Life Cycle Assessment of Good Knight Activ +

GODREJ CONSUMER PRODUCTS LIMITED

Study Author - **THINKSTEP SUSTAINABILITY SOLUTIONS PVT LTD**
A SPHERA COMPANY

Contact: **Nitin Nair** **Karunakar Avuram**	| CONSUMER PRODUCTS
Godrej Consumer Products Limited	*Address:* Godrej One 4th floor, Pirojshanagar, Eastern Express Highway, Vikhroli (East), Mumbai 400 079, India Web: www.godrejcp.com
	Email: nitinnair@godrejcp.com
Contact Dr. Rajesh Kumar Singh	sphera™ Advancing Operational Excellence™
thinkstep Sustainability Solutions Pvt. Ltd.	*Address:* 707, Meadows, Sahar Plaza, Andheri Kurla Road, Andheri East, Mumbai - 400059, India
	Email: rsingh@sphera.com

Acronyms

ADP	Abiotic Depletion Potential
AFR	Alternative Fuels and Raw Materials
AP	Acidification Potential
CFC	Chlorofluorocarbon
CML	Centre of Environmental Science at Leiden
CPP	Captive Power Plant
DG	Diesel Generator
EoL	End-of-Life
EP	Eutrophication Potential
GHG	Greenhouse Gas
GLO	Global
GWP	Global Warming Potential
ILCD	The International Reference Life Cycle Data System
ISO	International Organization for Standardization
kg	Kilogram
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MJ	Mega Joule
ng	Nanogram
NMVOC	Non-methane Volatile Organic Compound
ODP	Ozone Depletion Potential
POCP	Photochemical Ozone Creation Potential
UV	Ultraviolet
VOC	Volatile Organic Compound
WHRS	Waste Heat Recovery Systems

Glossary

ISO 14040:2006, Environmental management - Life cycle assessment - Principles and framework, International Organization for Standardization (ISO), Geneva.

Allocation
Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems.

Declared Unit
Quantified performance of a product system for use as a reference unit

Cradle to grave
Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of life.

Cradle to gate
Addresses the environmental aspects and potential environmental impacts (e.g. use of resources and environmental consequences of releases) throughout a product's life cycle from raw material acquisition until the end of the production process (“gate of the factory”). It may also include transportation until use phase.

Cumulative Energy Demand (CED)
An indicator that includes all direct and indirect energy consumption associated with a defined set of unit processes. It does not directly account for the impact of non-energetic raw material consumption or emissions to the environment. Values for CED are measured in terms of energy (e.g., joules). Note: CED is a proxy metric and not a formal impact assessment method.

IPCC GWP 100a
Global warming potential over a 100-year duration, as defined by the United Nation’s Intergovernmental Panel on Climate Change. The indicator reflects the potential relative climate change effect per kg of a greenhouse gas and their potency on climate.

Life cycle
A unit operation view of consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal. This includes all materials and energy input as well as waste generated to air, land and water.

Life Cycle Assessment - LCA

Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

Life Cycle Inventory - LCI

Phase of Life Cycle Assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.

Life Cycle Impact Assessment - LCIA

Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product.

Life Cycle Interpretation

Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations.

Executive Summary

Godrej Consumer Products Limited (GCPL) is an integral part of the over 120-year young Godrej Group. They are a leading emerging markets consumer goods company with a strong market position across global geographies. Their growth has been led by strong financial performance and a sound aptitude for innovation. However, as a Company, they go beyond financial metrics and ardently believe in creating unparalleled stakeholder value through their social, people and environmental interventions. This stems from living the Godrej Way, every day.

As a leading player in the Indian FMCG sector, the company seeks additional reliable scientific information to communicate the environmental performance of its products to customers or retailers and more generally those requiring such data for environmental labelling purposes. Responsible product stewardship is a key area of focus in GCPL's business sustainability strategy.

The life cycle approach holds great potential for environmental and broader sustainability work. Through its systemic cradle-to-grave approach, it reduces risks of sub-optimization and problem-shifting from one part of the life cycle to another or from one type of impact to another. It brings new insights about how action in one stage of the product life cycle may lead to upstream or downstream effects far away from the point of action, perhaps in vastly distant geographical locations as well. In order to further enhance their product stewardship, GCPL intends to involve life cycle assessments for their products.

thinkstep Sustainability Solutions Pvt Limited, a sphera Company, has been entrusted to carry out the Life Cycle Assessment as per the ISO 14040/44.

Good knight Power Activ + system is the most technologically Superior Liquid Vaporizer in India. The Combo Pack consists of a mosquito repellent liquid vaporizer that consists of the liquid Refill & a clip-on electronic machine. In normal machines there is only one heater but the superior Activ + machines come with dual heaters. The electronic machine comes with a dual mode technology, where the

- **Normal mode** is to be used when there are fewer mosquitoes
- **Intermediate mode** has been added in the study for scenario analysis
- **Active mode**, which has to be used when the infestation is high.

Objective of the Study:
"Quantification of life cycle environmental impacts for of **Good Knight Activ +** Liquid vaporiser machine and refill produced by GCPL over the cradle to grave system boundary as per ISO 14040/44 standard".

The reason for carrying out the study is to assess the environmental profile of **Good Knight Activ +** Liquid vaporiser machine and refill product and identify the hotspots in the value chain of the product for optimization and further reduction of environmental impacts.

Business Value of the Study:
This study will help in providing

- An indication of the status of environmental performance of the product being analyzed and enables optimization potentials to be identified,
- Detailed knowledge on significant parameters of characteristic product for improving the sustainability performance in the supply chain.
- On the other hand, this environmental knowledge provides the basis to identify existing and future cost potentials related to the production, utilization and End-of-Life of product.
- Development of environmental strategy (short term and long term) and get the potential quantified reduction due to individual improvements.
- Alignment with R&D team to run various scenarios on raw material quality, process and energy efficiency improvements, resource conservation, waste reduction and recycling, yield improvement.
- Results can be used to report in business responsibility reporting mandated by SEBI (principle 2).

Functional unit provides reference for inputs and outputs throughout the system. There are three functional units for which results have been drawn in order to analyse various sub-units of the product as individual products. These functional units are as follows-

1. One electric plug-in machine and 16 liquid vaporizer refills over time period of 2 years (730 days).
2. One liquid vaporizer refill over its lifetime of 45 days (Normal Mode).
3. One electric plug-in machine and 1 liquid vaporizer refill over its lifetime of 45 days (Normal Mode).

The study covers all the production steps from raw materials in the earth (i.e. the cradle) to production of electric plug-in machine and refill manufacturing and delivery at factory gate with packaging material, followed by use and disposal. The system boundary and geographical scope includes procurement of raw materials and manufacturing of the product within India. This is followed by a use phase comprising of energy consumption and refill consumption for a life span of 2 years for the first functional unit and 45 days for other two functional units. The EOL is assumed to be Landfilling in MSW site with no recycling/recovery as a conservative approach.

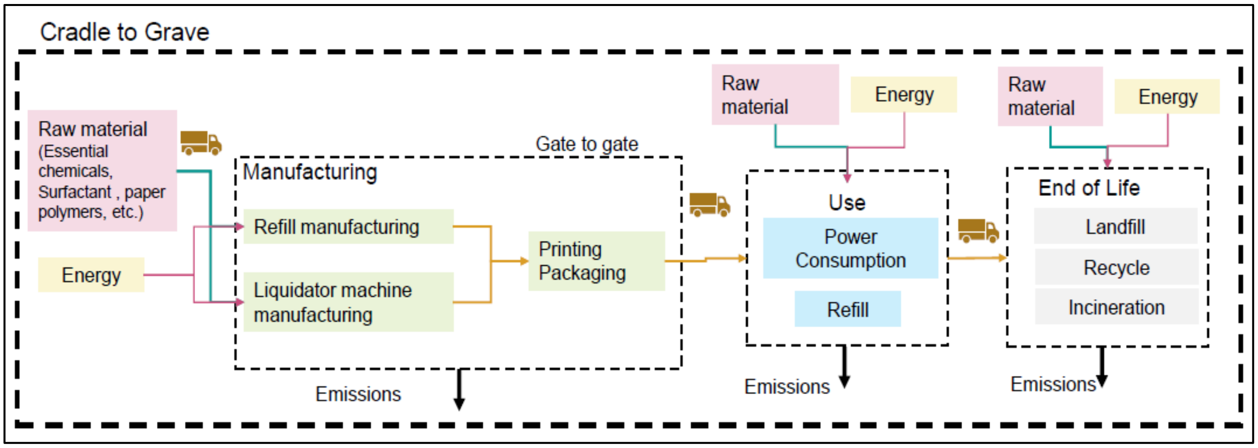


Figure 1 System boundary diagram for Good Knight Activ + LCA

Site specific data was collected through the data collection questionnaire for the year FY 2018. Completeness and consistency checks were performed. The LCA model was created using the GaBi ts Software system for life cycle engineering, developed by sphera (formerly thinkstep AG). The GaBi database provides the life cycle inventory data for several of the raw and process materials obtained from the upstream system. Environmental impact indicators are selected from the Product Environmental Footprint 3.0 version of impact models.

Results and Conclusion

Cradle to Grave Life Cycle Impact Assessment Results for 1 electric plug-in machine and 16 liquid vaporizer refill over time period of 2 years (730 days)

Table 1 LCIA results for 1 unit of Combo-pack

Impact Categories	Unit	Combo-pack (1 machine + 16 Refills)
Acidification terrestrial and freshwater	Mole of H+ eq.	0.45
Cancer human health effects	CTUh	7.91E-09
Climate change	kg CO_2 eq.	37.37
Ecotoxicity freshwater	CTUe	7594.70
Eutrophication freshwater	kg P eq.	1.59E-04
Ozone depletion	kg CFC-11 eq.	3.65E-09
Photochemical ozone formation - human health	kg NMVOC eq.	0.16
Resource use, energy carriers	MJ	422.75
Resource use, mineral and metals	kg Sb eq.	1.21E-05
Water scarcity	m^3 world eq.	5.73

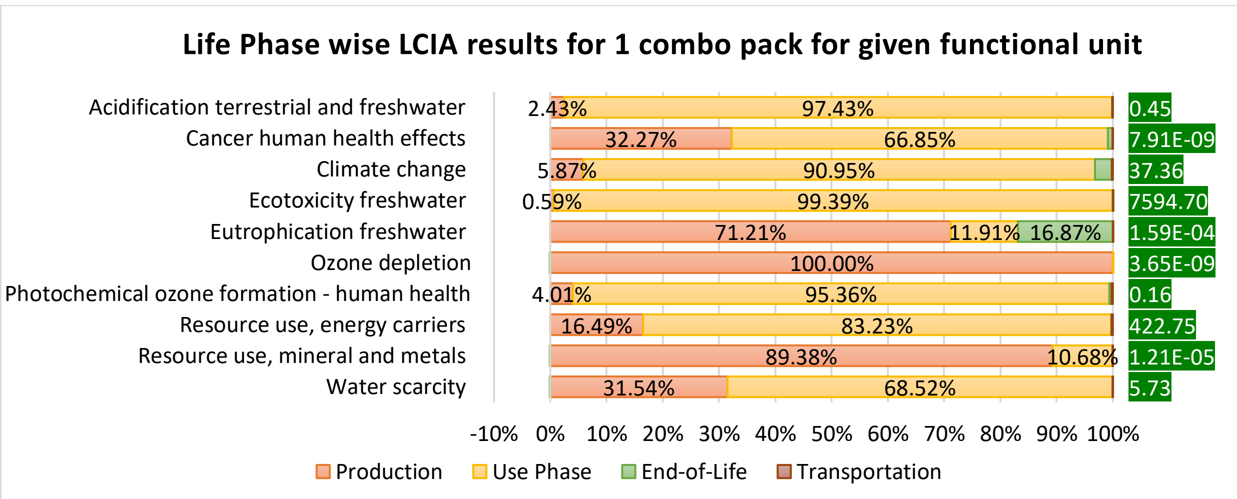


Figure 2 Life phase wise percentage breakup of LCIA Results for 1 Combo-pack

*values highlighted in green are absolute values in reference units of impacts

- Use phase contributes the highest to most of the impact categories with around 97.4% in Acidification terrestrial and freshwater impact, 66.9% in Human toxicity potential, 90.9% in Global warming potential, 99.4% in Ecotoxicity potential, 95.4% in Photochemical ozone formation potential, 83.2% in Abiotic depletion of fossils and 68.5% in water scarcity. The major contributor in the use phase is electricity consumption used for vaporization of the formulation.
- Production phase contributes the highest with 71.3% to Eutrophication potential (with 45.9% contributed by printed carton) and 89.4% to Abiotic depletion of elements.

