GEF-6 REQUEST FOR ONE-STEP MEDIUM-SIZED PROJECT APPROVAL

TYPE OF TRUST FUND: GEF Trust Fund

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PART I: PROJECT IDENTIFICATION

Project Title:	Guidance development and case study documentation of green chemistry and technologies		
Country(ies):	Global	GEF Project ID:[1]	9373
GEF Agency(ies):	UNIDO (select) (select)	GEF Agency Project ID:	150185
Other Executing Partner(s):	Yale University National Cleaner Production Center in Brazil	Submission Date: Re-submission date:	01/13/2016 06/02/2016
GEF Focal Area(s):	Chemicals and Wastes	Project Duration (Months)	36 months
Integrated Approach Pilot	IAP-Cities ☐ IAP-Commodities ☐ IAP-Food Security ☐		
Name of Parent Program:	[if applicable]	Agency Fee ($)	168,150

A. FOCAL AREA STRATEGY FRAMEWORK AND PROGRAM[2]:

Focal Area Objectives/programs	Focal Area Outcomes	Trust Fund	(in $) GEF Project Financing	Co-financing
(select) CW-1 Program 1 (select)	Develop and demonstrate new tools and economic approaches for managing harmful chemicals and waste in a sound manner	GEFTF	1,770,000	6,524,000
(select) (select) (select)		(select)		
(select) (select) (select)		(select)		
(select) (select) (select)		(select)		
(select) (select) (select)		(select)		
(select) (select) (select)		(select)		
(select) (select) (select)		(select)		
(select) (select) (select)		(select)		
Total project costs			1,770,000	6,524,000

B. PROJECT FRAMEWORK

Project Objective: To increase global awareness, and technical capacities on deployable Green Chemistry approaches for the design of products and processes that advance global environmental benefits throughout their life cycles

Project Components/ Programs	Financing Type[3]	Project Outcomes	Project Outputs	Trust Fund	(in $) GEF Project Financing	Confirmed Co-financing
Component 1: Guidance document, training and awareness raising	TA	Outcome 1: Guidance document developed, training and awareness for green chemistry build	Output 1.1: Training on green chemistry and technology, including policy aspects, provided; Output 1.2: Guidance document on green chemistry	GEFTF	970,000	1,000,000

[1] Project ID number will be assigned by GEFSEC and to be entered by Agency in subsequent document submissions.
[2] When completing Table A, refer to the excerpts on *GEF 6 Results Frameworks for GETF, LDCF and SCCF*.
[3] Financing type can be either investment or technical assistance.

			developed and globally promoted			
Component 2: Green chemistry case study documention	TA	Outcome 2: Documentation of a selected green chemistry case studies and up-scaling	Output 2.1. Green chemistry cases study, including required policy framework conditions, in selectd countries documented	GEFTF	570,000	4,624,000
	TA		Output 2.2. Partnerships and business models (e.g. incentives) set up to further promote green chemistry	GEFTF	100,000	400,000
Component 3: Monitoring and evaluation	TA	Outcome 3: Project monitoring and evaluation in line with GEF and UNIDO requirements	Output 3.1. Project monitoring and evaluation plan designed and implemented Output 3.2. Terminal project evaluation completed	GEFTF	50,000	100,000
	(select)			(select)		
	(select)			(select)		
	(select)			(select)		
	(select)			(select)		
			Subtotal		1,690,000	6,124,000
			Project Management Cost (PMC)[4]	GEFTF	80,000	400,000
			Total GEF Project Financing		1,770,000	6,524,000

For multi-trust fund projects, provide the total amount of PMC in Table B, and indicate the split of PMC among the different trust funds here: (   )

C. SOURCES OF CO-FINANCING FOR THE PROJECT BY NAME AND BY TYPE

Please include confirmed co-financing letters for the project with this form.

Sources of Co-financing	Name of Co-financier	Type of Co-financing	Amount ($)
Private Sector	Braskem	Grant	5,000,000
Private Sector	Braskem	In-kind	1,106,000
Others	Uganda Cleander Production Centre	In-kind	20,000
Others	Egypt National Cleaner Production Centre	In-kind	100,000
Others	Sri Lanka National Cleaner Production Centre	In-kind	30,000

[4] For GEF Project Financing up to $2 million, PMC could be up to10% of the subtotal; above $2 million, PMC could be up to 5% of the subtotal. PMC should be charged proportionately to focal areas based on focal area project financing amount in Table D below.

