6: Sensitivity analysis around Termidor® High Efficiency (HE) price

Pricing of termiticides can vary significantly based on PMP programs and available rebate incentives. The base case analysis positioned the HE formulation at a 10% over the SC formulation. As material costs are the major component of the life cycle costs sensitivity around the market pricing of Termidor® HE was conducted. The price was varied from a +20% premium over the SC formulation and pricing equivalent to the SC price (0% premium). Figure 34 reflects the results when a 20% premium is applied. As discussed in Section 8.2, the material costs are a significant component of the overall life cycle cost. This increase in premium eroded between 6% and 7% of the cost advantage of the HE alternatives and in real terms reduced the cost savings to the PMP by $40 to $45. However, incorporating these numbers into the base case cost savings for Termidor® HE reflected in Table 3, Termidor® HE will still deliver significant overall cost savings to the PMP relative to SC.

Decreasing the price of Termidor® HE to an equivalent pricing of Termidor® SC only further strengthens the economic and overall eco-efficient position of the Termidor® HE alternatives. This is clearly evident by the dramatic separation in relative position of the HE alternatives on the product portfolio, shown in Figure 35.

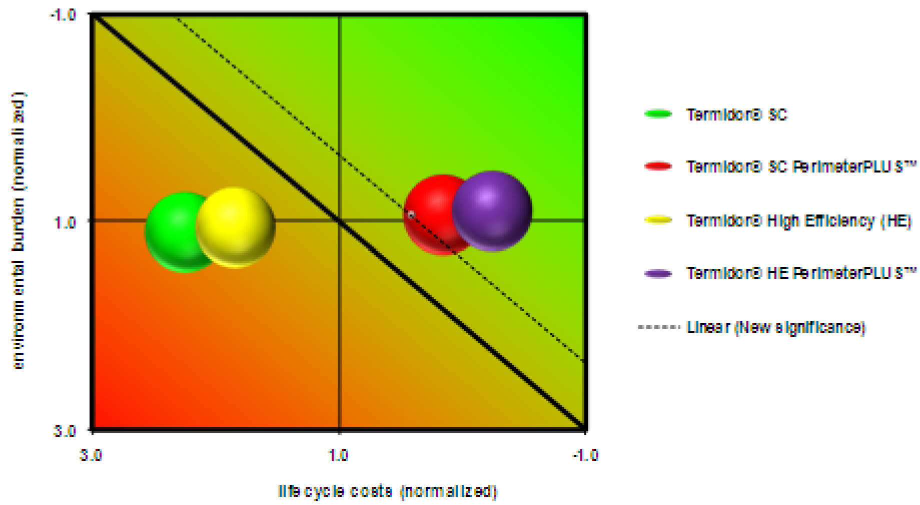

Figure 34: Scenario Analysis #6: Eco-Efficiency Portfolio, Termidor® Termiticide EEA (HE 20% price premium)

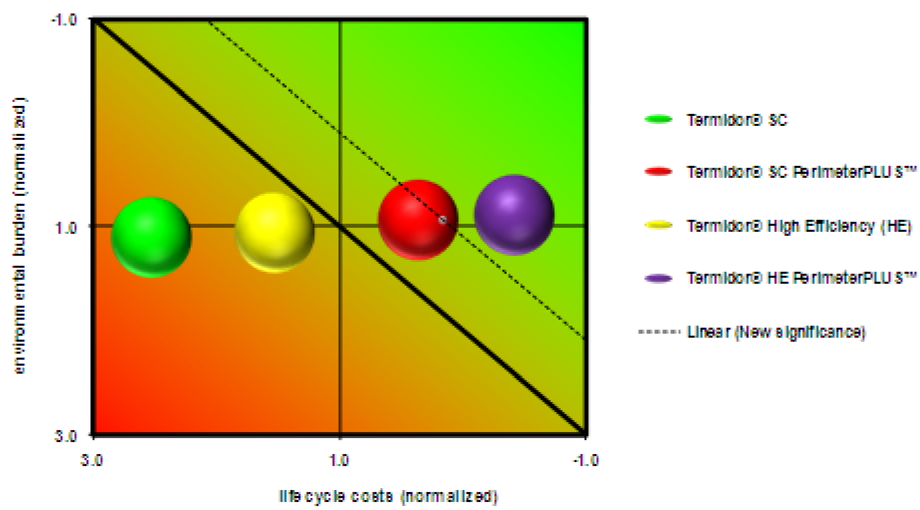

Figure 35: Scenario Analysis #6: Eco-Efficiency Portfolio, Termidor® Termiticide EEA (HE 0% price premium)