- Considering the sources of various impact categories, electricity consumption (most of it from use phase) contributes to most of the impact categories with 97.9% in Acidification potential, 67.2% in Human toxicity potential, 91.4% in Global warming potential, 95.8% in Photochemical ozone formation potential, 83.7% in Abiotic depletion of fossils and 68.9% in water scarcity.
- Production of raw materials contributes the highest with 71.1% in Eutrophication potential, 100.0% in Ozone depletion potential, 89.3% in Abiotic depletion of elements. The highest contributors to these impacts are Bottle-Refill-Activ + and Printed carton.
- Ecotoxicity potential is contributed highest by the emissions of the repellent from the use phase by 98.7%. But not contributing to human toxicity which has highest contributions from electricity. (Note- Pyrethrin has been used as the best available substitute for Transfluthrin for LCIA calculations).

Cradle to Grave Life Cycle Impact Assessment Results for one liquid vaporizer refill over its lifetime of 45 days (Normal Mode).

Table 2 LCIA results for 1 unit of Refill

Impact Categories	Unit	1 Refill
Acidification terrestrial and freshwater	Mole of H+ eq.	2.81E-02
Cancer human health effects	CTUh	4.84E-10
Climate change	kg CO_2 eq.	2.32
Ecotoxicity freshwater	CTUe	474.57
Eutrophication freshwater	kg P eq.	9.88E-06
Ozone depletion	kg CFC-11 eq.	2.28E-10
Photochemical ozone formation - human health	kg NMVOC eq.	1.01E-02
Resource use, energy carriers	MJ	26.21
Resource use, mineral and metals	kg Sb eq.	6.28E-07
Water scarcity	m^3 world eq.	0.35

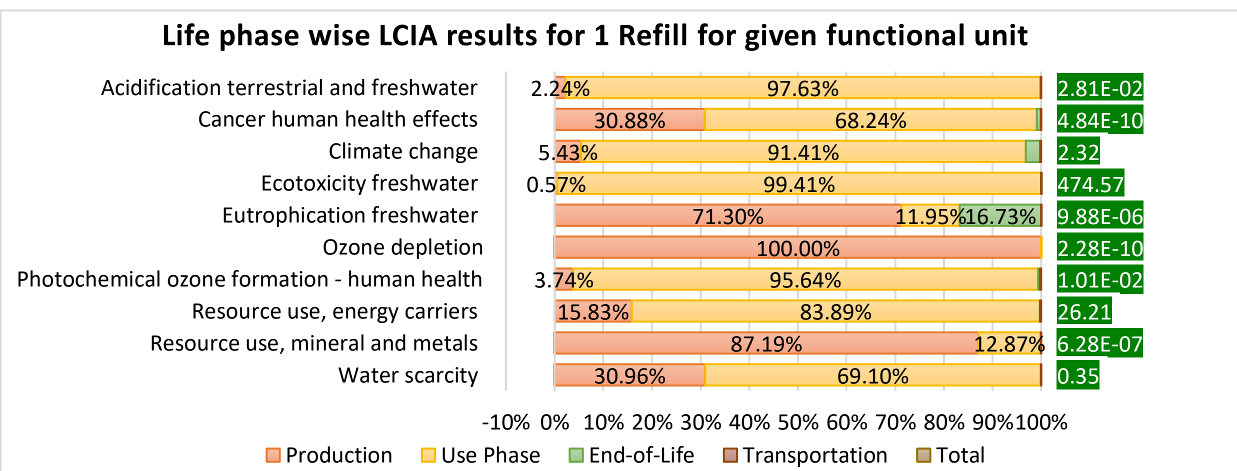


Figure 3 Life phase wise percentage breakup of LCIA Results for 1 refill

*values highlighted in green are absolute values in reference units of impacts

A similar trend is seen in the refill impact as in case of the combo pack, detailed assessment is given below.

- Use phase contributes the highest in most of the impact categories with around 97.6% in Acidification terrestrial and freshwater impact, 68.24% in Cancer human health effects, 91.41% in Climate change impact, 99.4% in Ecotoxicity freshwater impact, 95.4% in Photochemical ozone formation - human health, 83.4% in Resource use, mineral and metals and 69.1% in water scarcity. The major contributor in the use phase is electricity consumption.
- The high ecotoxicity in the use phase is coming from Transfluthrin emissions (Pyrethrin has been used as a substitute due to non-availability of toxicity characterization factors).
- Production phase contributes the highest with 71.2% in Eutrophication freshwater (with 49% contributed by printed carton and 12% from Refill bottle) and 89.4% in Resource use, mineral and metals.

Detailed results are given in section 4.1 and 4.2.

A scenario analysis has also been conducted to evaluate the environmental performance of the product in its use phase. For this, the normal and active mode available in the machine are studied along with a hypothetical intermediate stage.

Table 3 Details of Scenario Analysis applied in the study

Modes	Refill life (days)	No. of refill required in 2 years (730 days)*	Power (Watts)
Normal	45	16	5.0
Intermediate	33	22	7.5
Active	22	33	10.0

*if operated for 8 hours per day

Scenario Analysis results of Climate change for 1 electric plug-in machine and 16 liquid vaporizer refill over time period of 2 years (730 days)

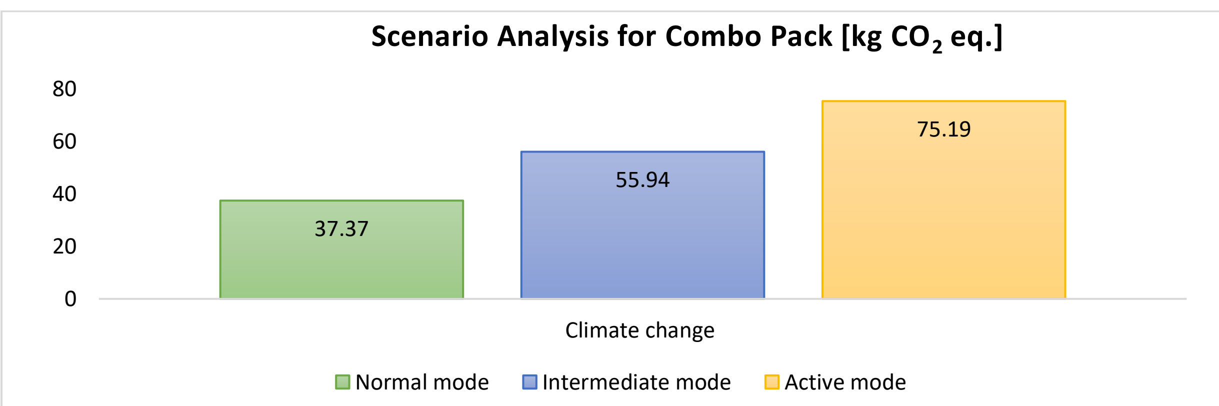


Figure 4 Comparison of climate change impact for Combo pack

The major impact comes from the use phase. In case of Active mode, the power usage is higher as well as the refill life is reduced to 22 days from 45 days, both these factors account for rise in the LCIA impacts of the product. Detailed results of scenario analysis are given in section 4.3.

Based on the outcomes of the study following directional recommendations are made-
Sourcing of electricity from renewable sources like wind and solar, leads to high reduction in most of the impacts, since electricity contributes in the range of 40% to 95% to various impacts. Thus, a solar operated device may be explored.

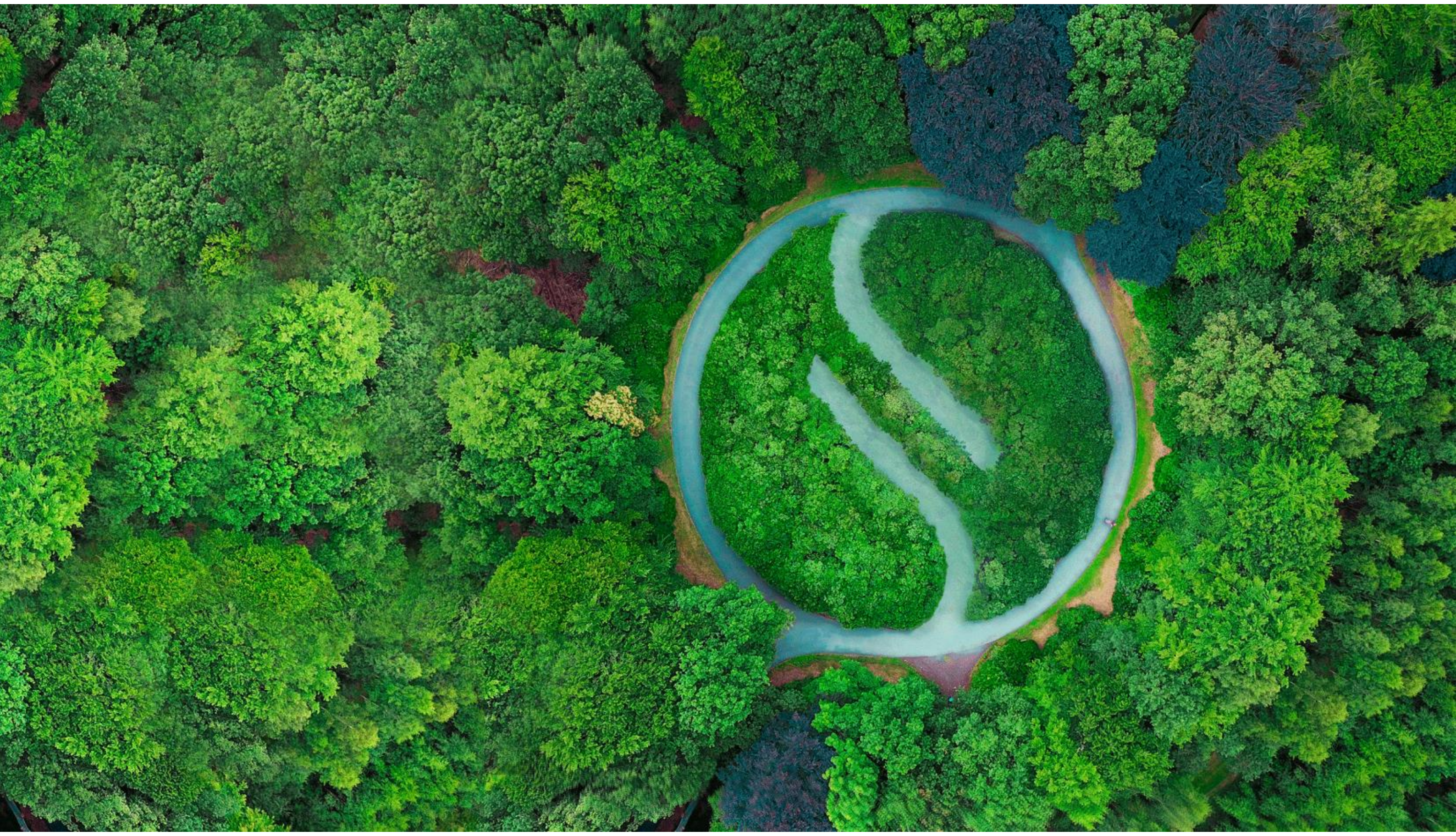
As polymers and metals used in the body parts contribute to the impact using recycled Polypropylene granulate, secondary aluminium, etc as well as weight reduction in packaging may lead to saving potentials in various impact categories.

Extension of service life has a saving potential as lesser products are needed to be produced for a longer usage.

From a circularity perspective in the End-of-Life phase, currently only disposal in landfill has been addressed. The savings potentials by utilising recovery and recycling for both product and packaging can be explored by actual data collection.

Further from an innovation perspective provision to supply formulation without manufacturing of refill bottles could be explored. (eg. Refill pouches/packs).

This study has helped generate a detailed Life cycle inventory of Good Knight Activ + product. In addition to the above analysis, an indexed single score methodology using weighting principles of ISO 14040/44 and Product Environmental Footprint has been developed for GCPL and indexed single score quantification for Liquid Vaporizer i.e. Good Knight Activ + product (described in Chapter 6). This will help in decision making to evaluate other products at a portfolio level in future.