Others	Colombia National Clearner Production Centre	In-kind	158,000
Others	Institute SENAI for Innovation on Green Chemistry	In-kind	80,000
GEF Agency	UNIDO	Grants	30,000
(select)		(select)	
(select)		(select)	
Total Co-financing			6,524,000

D. GEF/LDCF/SCCF Resources Requested by Agency(ies), Trust Fund, Country(ies), Focal Area and Programming of Funds

GEF Agency	Trust Fund	Country/ Regional/Global	Focal Area	Programming of Funds	(in $)		
					GEF Project Financing (a)	Agency Fee[a)] (b)	Total (c)=a+b
UNIDO	GEF TF	Global	Chemicals and Wastes	POPS	1,000,000	95,000	1,095,000
UNIDO	GEF TF	Global	Chemicals and Wastes	SAICM	770,000	73,150	843,150
(select)	(select)		(select)	(select as applicable)			0
(select)	(select)		(select)	(select as applicable)			0
(select)	(select)		(select)	(select as applicable)			0
(select)	(select)		(select)	(select as applicable)			0
(select)	(select)		(select)	(select as applicable)			0
(select)	(select)		(select)	(select as applicable)			0
(select)	(select)		(select)	(select as applicable)			0
(select)	(select)		(select)	(select as applicable)			0
Total Grant Resources					1,770,000	168,150	1,938,150

a) Refer to the Fee Policy for GEF Partner Agencies.

E. PROJECT'S TARGET CONTRIBUTIONS TO GLOBAL ENVIRONMENTAL BENEFITS[5]

Provide the expected project targets as appropriate.

Corporate Results	Replenishment Targets	Project Targets
1. Maintain globally significant biodiversity and the ecosystem goods and services that it provides to society	Improved management of landscapes and seascapes covering 300 million hectares	*hectares*
2. Sustainable land management in production systems (agriculture, rangelands, and forest landscapes)	120 million hectares under sustainable land management	*hectares*
3. Promotion of collective management of transboundary water systems and implementation of the full range of policy, legal, and institutional reforms and investments contributing to sustainable use and maintenance of ecosystem services	Water-food-ecosystems security and conjunctive management of surface and groundwater in at least 10 freshwater basins;	*Number of freshwater basins*
	20% of globally over-exploited fisheries (by volume) moved to more sustainable levels	*Percent of fisheries, by volume*
4. Support to transformational shifts towards a low-emission and resilient development	750 million tons of CO_{2e} mitigated (include both direct and indirect)	*metric tons*

[5] Provide those indicator values in this table to the extent applicable to your proposed project. Progress in programming against these targets for the projects per the *Corporate Results Framework* in the GEF-6 Programming Directions, will be aggregated and reported during mid-term and at the conclusion of the replenishment period. There is no need to complete this table for climate adaptation projects financed solely through LDCF and/or SCCF.

path		
5. Increase in phase-out, disposal and reduction of releases of POPs, ODS, mercury and other chemicals of global concern*	Disposal of 80,000 tons of POPs (PCB, obsolete pesticides)	* *metric tons*
	Reduction of 1000 tons of Mercury	*metric tons*
	Phase-out of 303.44 tons of ODP (HCFC)	*ODP tons*
6. Enhance capacity of countries to implement MEAs (multilateral environmental agreements) and mainstream into national and sub-national policy, planning financial and legal frameworks	Development and sectoral planning frameworks integrate measurable targets drawn from the MEAs in at least 10 countries	*Number of Countries:*
	Functional environmental information systems are established to support decision-making in at least 10 countries	*Number of Countries:*

***Global Environmental benefits**: see Part II, 1 e) Please note that the corporate targets in Table F are not directly applicable for this project. This is a global project to develop technical guidance on green chemistry and its applications and thus not focused yet on global environment impact interventions. However, it will provide the guidance both for the GEF and UN agencies for future programming. In addition, the project will include a pilot demonstration project which will provide a wide range of indirect global environmental benefits (as outlined in Part II, 1e). Additional case studies (with support from NCPCs) focusing on POPs, including the development of a Green Chemistry methodology to estimate POPs savings, will be incorporated into the guidance document.