9. Data Quality Assessment

9.1. *Data Quality Statement*: The data used for parameterization of the EEA was sufficient with most parameters of high or medium-high data quality, which means the data was specific to this study context and goals. Moderate data is where industry average values or assumptions pre-dominate the value. No critical uncertainties or significant data gaps were identified within the parameters and assumptions that could have a significant effect on the results and conclusions. The sensitivities analysis section addresses how moderate or reasonable changes to key project parameters and assumptions will affect the final results. Eco-profiles utilized were deemed of sufficient quality and appropriateness considering both the geographic specificity of the study as well as the time horizon considered. Table 5 provides a summary of the data quality for the eco-efficiency analysis.

Table 5: Data quality evaluation for EEA parameters.

Parameter	Quality Statement	Comments
Termiticide – Application		
Material Composition	High	BASF
Amount of Materials	High	Product Labels; BASF
Efficacy	High	BASF; USDA-FS
Maintenance Activities – Costs	Med-High	BASF; Field Data from Pest Management Professionals (PMPs)
Time Allocations for Application	Med-High	BASF; Field Data
Conventional Termiticide (5 yr efficacy)	Mod	MSDS; Technical Data Sheets (Label); BASF
Price		
Active Ingredients	High	BASF
Maintenance Requirements/Costs	Med-High	Pest Management Professionals; BASF
Equipment Costs	Med-High	Recommendations from IPCC and external articles
Labor Costs	High	BASF; PMPs
Price to Homeowner	Med-High	BASF
Peripheral Damage	Medium	BASF ; Field Data from Pest Management Expert
Transportation Distances	Mod	Manufacturer data – team estimate

10. Sensitivity and Uncertainty Analysis

10.1. *Sensitivity and Uncertainty Considerations:* A sensitivity analysis of the results indicates that the impacts with the highest environmental relevance (Figure 36) were emissions followed closely by resource consumption and then toxicity potential. These results were expected and can be attributed to the significance of the emissions related to manufacturing of the active ingredient fipronil and the additive required for the Termidor® HE as well as the emissions related to the production and use (combustion) of the on-site utilities and fuels required for logistics. The calculation factors, which consider both the social weighting factors (Figure 37), and the environmental relevance factors, and shown in Figure 38 indicate which environmental impact categories were having the largest affect on the outcome as reflected in the portfolio. The impacts with the highest calculation factors were the same as those with the highest environmental relevance factors, which is often the case. The input parameters that were related to these impact categories have sufficient data quality to support a conclusion that this study has a low overall uncertainty.