On behalf of Godrej Consumer Product Limited

Report on Life Cycle Assessment of HIT Aerosol

Client: Godrej Consumer Product Limited

Title: Life Cycle Assessment of HIT Aerosol

Report version: v1.0

Report date: 24/03/2022

On behalf of Sphera Solutions, Inc., and its subsidiaries

Document prepared by

Swapnil Nikam SNikam@sphera.com

Pravisha Jaiswal PJaiswal@sphera.com

Quality assurance by

Ritesh Agrawal RAgrawal@sphera.com

Director, Consulting

Under the supervision of

Dr. Rajesh Kumar Singh RSingh@sphera.com

Sr. Director, Consulting

1. Goal of the Study

The goal of Life Cycle Assessment study is the quantification of environmental impacts for selected product.

The goal of the study is quantification of life cycle environmental impacts for one HIT Aerosol manufactured at Godrej Consumer Products Limited plant, at Indonesia over the Cradle to Grave system boundary as per ISO 14040/44 standard.

The reasons for carrying out the study are as under:

- Identify opportunities to improve the environmental aspects at various stages of the product lifecycle by implementing eco-design practices to encourage increased efficiency and innovation
- Identification of areas to gain competitive advantage

This assessment is based on credible scientific approach and will provide reliable information to various stakeholders. The audience for the current LCA study is internal. Internal reports can be intended for product development or benchmarking the products. No critical review has been conducted as it is optional in case of internal reports as per ISO 14044.

The results of the study are not intended to be used in comparative assertions nor intended to be disclosed to the public. Any comparisons be made on a product system basis and must be carried out in accordance with the ISO 14040 and the ISO 14044 standards, including an additional critical review by a panel.

2. Scope of the Study

The following section describes the general scope of the project to achieve the stated goals. This includes the identification of specific products to be assessed, the supporting product systems (e.g. materials, technologies, etc.), and the boundary of systems under study, allocation procedures, and cut-off criteria.

2.1. Product System(s)

The partwise mass distribution of HIT Aerosol is provided in Figure 1 The major component are LPG gas (71%), Can (23%), Cap (3%), Valve (2%), MC box (1%). The parts of HIT Aerosol along with weight is provided in Table 1Table 1 Composition of HIT Aerosol Product. The percentage of raw material composition is given in Annexure A

Table 1 Composition of HIT Aerosol Product

Parts of HIT Aerosol	Unit	Mass
Can	kg	0.109
Cap	kg	0.0115
Valve	kg	0.0072
MC box	kg	0.0049
Premix	kg	0.00135
LPG gas	kg	0.335
Total product with packaging	kg	0.5356
Total product without packaging	kg	0.521

2.2. Product Function(s) and Functional Unit

HIT Aerosol is Anti-mosquito repellent in the form of brass yellowing aerosols to kill fly and cockroach mosquitoes in the room. The product uses various chemicals which are mixed together to form premix, which constitute as main component.

Functional Unit

The functional unit is a reference for the product whose lifecycle impact is being assessed. The functional unit allows quantification of the environmental impacts over Cradle-to-Grave life cycle stage. These environmental impacts are calculated based on the functional unit wherein each flow related to material consumption, energy consumption, emissions, effluent and waste is scaled to the reference flow.

The functional unit for the study is one piece of HIT Aerosol.

2.3. System Boundary

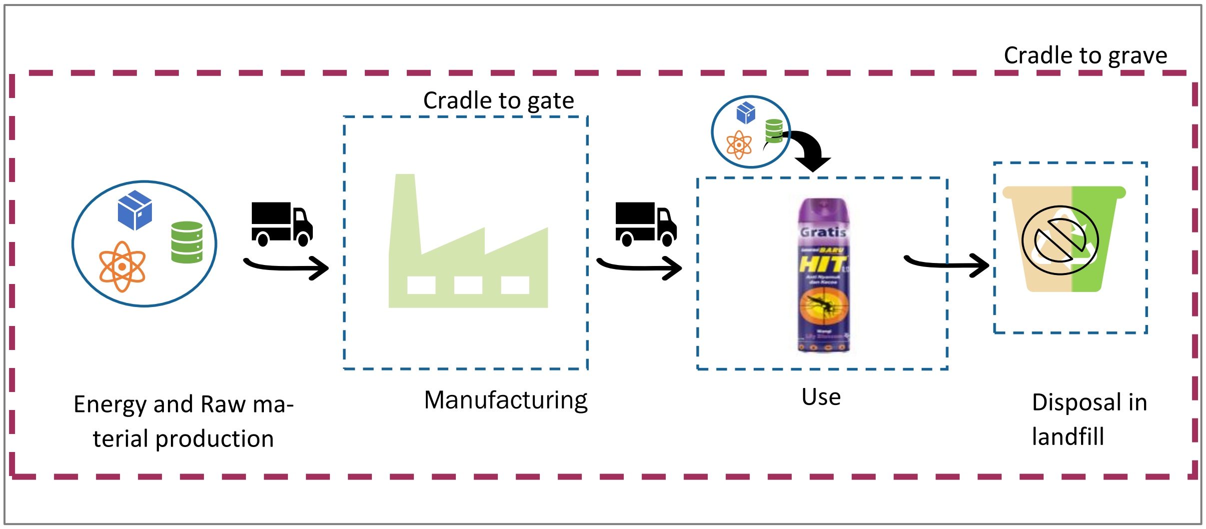


Figure 1 Generic System boundary for the selected product

The LCA model for HIT Aerosol represents a Cradle-to-Grave system. The scope covers the Production phase (raw materials supply, upstream transportation, manufacturing process), Use phase and End-of-Life phase of the product. Table 2 summarizes the processes that are included within the system boundaries of LCA.

Table 2 Details of system boundary included in the LCA

Phase	Life Cycle stages	Life Cycle sub-stages	Definitions
Production Phase	Materials	Primary raw materials production	Extraction and production of raw materials/ chemicals used in all four products
			Electricity from all sources (import from grid, captive power generation, DG set), energy, water and raw materials used in the production of these raw material/chemicals.
	Upstream transport	Rail and road transport	Transport of raw materials for the preparation

	Manufacturing	Production of HIT Aerosol	Energy and water consumption for product manufacturing of Pre color, coloring cream, activator and coloring cream
Use Phase	Use Phase	Use of Kit	Water Consumption for hair wash and emission of wastewater consisting of chemicals along with water
End-of-Life Phase	End-of-Life Phase	Disposal of packaging and gloves after use	Landfill, recycling and Incineration of packaging waste/materials after use, with energy recovery

Table 3 Inclusion and exclusion in system boundary

Included	Excluded
✓ Extraction of raw materials ✓ Transport of raw materials ✓ Assembly/production ✓ Packaging ✓ Outbound transportation ✓ Installation ✓ Use phase ✓ Transportation to EoL site ✓ EoL treatment	× Human labor × Construction of capital equipment × Maintenance and operation of support equipment × Services

2.3.1. Time Coverage

The data collection is related to one year of operation and the year of the data is indicated in the questionnaire for each data point. The data was derived from the year 2020.

2.3.2. Technology Coverage

The exact technological configuration was used for the various process's operation of the plants for efficient performance in production and minimizing environmental impacts. It was assumed that secondary data from databases that were used for this assessment, were temporally and technologically comparable to that of primary data and within the temporal coverage already addressed.

2.3.3. Geographical Coverage

The geographical system boundaries of the LCA cover the production of HIT Aerosol manufactured in Indonesia.

2.4. Allocation

No allocation has been done. As no co-products are produced, the flow of materials and energy and the associated release of substances and energy into the environment is related exclusively to the production.

2.5. Cut-off Criteria

Input and output data have been collected through detailed questionnaires which have been developed and refined. In practice, this means that, at least, all material flows going into the production processes (inputs) higher than 1% of the total mass flow (t) or higher than 1% of the total primary energy input (MJ) are part of the system and modelled in order to calculate elementary flows. All material flows leaving the product system (outputs) accounting for more than 1% of the total mass flow is part of the system. All available inputs and outputs, even below the 1% threshold, have been considered for the LCI calculation. For hazardous and toxic materials and substances the cut-off rules do not apply.

2.6. Selection of LCIA Methodology and Impact Categories

The impact assessment categories and other metrics considered to be of high relevance to the goals of the project. Various impact assessment methodologies are applicable for use in the European context including e.g. Environmental Footprint v3.0 (EF 3.0), CML, ReCiPe, etc. This assessment predominantly reports on the CML 2001-Aug 2016 impact assessment methods.

CML 2001 (January 2016) method developed by Institute of Environmental Sciences, Leiden University, Netherlands and have been selected for evaluation of environmental impacts. These indicators are scientifically and technically valid.

The impact assessment categories and other metrics considered to be of high relevance to the goals of the project and are shown in Table 4 and Table 5.

Table 4 Impact category descriptions

Impact Category	Description	Unit	Reference
Global warming	A measure of greenhouse gas emissions, such as CO_2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health and material welfare.	Kg CO_2 equivalent	(IPCC, 2013)
Acidification	A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H^+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.	Kg SO_2 equivalent	(Guinée, et al., 2002)

Abiotic Resource Depletion (ADP elements)	The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resources are reported separately. Depletion of mineral resources is assessed based on ultimate reserves.	Kg Sb equivalent	(Guinée, et al., 2002)
Eutrophication	Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.	Kg Phosphate equivalent	(Guinée, et al., 2002)
Ozone Depletion	A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.	kg CFC-11 equivalent	(Guinée, et al., 2002)
Photochemical Ozone Formation	A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O_3), produced by the reaction of VOC and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be injurious to human health and ecosystems and may also damage crops.	kg ethene equivalent	(Van Zelm R., 441-453)
Human Toxicity Potential (HTP)	A measure of toxic emissions directly harmful to the health of humans and other species.	kg DCB equivalent	(Rosenbaum, et al., 2008)

Table 5 Other environmental indicators

Indicator	Description	Unit	Reference
Primary Energy Demand (PED)	A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.	MJ (lower heating value)	(Guinée, et al., 2002)
Water Consumption	A measure of the net intake and release of fresh water across the life of the product system. This is not an indicator of environmental impact without the addition of information about regional water availability.	kg	(Sphera Solutions Inc., 2020)

A detailed description of the selected impact categories is given in Annex B.

It shall be noted that the above impact categories represent impact *potentials*, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the functional unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

2.7. Interpretation to be Used

The results of the LCI and LCIA were interpreted according to the Goal and Scope. The interpretation addresses the following topics:

- Identification of significant findings, such as the main process step(s), material(s), and/or emission(s) contributing to the overall results
- Conclusions, limitations and recommendations

Note that in situations where no product outperforms all of its alternatives in each of the impact categories, some form of cross-category evaluation is necessary to draw conclusions regarding the environmental superiority of one product over the other. Since ISO 14044 rules out the use of quantitative weighting factors in comparative assertions to be disclosed to the public, this evaluation will take place qualitatively and the defensibility of the results therefore depend on the authors' expertise and ability to convey the underlying line of reasoning that led to the final conclusion.

2.8. Data Quality Requirements

The data used to create the inventory model shall be as precise, complete, consistent, and representative as possible with regards to the goal and scope of the study under given time and budget constraints.

- Measured primary data are considered to be of the highest precision, followed by calculated data, literature data, and estimated data. The goal is to model all relevant foreground processes using measured or calculated primary data.
- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. The goal is to capture all relevant data in this regard.
- Consistency refers to modelling choices and data sources. The goal is to ensure that differences in results reflect actual differences between product systems and are not due to inconsistencies in modelling choices, data sources, emission factors, or other artefacts.
- Reproducibility expresses the degree to which third parties would be able to reproduce the results of the study based on the information contained in this report. The goal is to provide enough transparency with this report so that third parties are able to approximate the reported results. This ability may be limited by the exclusion of confidential primary data and access to the same background data sources.
- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope. The goal is to use the most representative primary data for all foreground processes and the most representative industry-average data for all background processes. Whenever such data were not available (e.g., no industry-average data available for a certain country), best-available proxy data were employed.