F. DOES THE PROJECT INCLUDE A "NON-GRANT" INSTRUMENT? No

(If non-grant instruments are used, provide an indicative calendar of expected reflows to your Agency and to the GEF/LDCF/SCCF Trust Fund) in Annex B.

N/A

G. PROJECT PREPARATION GRANT (PPG)[6]

Is Project Preparation Grant requested? Yes ☐ No ☒ If no, skip item G.

PPG AMOUNT REQUESTED BY AGENCY(IES), TRUST FUND, COUNTRY(IES) AND THE PROGRAMMING OF FUNDS*

GEF Agency	Trust Fund	Country/ Regional/Global	Focal Area	Programming of Funds	(in $)		
					PPG (a)	Agency Fee[7] (b)	Total c = a + b
(select)	(select)		(select)	(select as applicable)			0
(select)	(select)		(select)	(select as applicable)			0
Total PPG Amount					**0**	**0**	**0**

PART II: PROJECT JUSTIFICATION

1. *Project Description.* Briefly describe: a) the global environmental and/or adaptation problems, root causes and barriers that need to be addressed; b) the baseline scenario or any associated baseline projects, c) the proposed alternative scenario, GEF focal area[8] strategies, with a brief description of expected outcomes and components of the project, d) incremental/ additional cost reasoning and expected contributions from the baseline, the GEFTF, LDCF/SCCF and co-financing; e) global environmental benefits (GEFTF), and adaptation benefits (LDCF/SCCF); and 6) innovation, sustainability and potential for scaling up.

6 PPG of up to $50,000 is reimbursable to the country upon approval of the MSP.
7 PPG fee percentage follows the percentage of the Agency fee over the GEF Project Financing amount requested.
8 For biodiversity projects, in addition to explaining the project's consistency with the biodiversity focal area strategy, objectives and programs, please also describe which Aichi Target(s) the project will directly contribute to achieving.

The global environmental and/or adaptation problems, root causes and barriers that need to be addressed

1. There is empirical evidence that the purchase of chemicals for processing of products has dramatically grown since the 1970s. OECD's Environment Outlook notes that the global chemical purchase was worth US$ 171 billion in 1970, while it had grown to US$ 4.12 trillion in 2010. The report also notes that while annual global chemical sales doubled over the period 2000 to 2009, OECD's share decreased from 77% to 63% and the share of the BRIICS countries (Brazil, Russia, India, Indonesia, China, and South Africa) increased from 13% to 28%.

2. There is a need for innovative approaches to reduce the use of hazardous chemicals throughout the industrial life cycle. Many national governments have already enacted laws and established institutional structures with a view to reducing the amount of chemicals used and managing the hazards and environmentally sound management of this growing volume of chemicals. Companies have started to adopt sound chemical management programs and there are now many international conventions and institutions for addressing these chemicals globally. However, the increasing variety and complexity of chemicals and the ever longer and more intricate chemical supply chains and waste streams expose serious gaps, lapses and inconsistencies in government and international policies and corporate practices.

3. Consequently, international concerns are growing over the capacity to achieve the Johannesburg Plan of Implementation goal that, by 2020, chemicals will be produced and used in ways that minimize significant adverse effects on the environment and human health. These concerns are important to all countries, but are particularly salient in industrializing economies that face pressing needs to achieve development, national security and poverty eradication objectives.

4. Addressing the challenges posed by hazardous chemicals will require holistic, wide-ranging actions and environmentally sound management. Amongst other aspects, innovation, application and knowledge-transfer of greener approaches and technological solutions are essential elements of a reduction strategy. One approach is Green chemistry, which can be defined as the 'design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances' and as such green chemistry applies across the lifecycle of a chemical product, including its design, manufacture, use, and ultimate disposal. Green chemistry is also known as sustainable chemistry.