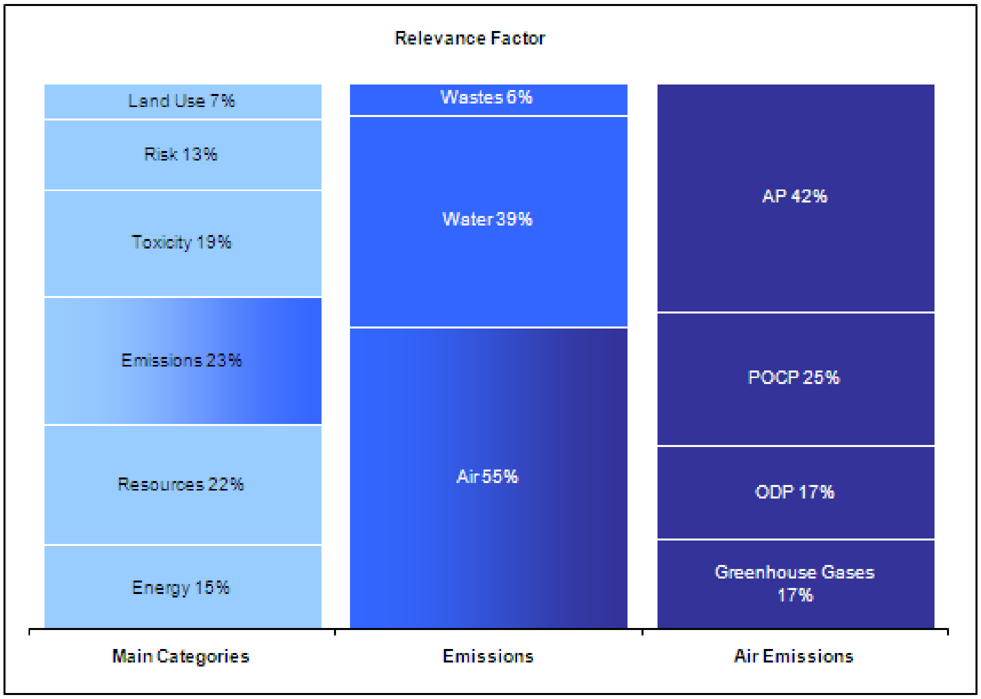

Figure 36: Environmental Relevance Factors – base case analysis

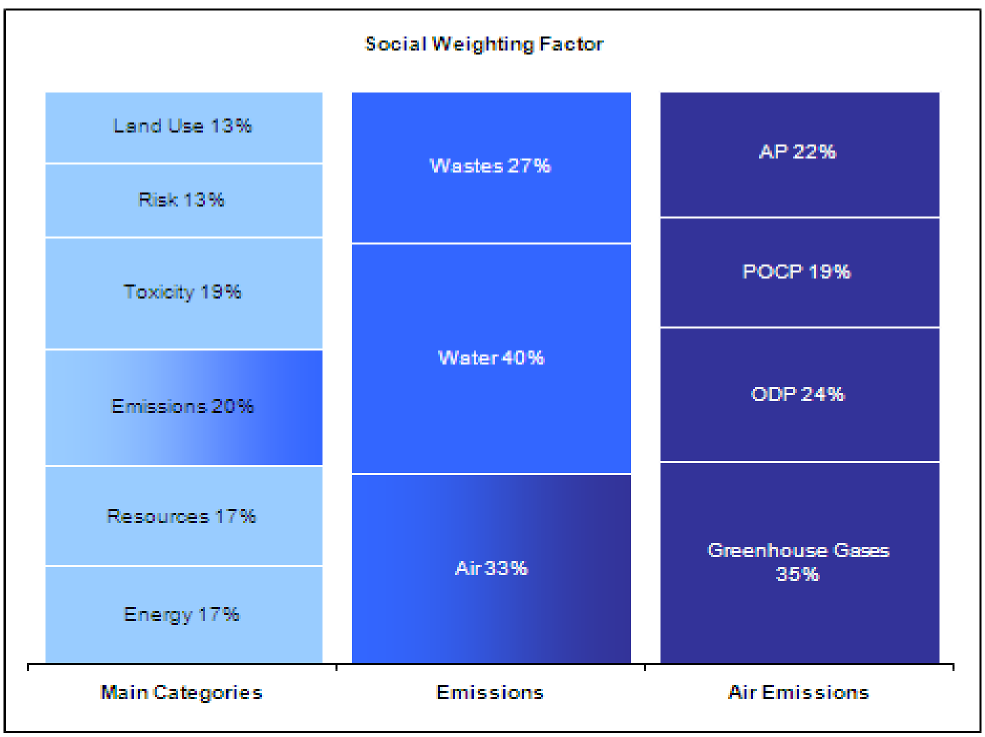

Figure 37: Social Weighting Factors – base case analysis

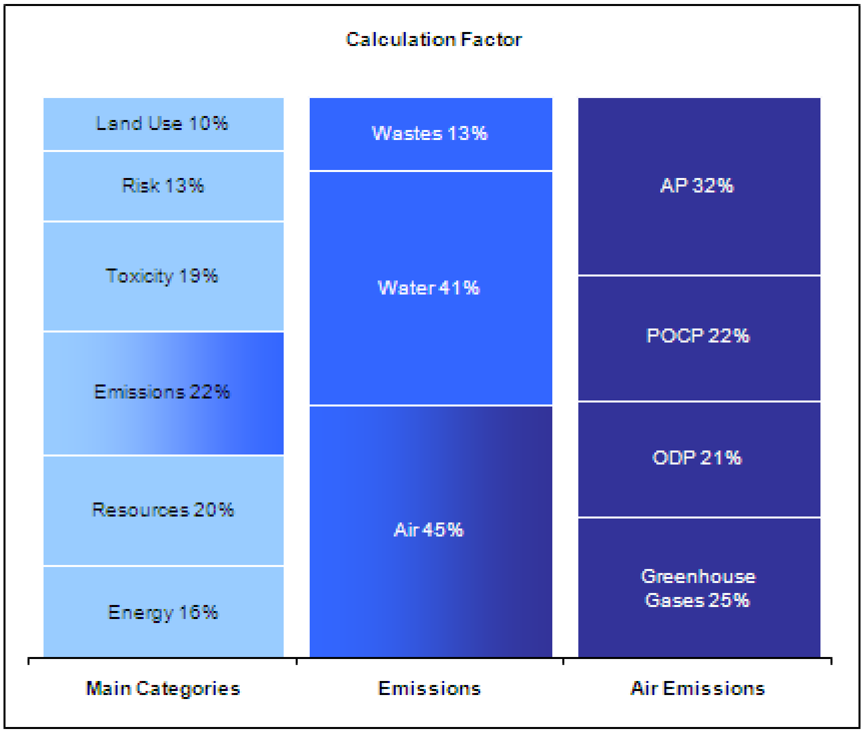

Figure 38. Calculation Factors – base case analysis

As mentioned in the study goals, this analysis was objective in the way it presented the overall sustainable value proposition for a termiticide. By presenting both a comprehensive environmental impact assessment along with a rigorous life cycle cost analysis, a more holistic and balanced report is presented to stakeholders who are interested in specifying a more eco-efficient termiticide. In addition, as discussed and reflected in Figure 38, other environmental impacts (than say the toxicity of the active ingredient) should be considered when determining the overall environmental impact of a termiticide. Even when looking at toxicity, other materials in the supply chain or common materials utilized by the pest management professional could have as significant impact on the life cycle human health impact of an alternative than the toxicity of the final product. Finally, the results presented in this report quantify the innovative improvements in sustainability the Termidor® family of termiticides have made over the years with the development of the PerimeterPlus™ label and the more recent development of Termidor® HE, a low water alternative to the current SC formulation.