2.9. Type and Format of the Report

In accordance with the ISO requirements (ISO, 2006) this document aims to report the results and conclusions of the LCA completely, accurately and without bias to the intended audience. The results, data, methods, assumptions and limitations are presented in a transparent manner and in sufficient detail to convey the complexities, limitations, and trade-offs inherent in the LCA to the reader. This allows the results to be interpreted and used in a manner consistent with the goals of the study.

2.10. Software and Database

The LCA model was created using the GaBi 10 Software system for life cycle engineering, developed by Sphera Solutions Inc. The GaBi 2021 LCI database provides the life cycle inventory data for several of the raw and process materials obtained from the background system.

2.11. Critical Review

No review was conducted for this study

4. LCIA Results

This chapter contains the results for the impact categories and additional metrics defined in Selection of LCIA Methodology and Impact Categories. It shall be reiterated at this point that the reported impact categories represent impact potentials, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the chosen functional unit (relative approach).

LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

4.1. Overall Results

The result of all the life cycle stages including manufacturing process, use and transport of HIT Aerosol is shown in Table 12 for the functional unit.

Table 12 Cradle to grave LCIA results for functional unit

Environmental Impact Category	Total	Manufacturing	Transport	Use
Abiotic Depletion (ADP elements)	4.03E-07	4.02E-07	0	1.08E-09
Abiotic Depletion (ADP fossil) [MJ]	13.344	13.288	0	0.0562
Acidification Potential (AP) [kg SO2 eq.]	0.0028	0.0027	0.00001	2E-05
Eutrophication Potential (EP) [kg Phosphate eq.]	0.0017	0.0004	0	0.0013
Global Warming Potential (GWP 100 years) [kg CO2 eq.]	1.0331	0.6732	0.00585	0.3541
Global Warming Potential (GWP 100 years), excl biogenic carbon [kg CO2 eq.]	1.3734	1.0588	0.00556	0.309
Ozone Layer Depletion Potential (ODP, steady state) [kg R11 eq.]	3.42E-12	3.42E-12	0	0
Photochem. Ozone Creation Potential (POCP) [kg Ethene eq.]	0.01377	0.0036	-0.00001	0.0134

Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]	22.447	22.383	0	0.0635
Blue water consumption [kg]	3.3502	3.34E+00	0	0.0066

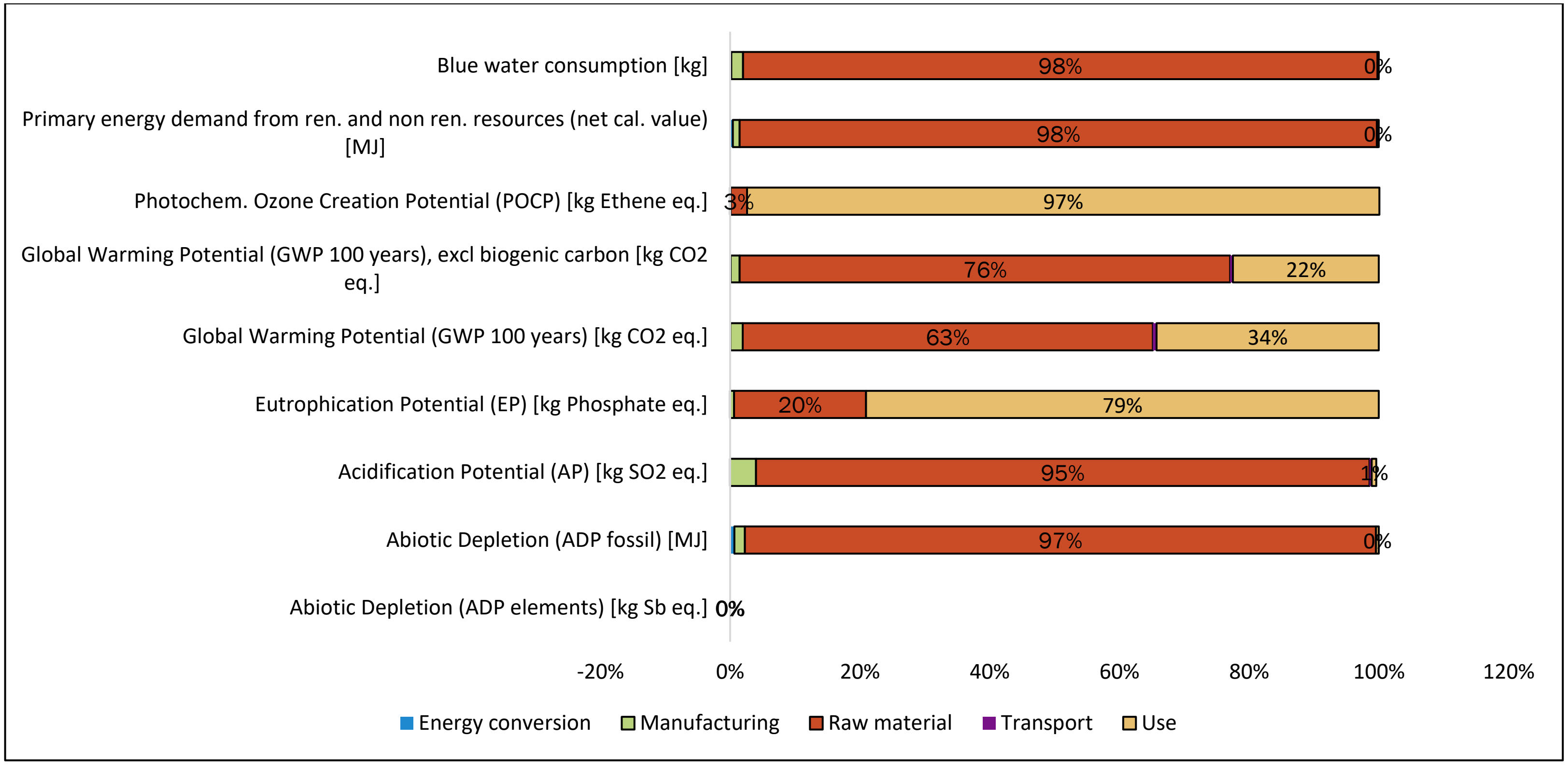


Figure 7 Cradle to grave LCIA results for functional unit

Figure 7 shows the percentage contribution of Life cycle stages of HIT Aerosol considering various impact categories. The major contribution in most of the impact categories is due to raw material of HIT Aerosol followed by use phase and production process.

4.2. Process-wise Analysis

This section shows the process wise results of all process involved in the manufacturing process and use of HIT Aerosol.

4.2.1. Process Wise LCIA Results for Manufacturing Process

The manufacturing process includes raw material and production process. The Production process involves the use of electricity for various process involved in HIT Aerosol. The impact of chemicals involved in all the raw material has been accounted. Table 13 shows process wise LCIA results for manufacturing process of HIT Aerosol

Table 13 Process wise LCIA results for manufacturing process

Environmental Impact Category	Total	Production	Raw material
Abiotic Depletion (ADP elements) [kg Sb eq.]	9.75E-10	9.75E-10	0
Abiotic Depletion (ADP fossil) [MJ]	1.33E+01	3.02E-01	12.9853
Acidification Potential (AP) [kg SO2 eq.]	2.72E-03	1.17E-04	0.0026
Eutrophication Potential (EP) [kg Phosphate eq.]	3.52E-04	1.16E-05	0.00034
Global Warming Potential (GWP 100 years) [kg CO2 eq.]	1.06E+00	2.02E-02	1.03858
Global Warming Potential (GWP 100 years), excl biogenic carbon [kg CO2 eq.]	1.05883	2.02E-02	1.03858
Ozone Layer Depletion Potential (ODP, steady state) [kg R11 eq.]	3.28E+00	6.62E-02	3.27747
Photochem. Ozone Creation Potential (POCP) [kg Ethene eq.]	3.56E-04	6.183E-06	0.00035
Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]	2.24E+01	3.32E-01	22.05088
Blue water consumption [kg]	3.34E+00	6.62E-02	3.28E+00

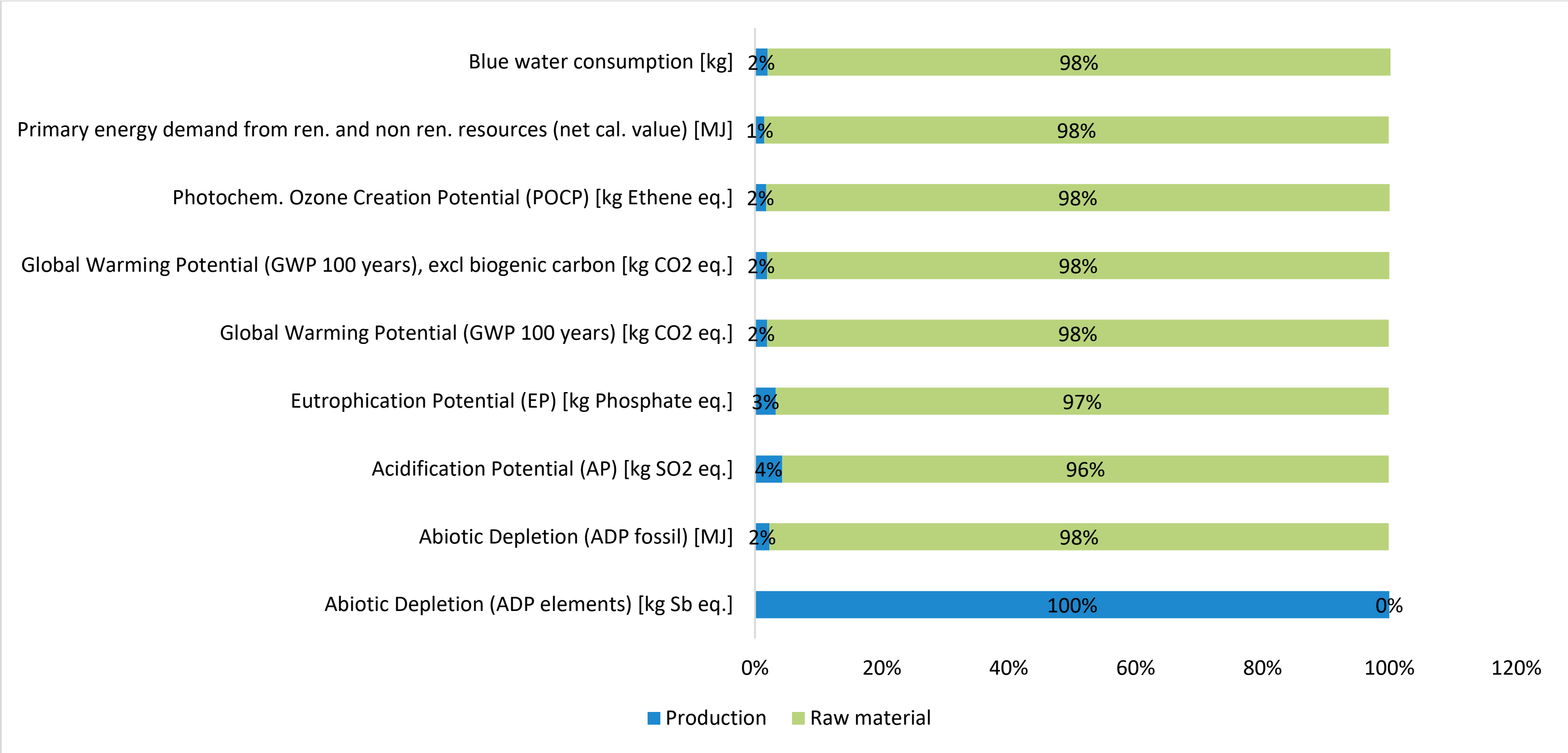


Figure 8 Percentage Contribution of each process involved in Manufacturing of HIT Aerosol

Figure 8 shows the percentage contribution of each process involved in the manufacturing of HIT Aerosol. The raw material contributes highest in major impact categories followed by use of raw material. The Abiotic Depletion (elements) has highest contribution from production process.