5. Green Chemistry focuses on the inherent nature/properties of chemicals, materials, products, processes, or systems and as such is transdisciplinary in nature, encompassing elements of chemistry, engineering, biology, toxicology and environmental science. Green Chemistry reduces pollution at its source by minimizing or eliminating the hazards of chemical feedstock, reagents, solvents and products; or encouraging the invention and innovation of new and non-hazardous solvents, surfactants, materials, processes and products. This is unlike remediation, which involves end-of-the-pipe treatment or cleaning up of environmental spills and other releases. While remediation removes hazardous materials from the environment, green chemistry keeps hazardous substances out of the environment in the first place.

6. While much of Green Chemistry is extremely scientific it is not necessarily high tech. Green Chemistry uses economically feasible products and processes which are guided by a rigorous framework known as the Twelve Principles Of Green Chemistry (see Annex E) that can be applied to a wide range of industry sectors and industrial processes.

7. While sufficient research ideas exist, barriers to the practical implementation and its documentation of green chemistry approaches stem from the lacking national, regional and international institutional and knowledge capacity, technological demonstration and financial capacities. The underlying causes are for example (i) the lack of knowledge and awareness, including target guidelines on green chemistry approaches and technologies, among government, private stakeholders and the general public; (ii) the lack of national, regional and global networks to promote the application of green chemistry approaches; (iii) the lack of technical demonstration, especially for companies in developing and countries in transition and (iv) the lack of partnership and business models among relevant stakeholders to increase and scale-up green chemistry opportunities. Additional efforts are therefore required to promote capacity building and information dissemination on green chemistry, and to support the application of green chemistry approaches in various

industrial sectors.

b) The baseline scenario or any associated baseline projects

Baseline scenario

8. The baseline scenario is composed of the on-going research on green chemistry, which is part of several university and research curricula especially in the United States of America and Germany; the existing network of RECPs and continuous use of chemicals during industrial product design and processing.

9. Green Chemistry has a scientific record since the 1990s and there are several publications describing the principles of green chemistry approaches and technologies and examples of green chemistry applications. However, there are only a few Universities who have included Green Chemistry into its curricula to lecture the principle to a wider range of chemistry students. There are no technical guidelines summarizing Green Chemistry, its technical applicability and practical case studies.

10. Without GEF intervention, research on green chemistry approaches and technologies will continue to be part of research, however, it will be challenging to provide training on green chemistry in developing and countries in transition, to encourage its inclusion into university and research curricula and more importantly, is practical demonstration.

11. Without GEF intervention, National Cleaner Production Centres (NCPCs) won't be trained on Green Chemistry and the RECP network won't be promoting the approach on the national, regional and global level. Likewise, partnerships and coordination with relevant governments, private stakeholders and NGOs won't advance to promote green chemistry approaches and technologies.

12. Without GEF intervention and international technical assistance, there might be companies demonstrating green chemistry approaches and technologies; however, it will be unlikely that that the demonstrations will be properly documented for its technical applicability and global environmental benefits and promoted to scale-up green chemistry approaches and technologies worldwide. With GEF intervention, a demonstration project in Brazil will be implemented which was selected in close consultation with GEF Secretariat, Yale University and according to criteria such as the Twelve Green Chemistry Principles, the availability and readiness of technology, relevance to achieve global environmental benefits, and co-financing commitment. In addition, the technical guidance will develop a methodology to estimate POPs savings in selected Green Chemistry case studies which will ensure that POPs will be a saving of Green Chemistry among other environmental benefits.

Baseline project

13. First consultations of UNIDO with STAP and the GEF secretariat on Green Chemistry can be traced back to 2014, when a discussion was started on how Green Chemistry can be established as an innovative narrative for sound chemicals management within the context of GEF implementation. At that occasion the Green Chemistry Institute from Yale University which is also the co-founder of the 12 Green Chemistry Principles, presented the current status of Green Chemistry from a scientific perspective. UNIDO continued researching along those lines with a particular focus on understanding the status quo of Green Chemistry in developing countries and economies in transition. Therefore, UNIDO hosted an Expert Group Meeting (EGM) on "Accelerating Green Chemistry Developments in Developing Countries and Transition countries" on 11 December 2014 at UNIDO Headquarters in Vienna, Austria. The meeting was attended by Green Chemistry experts/ experts in chemistry from academia, government bodies and NCPCs. The main objective of the Expert Group Meeting was to determine the level of advancement and understanding of green chemistry principles and applications within developing countries and economies in transition, and to discuss about the formulation and selection process of pilot demonstrations related to this proposed green chemistry project. It was also the opportunity to review the content of technical guidance and training materials needed to promote green chemistry approaches and technologies, with emphasis on countries' needs; and to discuss and review relevant pilot demonstrations, project partners and pilot countries.