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, application (use), and disposal, for the described customer benefit, termiticide alternatives and system boundaries. Transfer of these results and conclusions to other production methods, application methods, products or customer benefit 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. Wagner T., Peterson C., Shelton T., Pest Management Professional, “Termiticide Efficacy Res 2010”, February 2011. pages 28 -34.
2. Formulation Manufacturing Manual, BAS 350 69 I (Termidor® SC); BASF SE Beziers,France; January 19, 2007.
3. Formulation Manufacturing Manual, BAS 270 00 S (HE Additive); BASF SE Limburgerhof, Germany; November 25, 2010.
4. Formulation Release Summary Document, BAS 350 95 I; BASF SE Limburgerhof, Germany. April 29, 2010.
5. Termidor® SC Termiticide/Insecticide Master Label. EPA Reg. No. 769-210; May 2009
6. Termidor® LW Termiticide Label. Draft as submitted to E.P.A. 2011 BASF Corporation
7. Nishimura, T., Termidor® LW (HE) Time Studies – Arizona EUP Trials; Power Point Presentation; BASF Corporation. April 2011
8. Nichols, Philip Dr.; “Time Requirements to Perform Termite Treatments”; Word Document; October 2000.
9. Weber, R.; Termidor® Financial Analysis BASE 6.22 spreadsheet; Profitability Worksheet; BASF Corporation 2011.
10. Boustead Consulting Ltd UK, The Boustead Model 5.1.2600.2180 Life Cycle Inventory Database.
11. Stephenson Equipment Company; Equipment & Material pricing. http://www.stephensonequip.com/home.php
12. Bio-energy Conversion Factors. http://bioenergy.ornl.gov/papers/misc/energy_conv.html