The raw material involves the use of Cap, HIT Box, Premix process, Tin Can, Premix process, Tin Can. material. The environmental impact of each of the material of HIT Aerosol is shown in Table 14

Environmental Impact Categories	Total	Cap	HIT Box	Premix process	Tin can	Valve	LPG
Abiotic Depletion (ADP elements) [kg Sb eq.]	0.000000401	7.86E-09	6.98E-08	0.000000198	2.94E-08	9.07E-08	4.96E-09
Abiotic Depletion (ADP fossil) [MJ]	12.98531	1.39245	1.2701	4.25758	4.52254	0.44506	1.03939
Acidification Potential (AP) [kg SO2 eq.]	0.0026	0.00029	0.00045	0.00016	0.00107	0.00007	0.00054
Eutrophication Potential (EP) [kg Phosphate eq.]	0.000336	0.0000177	0.000138	0.0000213	0.000106	0.0000107	0.0000392
Global Warming Potential (GWP 100 years) [kg CO2 eq.]	0.65327	0.05361	-0.28239	0.12198	0.51467	0.03162	0.20943
Global Warming Potential (GWP 100 years), excl biogenic carbon [kg CO2 eq.]	1.03858	0.05359	0.1024	0.1218	0.51449	0.03253	0.20942
Ozone Layer Depletion Potential (ODP, steady state) [kg R11 eq.]	3.42E-12	2.49E-16	3.42E-12	4.34E-16	1.32E-15	1.02E-16	1.9E-16
Photochem. Ozone Creation Potential (POCP) [kg Ethene eq.]	0.00035	0.0000216	0.0000509	0.0000429	0.000173	0.0000104	0.0000538
Primary energy demand from ren. and non ren. resources (net cal. value) [MJ]	22.1	1.51	9.36	4.37	5.31	0.505	1.13
Blue water consumption [kg]	3.28	0.24064	0.99314	0.49091	1.09978	0.36318	0.08632

Table 14 Environmental Impact of Raw material present in HIT Aerosol

A
Life Cycle Assessment Report

on

Good Kinght Coils

for

M/s Godrej Consumer Products Limited

Godrej One, Pirojshanagar, Vikhroli,
Mumbai, Maharashtra, 400079

Prepared by

M/s Sus-Tech Solutions
www.sustechsolutions.in

Supported by

Visvesvaraya National Institute of Technology
Nagpur- 440010 (India)

May 2021

1.	Name of Company	:	M/s Godrej Consumer Products Limited
2.	Address	:	Godrej One, Pirojshanagar, Vikhroli, Mumbai, Maharashtra, 400079
3.	Contact Person	:	Mr. Sushant Shetty
4.	Contact Details	:	+91-8879448102
5.	Report type	:	Life cycle assessment report

Note:

This Life cycle assessment report has been prepared for technical guidance based on data and information made available to Sus-Tech Solutions. Sus-Tech Solutions shall not be responsible for any consequence due to incorrect data information furnished by M/s Godrej Consumer Products Limited or due to any reasons beyond the control of Sus-Tech Solutions. This report shall not form a document in any dispute/litigation.

For Sus-Tech Solutions

Managing Partner

2. Due to non-availability of separate databases, similar entities are combined and modeled as follows:

Table 2 Raw materials and corresponding modeling substitutions

Sr. No.	Raw Materials	Modeled As
1	Prallethrin	Pyrethroid
2	Tamarind Starch Powder, Modified Starch	Starch
3	Leaflet, Barcode stickers	Graphic Paper
4	Coil Stand	Steel Tinplated
5	HDPE bag, Ribbon roll, BOPP tape	HDPE
6	Corrugated box, Printed cartons	Corrugated Boards

3. A truck with a gross weight of 20-26 tonnes and a payload capacity of 17.3 tonnes (Bharat Stage IV engine) with an average utilization of 55% is assumed to be used for transportation of raw materials and products. The source of emission calculations is as per Handbook Emission Factors for Road Transport (HBEFA) 3.3 status April 2017. India specific Diesel refinery mix is used to take into account emissions due to production of diesel
4. Pre-modeled India specific database for electricity mix is used for simulating the indirect emissions associated with consumption of electricity by the industry. The electricity production mix stands as a culmination of electricity produced from different sources across the country with appropriate proportions, supported by literature and research data.
5. Following weight assumptions are considered for modeling:

Table 3 Weight assumptions for packing fitments

Sr. No.	**Raw Material**	**Weight**
1	Barcode stickers	1 g per packet
2	BOPP	10 g per case
3	Ink	1 g per packet
4	Ribbon roll	2 g per packet

6. For modeling of use phase, the following emission data is considered [8]:

Table 4 Emissions due to coil burning in use phase

Sr. No.	**Emission stream**	**Emission rate (mg/g)**
1	Methane (CH4)	4.70
2	Carbon monoxide (CO)	82.38
3	Carbon dioxide (CO_2)	13.78
4	Oxides of Nitrogen (NOx)	0.26
5	PM2.5	32.48
6	PM10	30.02

7. End of life modeling of leaflet, barcode stickers, printed carton and corrugated boxes is considered as landfill of paper waste which is India specific
8. End of life of HDPE 50 micron bag, ribbon roll, BOPP tape is considered as landfill of plastic waste which is India specific
9. The present analysis is for all operations of the plant that includes raw material production (cradle), raw material transportation, raw material processing, product handling, product transportation, use phase and end of life disposal (grave).

10. Due to absence of the data of solvent and cleaning solution, these are kept out of scope of the study
11. The results are subject to inventory data provided by M/s Godrej Consumer Products Limited

All the data is considered for one batch production of product (Maha Jumbo and Low Smoke).

5.3 Impact Assessment Method

The present study uses CML 2001 (updated version Jan. 2016) life cycle impact assessment method for evaluation of environmental impacts. The environmental impacts are quantified in terms of several mid-point indicators namely, Abiotic Depletion (ADP elements) [kg Sb eq.], Abiotic Depletion (ADP fossil) [MJ], Acidification Potential (AP) [kg SO_2 eq.], Eutrophication Potential (EP) [kg Phosphate eq.], Freshwater Aquatic Ecotoxicity Pot. (FAETP inf.) [kg DCB eq.], Global Warming Potential (GWP 100 years), excl biogenic carbon [kg CO_2 eq.], Human Toxicity Potential (HTP inf.) [kg DCB eq.], Marine Aquatic Ecotoxicity Pot. (MAETP inf.) [kg DCB eq.], Ozone Layer Depletion Potential (ODP, steady state) [kg R11 eq.] and Terrestrial Ecotoxicity Potential (TETP inf.) [kg DCB eq.] [9]. The method originally developed by the University of Leiden, Netherlands in the year 2001 contains around 1700 flows that allow different modeling of different product. This study utilizes the professional database integrated with CML methodology [10].

.

6. Analysis

6.1 Good Knight Maha Jumbo

From the analysis done using the data provided for the functional unit, Figure 4 shows the system boundary and Table 5 shows the overall midpoint indicators for Good Knight Maha Jumbo.

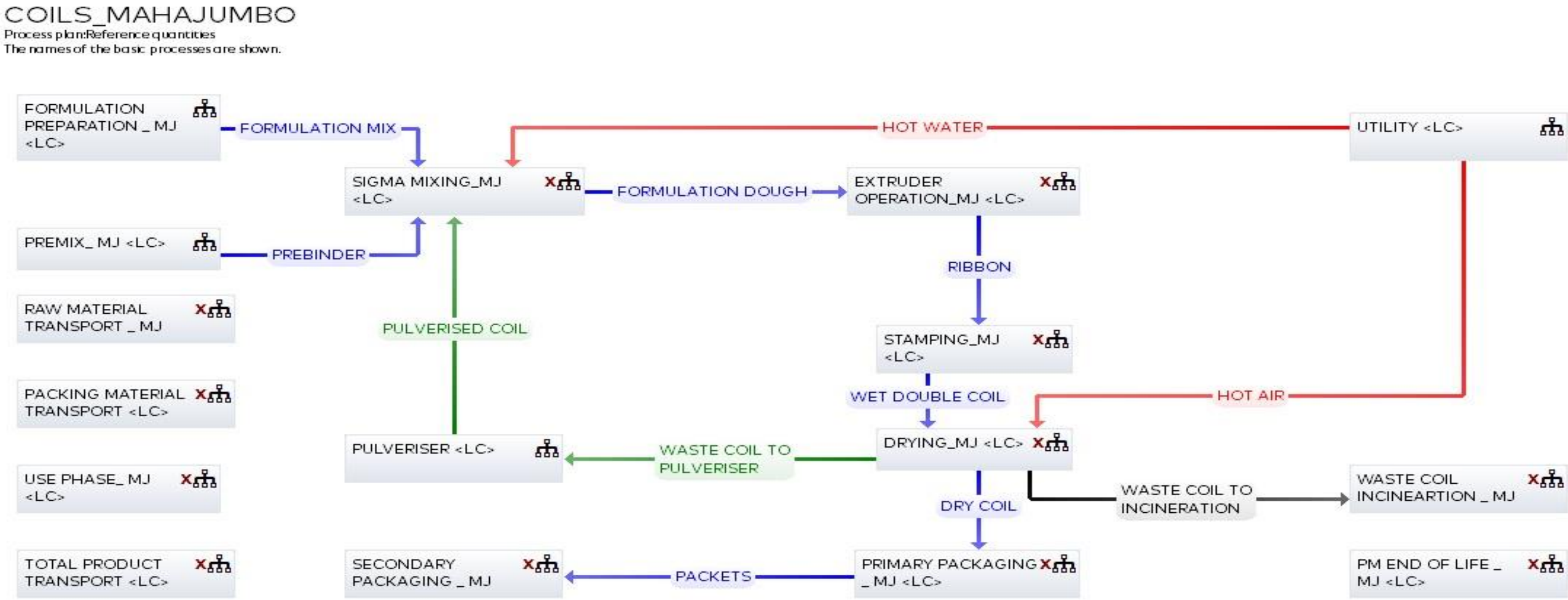


Figure 4 System boundary for Good Knight Maha Jumbo

Table 5 Midpoint indicators for Good Knight Maha Jumbo

Steps \ Environmental Indicators	GWP	AP	EP	ODP	TETP	HTP
TOTAL	621.628	2.565	3.94E-01	1.39E-08	1.783	72.846
DRYING_MJ <LC>	29.500	0.344	1.57E-02	1.50E-13	0.070	9.050
EXTRUDER OPERATION_MJ <LC>	13.500	0.158	7.18E-03	6.86E-14	0.032	4.150
FORMULATION PREPARATION _ MJ <LC>	2.330	0.017	1.03E-03	8.30E-15	0.004	0.366
PACKING MATERIAL TRANSPORT <LC>	1.340	0.006	1.27E-03	1.49E-16	0.000	0.029
PM END OF LIFE _ MJ <LC>	47.600	0.020	2.18E-02	1.33E-14	0.046	0.235
PREMIX_ MJ <LC>	61.626	0.182	1.04E-01	1.48E-10	0.098	5.566
PRIMARY PACKAGING _ MJ <LC>	115.659	0.616	6.60E-02	1.35E-08	0.832	16.497
PULVERISER <LC>	0.353	0.004	1.88E-04	1.79E-15	0.001	0.108
RAW MATERIAL TRANSPORT _ MJ <LC>	54.229	0.238	5.14E-02	6.03E-15	0.017	1.190
SECONDARY PACKAGING _ MJ <LC>	74.141	0.451	4.86E-02	2.57E-10	0.608	11.279
SIGMA MIXING_MJ <LC>	15.213	0.163	8.44E-03	8.56E-14	0.040	4.238
STAMPING_MJ <LC>	8.730	0.102	4.64E-03	4.43E-14	0.021	2.678
TOTAL PRODUCT TRANSPORT <LC>	2.853	0.012	2.70E-03	3.17E-16	0.001	0.063

USE PHASE_ MJ <LC>	36.819	0.033	8.56E-03	0.00E+00	0.000	13.059
UTILITY <LC>	153.391	0.216	5.14E-02	5.08E-15	0.013	2.797
WASTE COIL INCINEARTION _ MJ <LC>	4.342	0.004	1.01E-03	0.00E+00	0.000	1.540

Steps / **Environmental Indicators**	**ADP elements**	**ADP fossil**	**FAETP**	**MAETP**	**FD**	**FWC**
TOTAL	4.96E-04	7881.071	2.886	2.21E+05	189.19	1.982
DRYING_MJ <LC>	2.16E-06	302.000	0.064	4.45E+04	7.18	0.113
EXTRUDER OPERATION_MJ <LC>	9.90E-07	138.000	0.029	2.04E+04	3.29	0.052
FORMULATION PREPARATION _ MJ <LC>	1.15E-04	43.600	0.007	1.64E+03	1.05	0.011
PACKING MATERIAL TRANSPORT <LC>	1.84E-08	18.000	0.004	5.33E+01	0.42	0.000
PM END OF LIFE _ MJ <LC>	5.99E-07	58.700	0.011	8.40E+02	1.42	0.007
PREMIX_ MJ <LC>	3.67E-05	848.442	1.591	1.14E+04	21.52	0.622
PRIMARY PACKAGING _ MJ <LC>	2.12E-04	1804.492	0.604	5.90E+04	42.59	0.505
PULVERISER <LC>	2.59E-08	3.614	0.001	5.33E+02	0.09	0.001
RAW MATERIAL TRANSPORT _ MJ <LC>	7.45E-07	729.353	0.149	2.16E+03	17.08	0.006

SECONDARY PACKAGING _ MJ <LC>	3.35E-05	989.181	0.301	4.61E+04	23.30	0.371
SIGMA MIXING_MJ <LC>	8.84E-05	171.667	0.040	2.06E+04	4.12	0.254
STAMPING_MJ <LC>	6.39E-07	89.279	0.019	1.32E+04	2.13	0.034
TOTAL PRODUCT TRANSPORT <LC>	3.92E-08	38.372	0.008	1.14E+02	0.90	0.000
USE PHASE_ MJ <LC>	0.00E+00	0.000	0.000	0.00E+00	0.00	0.000
UTILITY <LC>	5.14E-06	2646.371	0.059	4.06E+02	64.10	0.004
WASTE COIL INCINEARTION _ MJ <LC>	0.00E+00	0.000	0.000	0.00E+00	0.00	0.000

Figure 5 shows the shows pictorially the individual contribution of steps under study to the overall environmental indicator values.