14. Green Chemistry has been included into a limited number of governmental programmes (e.g. US-EPA, Sustainable chemistry initiative of the German Federal Environment Agency, Brazilian Year of Green Chemistry). The year 2011 was chosen as the International Year of Chemistry and it was focused on the importance of sustainability in the field of chemistry. The programme "Alternative Synthetic Routes for the Prevention of Pollution", implemented more than 20 years ago in the USA marked the official start of Green Chemistry. However, there is still a lack of governments to initiate more green chemistry projects.

15. Yale University launched the first Green Chemistry Institute in 2003. Since then, a number of research programs on Green Chemistry have been initiated in developed countries (e.g. University of York, ETH Zurich, RWTH Aachen). The NCPC's have provided an overview of universities and research institutions within their respective countries (Annex G). While some activities on Green Chemistry were reported at the meeting, generally, it was evident that there is a large gap of awareness on green chemistry related methods and applications. Green Chemistry courses and degrees are sparsely offered, mostly at the PhD level. There are no technical guidelines which bridge the gap between science and practical application, including case studies addressing specific needs of developing countries and economies in transition; however, the knowledge would already be available and the drafted guidance under this project would make a comprehensive technical green chemistry document available. University research programmes and curricula and Yale University and SENAI Brasil have established Institutes for Green Chemistry who will reach out to national and regional chambers and associations relevant to Green Chemistry.

16. The US-EPA Presidential Green Chemistry Challenge Awards Programe recognizes and awards groundbreaking scientific solutions to real-world environmental problems. Through the receipt of nominations under the awards programme a vast amount of case studies on green chemistry technology in the areas of greener synthetic pathways, greener reaction conditions and design of greener chemicals have been generated. However, there is missing documentation of the link between science and practical implementation.

17. Besides the development of guidance documents, this project also aims to document green chemistry demonstration at the private sector level. Proposals send by companies have been screened against the i) Twelve Green Chemistry Principles, ii) the availability and readiness of technology, (iii) relevance to achieve global environmental benefits, and iv) co-financing commitment. According to these criteria, three companies (large, medium and small-scale company) have been technically screened and selected from two different regions.

18. National, regional and global awareness raising of Green Chemistry will be another important element of the project. For information dissemination, a comprehensive set of outreach activities will be performed at different levels and with different stakeholders, including academic, governmental and business partners , scientific, industry and trade associations as well as technical institutes and non-for-profit organizations. There are already some Universities (e.g. Yale Univeristy) and governmental programmes (e.g. US-EPA, German Federal Environmental Agency) studying green chemistry (and sustainable chemistry) approaches and technologies that will be activelly involved in awareness rasing activities by means of workshops, trainings, university lectures etc. In addition, the German Federal Environmental Foundation has expressed its high interest for the Project and has provided a technical supporting letter for information exchange on Green Chemistry cases. A frequent coordination with the International Sustainable Chemistry Collaborative Center (ISC3), that will be launched by the German Government and partners in early 2017, will be established to allow joint actions on information dissemination on green and sustainble chemistry concepts. The Brazilian Green Chemistry Institute will particularly support the national awareness raising and support the link to business partners and associations. On the ground, the existing UNIDO-UNEP Resource Efficient and Cleaner Production (RECP) network and the National Cleaner Production Centres (NCPCs) will be part of the global global approach and knowledge management, as they provide an excellent working network with national and regional chambers, associations and the private sector and will be able to promote Green Chemistry and its technological application in different regions of the world.

19. In addition to working with established networks, there will be a comprehensive identification and engagement strategy to bring in other local networks including trade associations, business groups, universities, and not-for-profit groups engaged in sustainability. Through this broader engagement, the efforts will be able to serve the larger context of bringing sustainable value and impact through the awareness of

green chemistry approaches. In this regard, the development of an on-line platform on Green Chemistry shall support interlinking the different relevant actors, sharing news and events as well as supporting the further progress of the Project, also particularly addressing the needs of developing countries and economies in transition when advancing Green Chemistry.