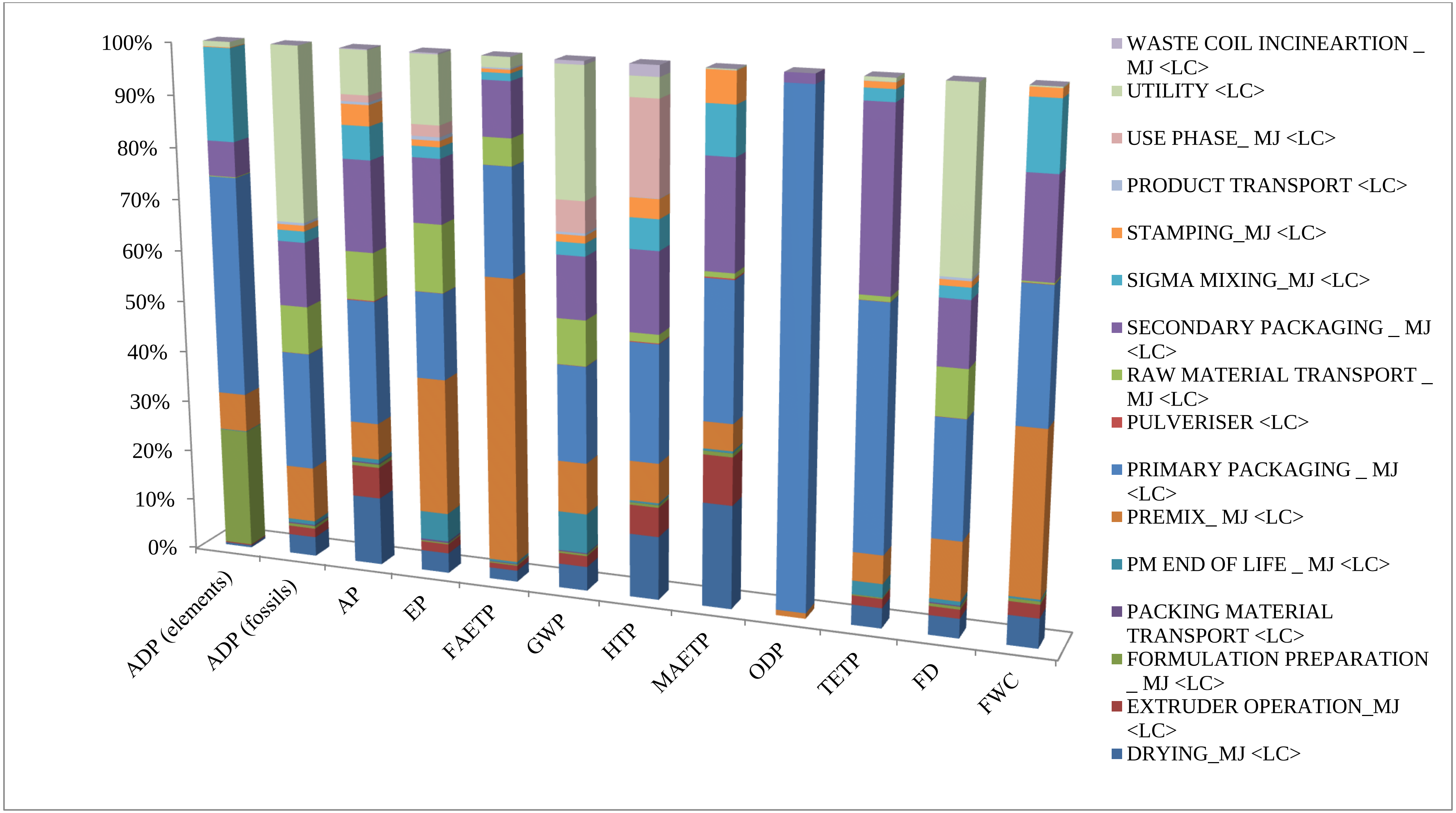


Figure 5 Percentage contributions of Midpoint Indicators for Good Knight Maha Jumbo

Observations:

1. The step "UTILITY" contributed maximum of 24.68 % to the overall GWP attributed to the use of thermal energy
2. The transport of raw materials contributes 8.94% of the overall GWP
3. The transport of product contributes 0.46 % of the overall GWP
4. The percentage contribution of indirect emissions to GWP due to manufacture of raw materials is 40.63 % which is attributed to Pyrethroid (0.37 %), sodium benzoate (0.23 %), starch (8.54 %), steel tinplated (2.53 %), graphic paper (0.09 %), cationic dye (0.47 %), corrugated boards (25.82 %), HDPE (1.62 %), saw dust (0.76 %), sodium chloride (0.07 %) and acid dye (0.12 %)
5. A 10% reduction in electricity consumption reduces the GWP by 1.09 %
6. A 10% reduction in thermal energy consumption reduces the GWP by 2.46 %

Hotspots:

A hotspot can be defined as the unit process/step that contributes maximum towards the overall impact. Table 6 describes the top three contributors for Good Knight Maha Jumbo aligned in descending order of their percentage contribution.

Table 6 Table of observed hotspots for Good Knight Maha Jumbo

Sr. No.	Indicator	Step	% Contribution	Attribution
1	GWP	**UTILITY**	**24.68**	**Thermal energy**
		PRIMARY PACKAGING _ MJ	18.61	Steel tinplate, graphic paper, basic blue (ink), corrugated boards, HDPE
		SECONDARY	11.93	Corrugated boards

		PACKAGING _ MJ		
2	AP	**PRIMARY PACKAGING _ MJ**	**24.02**	**Steel tinplate, graphic paper, basic blue (ink), corrugated boards, HDPE**
		SECONDARY PACKAGING _ MJ	17.58	Corrugated boards
		DRYING_MJ	13.41	Electricity
3	EP	**PREMIX_ MJ**	**26.47**	**Electricity, sodium benzoate, starch, saw dust**
		PRIMARY PACKAGING _ MJ	16.74	Steel tinplate, graphic paper, basic blue (ink), corrugated boards, HDPE
		RAW MATERIAL TRANSPORT _ MJ	13.04	Transport
4	ODP	**PRIMARY PACKAGING _ MJ**	**97.09**	**Steel tinplate, graphic paper, basic blue (ink), corrugated boards, HDPE**
		SECONDARY	1.85	Corrugated boards

		PACKAGING _ MJ		
		PREMIX_ MJ	1.06	Electricity, sodium benzoate, starch, saw dust
5	FWC	**PREMIX_ MJ**	**31.38**	**Electricity, sodium benzoate, starch, saw dust**
		PRIMARY PACKAGING _ MJ	25.48	Steel tinplate, graphic paper, basic blue (ink), corrugated boards, HDPE
		SECONDARY PACKAGING _ MJ	18.73	Corrugated boards

6.2 Good Knight Low Smoke

From the analysis done using the data provided for the functional unit, Figure 6 shows the system boundary and Table 7 shows the midpoint indicators for Good Knight Low Smoke

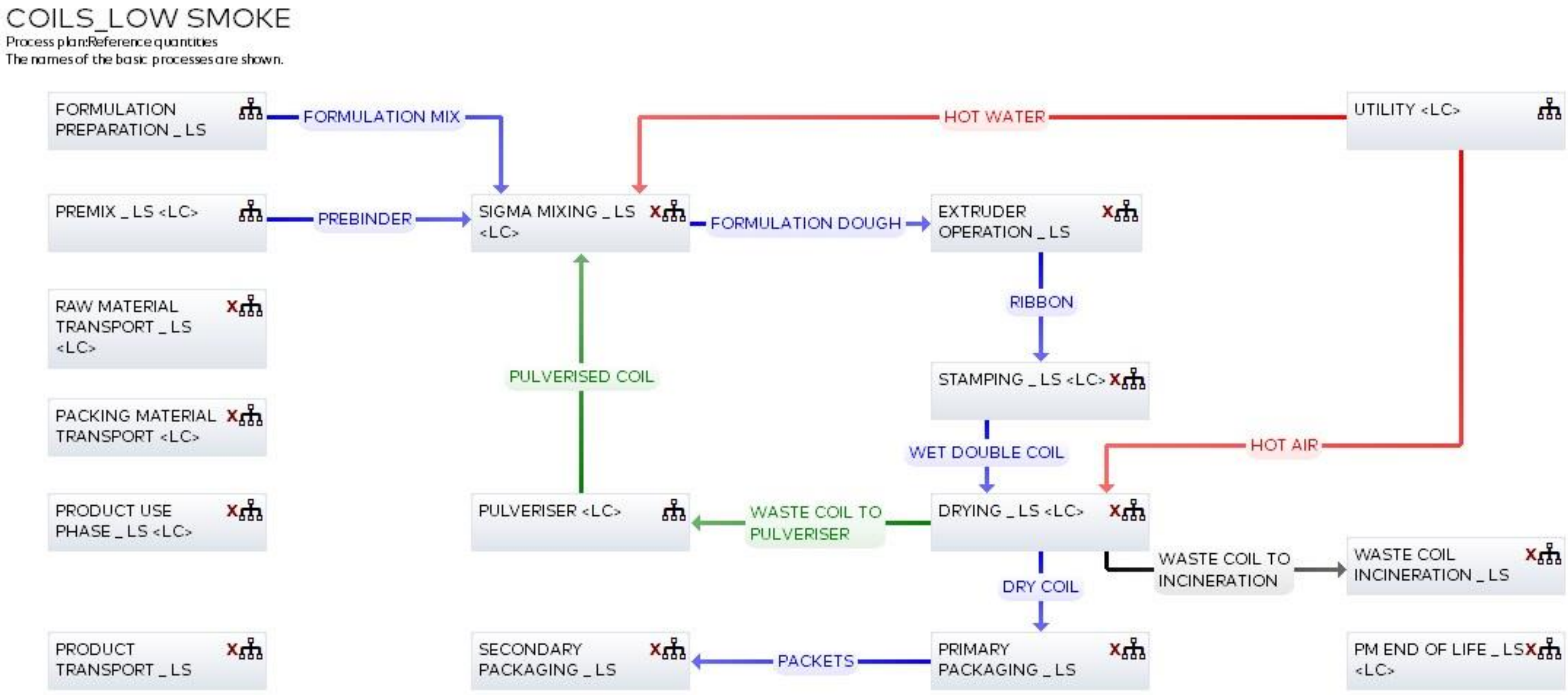


Figure 6 System boundary for Good Knight Low Smoke

Table 7 Midpoint indicators for Good Knight Low Smoke

Steps \ Environmental Indicators	GWP	AP	EP	ODP	TETP	HTP
TOTAL	980.774	3.949	9.10E-01	4.65E-06	34.918	383.166
DRYING _ LS <LC>	29.500	0.344	1.57E-02	1.50E-13	0.070	9.050
EXTRUDER OPERATION _ LS <LC>	13.500	0.158	7.18E-03	6.86E-14	0.032	4.150
FORMULATION PREPARATION _ LS <LC>	2.920	0.021	1.29E-03	1.04E-14	0.005	0.458
PACKING MATERIAL TRANSPORT <LC>	0.648	0.003	6.14E-04	7.20E-17	0.000	0.014
PM END OF LIFE _ LS <LC>	51.100	0.022	2.38E-02	1.49E-14	0.053	0.262
PREMIX _ LS <LC>	37.855	0.110	4.56E-02	6.25E-08	0.062	3.516
PRIMARY PACKAGING _ LS <LC>	319.017	1.407	4.30E-01	4.59E-06	33.856	320.997
PRODUCT TRANSPORT _ LS <LC>	2.985	0.013	2.83E-03	3.32E-16	0.001	0.066
PRODUCT USE PHASE _ LS <LC>	38.352	0.034	8.92E-03	0.00E+00	0.000	13.603
PULVERISER <LC>	0.368	0.004	1.96E-04	1.87E-15	0.001	0.113
RAW MATERIAL TRANSPORT _ LS <LC>	167.721	0.735	1.59E-01	1.86E-14	0.052	3.681
SECONDARY PACKAGING _ LS <LC>	77.228	0.470	5.06E-02	2.68E-10	0.633	11.749
SIGMA MIXING _ LS <LC>	68.999	0.300	1.06E-01	1.22E-10	0.119	8.356

STAMPING _ LS <LC>	8.730	0.102	4.64E-03	4.43E-14	0.021	2.678
UTILITY <LC>	157.324	0.221	5.27E-02	5.21E-15	0.014	2.869
WASTE COIL INCINERATION _ LS <LC>	4.526	0.004	1.05E-03	0.00E+00	0.000	1.605

Environmental Indicators / **Steps**	**ADP elements**	**ADP fossil**	**FAETP**	**MAETP**	**FD**	**FWC**
TOTAL	4.83E-04	12631.947	52.218	4.45E+05	325.97	16.345
DRYING _ LS <LC>	2.16E-06	302.000	0.064	4.45E+04	7.18	0.113
EXTRUDER OPERATION _ LS <LC>	9.90E-07	138.000	0.029	2.04E+04	3.29	0.052
FORMULATION PREPARATION _ LS <LC>	1.43E-04	54.500	0.009	2.06E+03	1.31	0.014
PACKING MATERIAL TRANSPORT <LC>	8.90E-09	8.710	0.002	2.58E+01	0.20	0.000
PM END OF LIFE _ LS <LC>	6.69E-07	65.500	0.012	9.37E+02	1.58	0.008
PREMIX _ LS <LC>	2.81E-05	647.979	0.549	6.75E+03	16.00	0.922
PRIMARY PACKAGING _ LS <LC>	2.26E-04	4395.693	49.262	2.74E+05	128.03	13.953
PRODUCT TRANSPORT _ LS <LC>	4.10E-08	40.142	0.008	1.19E+02	0.94	0.000
PRODUCT USE PHASE _ LS <LC>	0.00E+00	0.000	0.000	0.00E+00	0.00	0.000

PULVERISER <LC>	2.70E-08	3.767	0.001	5.56E+02	0.09	0.001
RAW MATERIAL TRANSPORT _ LS <LC>	2.30E-06	2255.774	0.460	6.69E+03	52.83	0.018
SECONDARY PACKAGING _ LS <LC>	3.49E-05	1030.367	0.313	4.81E+04	24.30	0.387
SIGMA MIXING _ LS <LC>	3.89E-05	886.010	1.429	2.72E+04	22.39	0.838
STAMPING _ LS <LC>	6.39E-07	89.279	0.019	1.32E+04	2.13	0.034
UTILITY <LC>	5.27E-06	2714.226	0.061	4.16E+02	65.70	0.004
WASTE COIL INCINERATION _ LS <LC>	0.00E+00	0.000	0.000	0.00E+00	0.00	0.000

Figure 7 shows the shows pictorially the individual contribution of steps under study to the overall environmental indicator values.

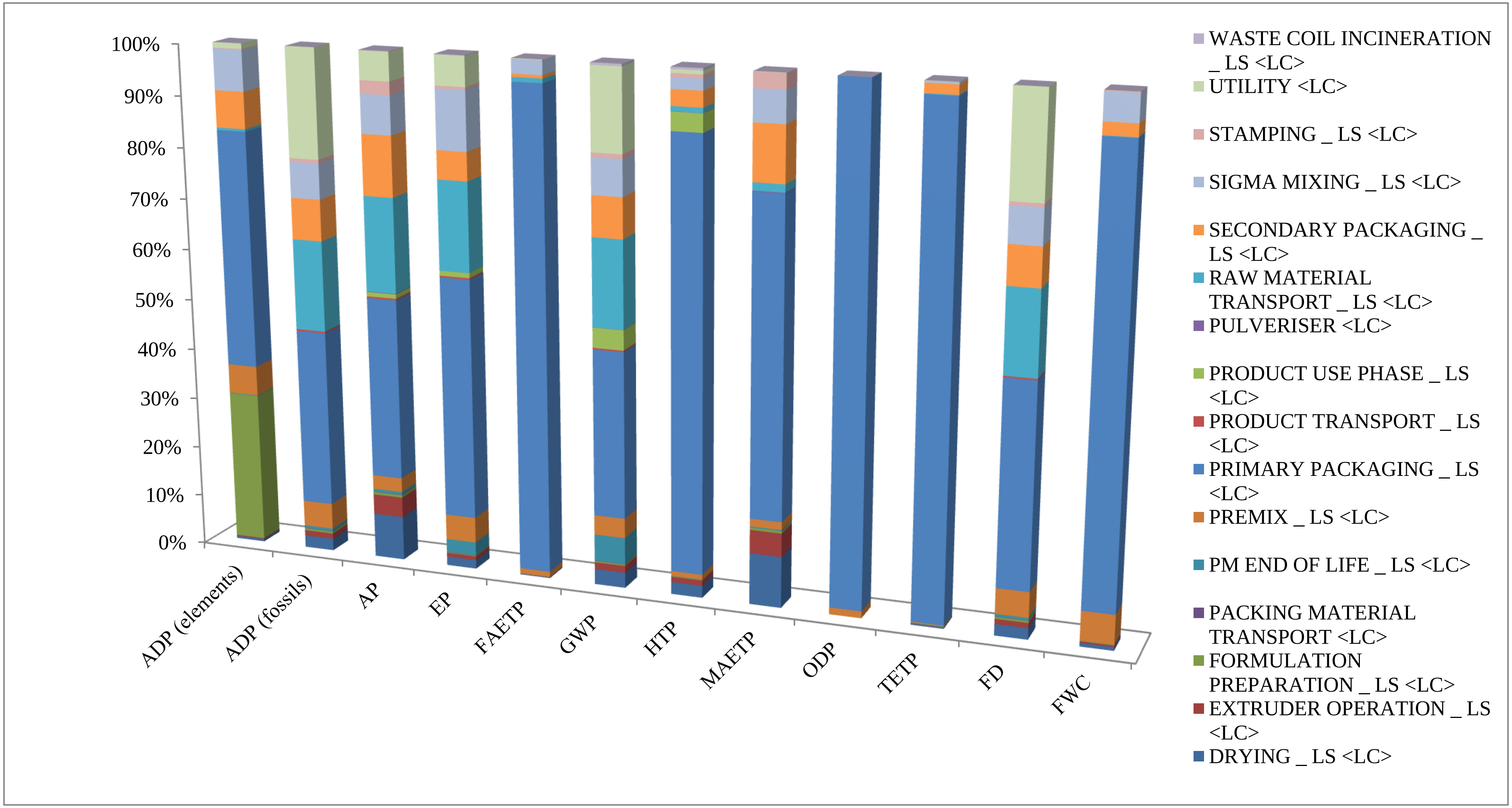


Figure 7 Percentage contributions of Midpoint Indicators for Good Knight Low Smoke

Observations:

1. The step "PRIMARY PACKAGING_LS " contributed maximum of 32.53 % to the overall GWP attributed to the use of steel tinplate, clay, graphic paper, basic blue (ink), corrugated boards and HDPE
2. The transport of raw materials contributes 17.17 % of the overall GWP
3. The transport of product contributes 0.30 % of the overall GWP
4. The percentage contribution of indirect emissions to GWP due to manufacture of raw materials is 50.14 % which is attributed to Pyrethroid (0.30 %), sodium benzoate (0.51 %), starch (7.44 %), steel tinplated (1.67 %), graphic paper (19.78 %), cationic dye (0.31 %), corrugated boards (17.05 %), HDPE (1.62 %), saw dust (0.46 %), activated carbon (0.85 %), clay (0.06 %) and calcium carbonate (0.09 %)
5. A 10% reduction in electricity consumption reduces the GWP by 0.67 %
6. A 10% reduction in thermal energy consumption reduces the GWP by 1.60 %

Hotspots:

A hotspot can be defined as the unit process/step that contributes maximum towards the overall impact. Table 8 describes the top three contributors for Good Knight Low Smoke arranged in descending order of their percentage contribution.

Table 8 Table of observed hotspots for Good Knight Low Smoke

Sr. No.	Indicator	Step	% Contribution	Attribution
1	GWP	**PRIMARY PACKAGING _ LS**	**32.53**	**Steel tinplate, graphic paper, basic blue (ink), corrugated boards, HDPE**

		RAW MATERIAL TRANSPORT _ LS	17.10	Transport
		UTILITY	16.04	Thermal energy
2	AP	**PRIMARY PACKAGING _ LS**	**35.63**	**Steel tinplate, graphic paper, basic blue (ink), corrugated boards, HDPE**
		RAW MATERIAL TRANSPORT _ LS	18.61	Transport
		SECONDARY PACKAGING _ LS	11.90	Corrugated boards
3	EP	**PRIMARY PACKAGING _ LS**	**47.25**	**Steel tinplate, graphic paper, basic blue (ink), corrugated boards, HDPE**
		RAW MATERIAL TRANSPORT _ LS	17.48	Transport
		SIGMA MIXING _ LS	11.61	Electricity, Starch, saw dust
4	ODP	**PRIMARY PACKAGING _ LS**	**98.65**	**Steel tinplate, graphic paper, basic blue (ink),**

				corrugated boards, HDPE
		PREMIX _ LS	1.34	Electricity, sodium benzoate, clay, calcium carbonate, starch, activated carbon
		SECONDARY PACKAGING _ LS	0.01	Corrugated boards
5	FWC	**PRIMARY PACKAGING _ LS**	**85.36**	**Steel tinplate, graphic paper, basic blue (ink), corrugated boards, HDPE**
		PREMIX _ LS	5.64	Electricity, sodium benzoate, clay, calcium carbonate, starch, activated carbon
		SIGMA MIXING _ LS	5.13	Electricity, Starch, saw dust

7. Results

As per the results obtained, the **GWP intensity** based on number of packets produced for **Good Knight Maha Jumbo** and **Good Knight Low Smoke** were determined as presented in Table 9. It is evident from the table that the net GWP associated with production of Good Knight Low Smoke are higher than that of Good Knight Maha Jumbo.

Table 9 GWP intensity based on number of packets produced

Sl. No.	**Product**	**Total GWP (kg CO2 eq)**	**Total number of packets**	**GWP intensity (kg CO2/packet of coil)**
1	Good Knight Maha Jumbo	621.628	1369	0.454
2	Good Knight Low Smoke	980.774	1426	0.688

Another analysis done based on total quantity of production (in kg) for **Good Knight Maha Jumbo** and **Good Knight Low Smoke** revealed a similar pattern as presented in Table 10. The total quantity takes into account the weight of packing materials and standard packet contents as well.