20. A Green Chemistry documentation for the company Braskem (located in Brazil). Detailed description of the proposed green chemistry documentation and its compliance with the 12 Green Chemistry Principles are given in Annex G. In addition, the life-cycle assessment from Braskem in Annex H can be found. The initiative will be documented with the GEF grant under this project by applying the 12 Green Chemistry Principles, and the third company is in a more initial stage and the project will also ensure its documentation along the Green Chemistry principles.

21. Braskem (located in Brazil) has been producing substantial amounts of polyethylene resins for a wide variety of applications and market segments, using ethylene obtained from sugar cane based-ethanol as feedstock by a dehydration process. The total capacity of the current green ethylene plant is 200 thousand metric tons yearly (kty), which makes Braskem the world leading player in this business. Current clients are mostly global brand-owner companies located worldwide, especially in Japan, Germany and Brazil.

22. The green chemistry demonstration case in Brazil will be about "Green" ethylene produced from the existing plant which can be fed by pipeline to the three existing polymerization units to produce the green high density polyethylene, green low density polyethylene and green linear low density polyethylene. The reason for interference came from the observation that in the current existing linear low density polyethylene industrial plant the current polymerization technology, which is predominantly used in flexible food packaging, has shown not to fully meet highly demanding requirements set by the Market, especially with regard to the optical (transparency and gloss) and sealing (the ability to seal a packaging) properties.

23. Braskem is now planning to implement a new licensable and commercially proven technology based on the use of novel type catalysts combined with some process optimization in one of its existing polymerization lines. Compliance of this process with the 12 Green Chemistry Principles is given in Annex H. Since the project focuses on a change in the catalyst and the required adaptations in the process, mainly principles 1 (prevention) and 2 (atom economy) are substantially improved. Other principles, such as 7 (renewable feedstocks) are already highlights of the current product and are maintained.

c) The proposed alternative scenario, GEF focal area strategies, with a brief description of expected outcomes and components of the project

24. The main objective of the project will be to increase the general global awareness, and capacities on deployable Green Chemistry approaches for the design of products and processes that advance global environmental benefits throughout their life cycles. The two main outcomes of the project will be: i) capacity building and training of national industry experts (T-T-T), National Cleaner Production Centres, scientists and academia through training on Green Chemistry Principles and technologies, and ii) pilot demonstrations on deployable green chemistry applications and technologies at the plant level for selected developing and countries in transition. Due to the general gap in awareness on Green Chemistry, the project will draft technical guidelines and will pay attention to capacity building and networking.

25. The project fits into CW 1: *Develop the enabling conditions, tools and environment for the sound management of harmful chemicals and wastes and program* 1: *Develop and demonstrate new tools and economic approaches for managing harmful chemicals and waste in a sound manner*, because it supports GEF initiative e) through developing, testing, demonstrating and promoting Green Chemistry. The second project component will undertake a pilot documentation to achieve an 'enhanced know-how of industry, selected stakeholders and policy makers on Green Chemistry applications and technologies'. Although this field has substantially evolved from its inception phase, there is still a general lack of awareness on the potential of Green Chemistry to solve many of the pressing environmental pollution and resource depletion challenges.

26. Outcome 1: Guidance deevelopment and networking on Green Chemistry approaches and technologies

To achieve this outcome the project will deliver the following outputs:

27. Output 1.1 Training on green chemistry and technology, including policy aspects, provided

28. Green Chemistry has been an emerging area of sustainable design since its introduction in the 1990s. While the progress has touched virtually all sectors of society and industry ranging from agriculture to energy to building materials to pharmaceuticals and personal care products and cleaners, these accomplishments have taken place largely in the industrialized nations of the work. There are nascent efforts to advance Green Chemistry in a small number of emerging nations with the lack of awareness of the mechanisms and the potential of Green Chemistry as the single largest barrier to its broad-based adoption. The most important actions that can be taken at this time are to engage in awareness raising and training in the fundamentals and approaches of Green Chemistry. These efforts will allow for people on the ground to not only understand the possibilities for their local and regional economies, they will be able to apply the tools of Green Chemistry to a vast array of existing businesses while new businesses that are non-toxic, non-depleting, and renewable/bio-based will be launched.