Table 10 GWP intensity based on production quantity (in kg)

Sl. No.	Product	Total GWP (kg CO2 eq)	Total production quantity (kg)	GWP intensity (kg CO2/kg of coil)
1	Good Knight Maha Jumbo	621.628	293.050	2.121
2	good Knight Low Smoke	980.774	305.250	3.213

Life cycle phase-wise impacts

The current analysis considers all the life cycle phases involved for evaluation of total impacts, namely:

1. **Raw material acquisition-** Considers environmental impacts due to raw material manufacturing; includes packing material as well
2. **Raw material transport-** Transport of process raw materials and packing materials
3. **Manufacturing-** Production process, Gate-to-gate
4. **Product transport**
5. **Use phase-** Assumes emissions due to coil burning
6. **End of life/Disposal-** Impacts due to disposal of packing materials

Table 11 shows phase wise impacts associated with Good Knight Maha Jumbo while Table 12 shows the same for Good Knight Low Smoke.

Table 11 Phase-wise impacts for Good Knight Maha Jumbo

Sl. No.	Life Cycle Phase	Impact Indicators			
		GWP	**AP**	**EP**	**ODP**
1	Raw material acquisition	252.555	1.241	0.220	1.39E-08
2	Raw material transport	55.569	0.243	0.053	6.18E-15
3	Manufacturing	226.232	1.015	0.089	3.62E-13
4	Product transport	2.853	0.012	0.003	3.17E-16
5	Use	36.819	0.033	0.009	0.00E+00
6	End of Life	47.600	0.020	0.022	1.33E-14
Total		**621.628**	**2.565**	**0.394**	**1.39E-08**

Table 12 Phase-wise impacts for Good Knight Low Smoke

Sl. No.	Life Cycle Phase	GWP	AP	EP	ODP
1	Raw material acquisition	491.737	2.142	0.625	4.65E-06
2	Raw material transport	168.369	0.738	0.160	1.87E-14
3	Manufacturing	228.231	1.000	0.090	-4.19E-09
4	Product transport	2.985	0.013	0.003	3.32E-16
5	Use	38.352	0.034	0.009	0.00E+00
6	End of Life	51.100	0.022	0.024	1.49E-14
Total		**980.774**	**3.949**	**0.910**	**4.65E-06**

Scope-wise emissions

The overall emissions due to the production activities may be divided into three different scopes based on the individual contributors, namely:

Scope 1: Comprises of all direct emissions occurring due to on campus activities

Scope 2: Emissions due to electricity

Scope 3: All indirect emissions (includes emissions due to raw material manufacturing, product use, end of life and all transport activities)

Table 13 represents the percent contributions for Good Knight Maha Jumbo and Good Knight Low Smoke while Figures 8 and 9 represent the same pictorially for Good Knight Maha Jumbo and Good Knight Low Smoke respectively.

Table 13 Scope-wise GWP for Good Knight Maha Jumbo and Good Knight Low Smoke

Sl. No.	Scope	Percent contribution	
		Good Knight Maha Jumbo	**Good Knight Low Smoke**
1	Scope 1	25.45	16.52
2	Scope 2	10.94	6.75
3	Scope 3	63.61	76.73
Total Impact (kg CO_2equivalents)		**621.628**	**980.774**

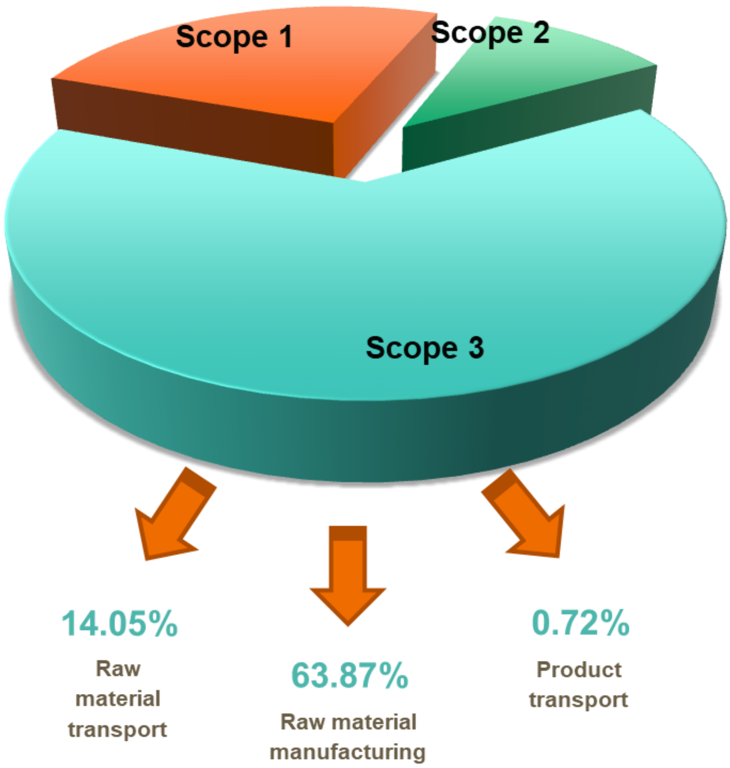


Figure 8 Scope-wise GWP for Good Knight Maha Jumbo

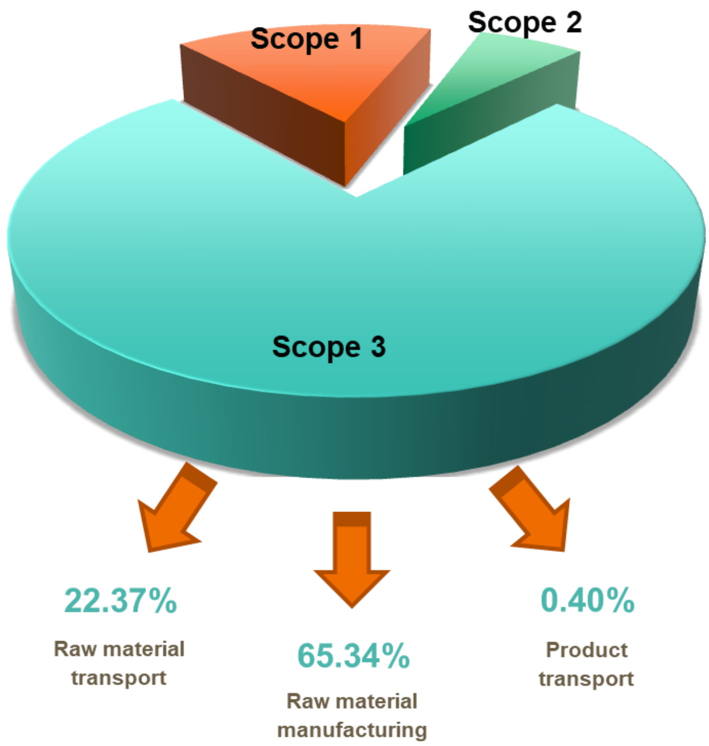


Figure 9 Scope-wise GWP for Good Knight Low Smoke

8. Recommendations

The present report discusses the environmental impacts for Good Knight Maha Jumbo and Low Smoke. Cradle-to-grave approach for evaluation of impacts has been adopted which includes raw material acquisition, raw material transport, manufacturing, product transport, use phase and end of life. Following are certain recommendations/observations based on the study:

1. Emissions pertaining to raw material manufacturing contributed around 40.63 % and 50.13 % of overall GWP for Maha Jumbo and Low Smoke respectively. A detailed environmental impact disclosure from the vendors of GCPL is recommended in the interest of obtaining GCPL specific environmental impacts.

2. Tables 6 and 8 discuss the hotspots in manufacturing activities across five major impact indicators. A reduction in the values can be sought by:
    a. Using greener (lesser environmental impact) raw materials
    b. Decreasing the overall energy requirement of the facility
3. Use of renewable energy sources: It is observed that the two major energy sources namely, natural gas and electricity, are being used and are majorly responsible for Scope 1 and Scope 2 emissions respectively. It is recommended to shift from conventional energy sources to renewable sources to further decrease the overall environmental footprint of Good Knight Coils.

4. Change of Equipment/ operating strategies: It is also recommended to install pumps with Variable frequency drive to further decrease their electricity consumption. Commission of electric motors adhering to IE3 standards can be achieved through EESL's National Motor Replacement Program (NMRP)

(https://eeslindia.org/en/nmrp/#). Specific solar power driven motors and pumps can be installed to decrease the operating environmental impact.

5. Periodic energy auditing focused on generating accurate inventory values for the aforementioned functional unit is recommended.

6. Primary and secondary packaging contributed around 18.61 % & 11.93 % for Maha Jumbo and 32.53 % & 7.87 % for Low Smoke respectively towards overall GWP, primarily attributed to use of graphic paper and corrugated boards. Hence, it is recommended to:

   a. Generate inventory details for specific LCA of packaging material

   b. Explore the possibility of utilization of greener packaging materials and/or develop recycling strategies for packing materials.

   This may be enabled by implementation of EPR (Extended Producer Responsibility). EPR is a concept which requires the producer to bear a notable responsibility for the environmental impact by their products, formulate a post-collection strategy and ensure recycle.

7. It is observed that mild steel used for making coil stands accounts for around 2.53 % and 1.67 % of overall GWP emissions for Maha Jumbo and Low Smoke respectively. It is recommended to explore the possibility of substitution of mild steel with appropriate greener alternative.

It is evident from above discussions that raw material converted to product is often associated with unavoidable environmental impacts for which some compensating measures have to be implemented by the manufacturer. It is realized that major environmental impact is caused due to indirect emissions beyond the control of GCPL and hence to compensate the emissions by enhancing green cover wherever possible can be an excellent option. The carbon sequestrated can be computed on an annual basis achieving carbon neutral status of the product. In addition to this, a detailed environmental impact study of other raw materials required for manufacturing is recommended.

9. Key Takeaways

- The report has been prepared in compliance with ISO 14040:2006
- The LCA results of Good Knight Coils plant are presented which clearly point out the 'hot spots' of the process. This will help GCPL to work on the process to improve/correct it
- This report can be used to inculcate life cycle thinking in the stakeholders of GCPL. It can be used to sensitize the stakeholders about the impact of each action
- The GWP of Good Knight Coils can be used for branding/marketing. GWP data can also be used in 'Green Marketing'
- With rising environmental awareness many European customer demands disclosure of GHG emission by vendor, the report can be used for the same purpose.
- Environmental burden indicators like GWP can be used by GCPL in its annual report/sustainability report offering commitment to its green resolve

10. References

1. Joglekar, S.N., Kharkar, R.A., Mandavgane, S.A., Kulkarni, B.D.: Sustainability assessment of brick work for low-cost housing : A comparison between waste based bricks and burnt clay bricks. Sustain. Cities Soc. 37, 396–406 (2018). doi:10.1016/j.scs.2017.11.025

2. Joglekar, S.N., Tandulje, A.P., Mandavgane, S.A., Kulkarni, B.D.: Environmental Impact Study of Bagasse Valorization Routes. Waste and Biomass Valorization. 0, 0 (2018). doi:10.1007/s12649-018-0198-9

3. ISO, I. "ISO 14040": Environmental management-Life cycle assessment-Principles and framework (ISO 14040: 2006). , Brussels (2006)

4. GaBi Database & Modelling Principles Principles Principles. (2016)

5. Acero, A.A.P., Rodríguez, C., Ciroth, A.: LCIA methods Impact assessment methods in Life Cycle Assessment and their impact categories. 1–23 (2016)

6. Rosenbaum, R.K., Bachmann, T.M., Jolliet, O., Juraske, R., Koehler, A., Hauschild, M.Z.: USEtox — the UNEP-SETAC toxicity model : recommended characterisation factors for human toxicity and freshwater ecotoxicity in life cycle impact assessment. Int. J. Life Cycle Assess. 532–546 (2008). doi:10.1007/s11367-008-0038-4

7. Guinee, J.B.: Handbook on Life Cycle Assessment. Operational Guide to the ISO Standards. (2002)

8. Lee, S.C.Ã., Wang, B.: Characteristics of emissions of air pollutants from mosquito coils and candles burning in a large environmental chamber. Atmos. Environ. 40, 2128–2138 (2006). doi:10.1016/j.atmosenv.2005.11.047

9. Thinkstep Gabi: CML 2001

10. Hischier, R., Editors, B.W., Althaus, H., Bauer, C., Doka, G., Dones, R., Frischknecht, R., Hellweg, S., Humbert, S., Jungbluth, N., Köllner, T., Loerincik, Y., Margni, M., Nemecek, T.: Implementation of Life Cycle Impact Assessment Methods. (2010)