29. Activity 1.1.1. Green Chemistry Awareness Raising Materials Generation

30. A critical initial activity that will be launched as part of the UNIDO green chemistry initiative focusing on POPs is the Green Chemistry Awareness Raising Campaign. Awareness raising materials will be developed by international green chemistry experts and will provide a detailed overview of the theory and practice of Green Chemistry ranging from its conceptual and scientific basis to its current state of achievements in advancing environmental/economic/societal goals. The specific challenges and needs for applying Green Chemistry in developing and transition countries will be adequately taken into account. Awareness raising with support from the NCPCs will reach the national, regional and global level and most relevant stakeholders from the private, government and general public.

31. Activity 1.1.2 Conduct of Awareness Raising Workshops

32. These workshops will be the first events of the project and will be based on the materials generated in the first months of the project. They will be held for the National Cleaner Production Centres (NCPCs), academia and general public. At least 25 people will be trained in each country. The workshops will stimulate the Green Chemistry Initiative, frame the project content, expected deliveries of all involved partners, support networking and facilitate communication on the overall project objectives. Min. 1 senior expert of the consortium is expected to attend and speak at each awareness raising workshop.

33. Activity 1.1.3 Development of Train-the-Trainers Curriculum

34. An essential part of the project will be the train-the-trainers courses that will be designed to give an in-depth understanding of Green Chemistry including its origins, technologies, and how it simultaneously drives environmental and economic goals for societal benefit. Selected NCPCs will be trained by international consultants and will then further disseminated nationally. These intensive training courses will utilize a variety of case studies, hands-on technologies, and models to provide cohesive and lasting insights into Green Chemistry that can be practically applied. The development of the curriculum, with specific focus on technologies that may be most immediately practical in emerging economies, will be developed under the direction of leading scientists and engineers in the field of green chemistry and will be presented by internationally renowned instructors. The curriculum will address scientific, technical and political expertise relevant for the work in the area of Green Chemistry. Required policy conditions, especially for green chemistry cases which require an established and/or strengthed legislative framework, will be extremely important and thus will be assessed and shared together with the technical requirements whenever feasible.

35. Activity 1.1.4 Conduct of Train-the-Trainers Curriculum

36. The train-the-trainers courses are designed to train national green chemistry experts in developing and transition countries and aims to contribute to the objective that National Cleaner Production Centres (NCPCs)

can become regional hubs for education and training in Green Chemistry. The courses will be organized in close cooperation with the UNIDO-UNEP RECPnet members and academia. Participants are requested to have basic or advanced knowledge of chemistry and technologies and processes used in the chemical industry. Participants will be trained in 5-day workshops to become experts on Green Chemistry. Each 5-day course should be conducted by at least 2 International Experts on Green Chemistry with senior expertise on the matter. Locations of the six train-the-trainers courses will potentially be in Brazil, Colombia, Egypt, Serbia OR Ukraine (tbc), China, Uganda and Sri Lanka and they will be completed within 24 months workshop with an average of 15-20 attendees at each workshop.

37. Activity 1.1.5 Development of University Level Curriculum on Green Chemistry with Teaching Guides

38. University level curriculum is the foundation for future lasting development of an independent green chemistry infrastructure in a developing/emerging economy. The development of green chemistry curriculum materials in cooperation and coordination with the local academics would include both lecture/class room elements as well as appropriate research/laboratory elements. The balance of making the curricula broadly useful and generic while maintaining its local relevance will be a high priority. The curriculum will cover the scientific fundamentals underlying Green Chemistry as well as the more advanced scientific discoveries and approaches being used in green chemistry institutions around the world. Significant efforts will be invested in ensuring that the practical applications of Green Chemistry are equally represented with the scientific material.

39. Output 1.2 Guidance document on green chemistry approach and technologies developed and globally promoted

40. A “Green Chemistry Guidance Document and Technology Compendium” will be drafted and used as a roadmap to green chemistry implementation for a wide distribution. Part One of the document will provide an understanding of what Green Chemistry is and why it is different from many approaches to environmentally friendly/sustainable technologies. The document will focus on the aspects of Green Chemistry that allow for economic and societal benefit through the use of innovative green chemistry technologies. In addition, a methodology will be developed to estimate and demonstrate POPs savings through Green Chemistry case studies. The methodology will be tested in selected countries and companies with support from NCPCs and documented as part of the guidance.

41. Part Two of the document will focus on “How to Implement Green Chemistry” and will focus on the various business/educational/policy approaches that can be used to install and drive green chemistry efforts forward. Part Three of the document will be the technology compendium that will survey the broad array of green chemistry innovations that are available and commercialized today or are near-term emerging opportunities. An important part will be the case studies documented and reviewed by Yale University and international peer review under this project which will highlight the technical applicability. Currently, a document such as this does not exist. It will require input from leading experts on Green Chemistry from many regions and from a variety of sectors in order to get usefully cohesive and comprehensive coverage of the document. The technology compendium should be designed to be a living document if possible, for web usage with occasional updating to keep pace with innovation, as well as a tangible physical document. The guidance documents will be peer-reviewed by the relevant international community.

42. National Cleaner Production Centers will reach out to national and regional chambers and associations to ensure a national, regional and global outreach. There will be also a comprehensive identification and engagement strategy to bring in other local networks including trade associations, business groups, universities, and not-for-profit groups engaged in sustainability. Through this broader engagement, the efforts will be able to serve the larger context of bringing sustainable value and impact through the awareness of green chemistry approaches.

43. Activity 1.2.1 Development of Guidance Document

44. The guidance document will be developed under the lead of Yale University which has long-term

experience in green chemistry research and is part of a global green chemistry network. The document will outline the approaches and strategies used to engage a wide range of sectors including business/industry/government/academia, and civil society. The guidance document will use case studies of how different countries with different backgrounds and histories have mobilized around green chemistry for significant benefit, including a methodology highlight green chemistry approaches for POPs eliminitation. The final document will provide references and contacts for the users to be able to further pursue the development of their programs directly by reaching out to the greater green chemistry community. The writing team will consist of individuals from a variety of national backgrounds and sector experiences.

Activity 1.2.2 Development of Technology Compendium

45. The technology compendium will be constructed by a team of scientists and engineers with in-depth knowledge of the history and current state of green chemistry science and technology. This writing team will conduct a systematic review of the academic and industrial/patent literature to provide a comprehensive snap-shot of green chemistry technologies. The compendium will be cross-reference by sector, application, and discipline. Ideally, the compendium will be structured both as a hard-copy document and an online database for widest possible dissemination and use. The consortium is requested to integrate case study information of the project results of component 2 of the UNIDO GEF projects (pilot demonstration in Brazil) into the technology compendium and particularly include green chemistry technologies designed for POPs elimination.

46. Activity 1.2.3 Review and Revision of “Green Chemistry Guidance Document”

47. The Green Chemistry Guidance Document will be circulated for review to two main groups, users and green chemistry experts. The users would include representatives at least from UNIDO and NCPCs. The green chemistry experts will be people who have built green chemistry programs, initiatives and networks that were not part of the writing team. Reviewers will be given 60 days to review and supply comments to the writing team for revision of the final guidance document.

48. Outcome 2: Documentation of selected green chemistry case studies and up-scaling

49. In parallel to the guidance development, this project will accomplish the documentation and analysis of green chemistry applications and technologies. The case study provide global environmental benefits in the areas of chemicals and waste and cross-cutting benefits to climate change. In addition, knowledge management, awareness raising and private-public partnerships will be an integral aspect of the project to ensure that acquired data, information and lessons learned are properly documented, shared among relevant stakeholders and a platform for future green chemistry communication and application are given. Especially the demonstration, documentation and analysis of the green chemistry case studies will be a driver for showing opportunities, application possibilities of green chemistry and creating partnerships among different stakeholders. This will be beneficial for sustainability of the project and up-scaling opportunities.

50. Output 2.1. Green chemistry case studies, including required policy framework conditions, in selected countries documented

51. These documented Braskem case studies will be included into the guidance documents to show a link between green chemistry science and green chemistry application, if agreeable by the companies and guidance drafting committee. Detailed descriptions of the case study can be found in Annex H, including the relation to the 12 Green Chemistry Principles.

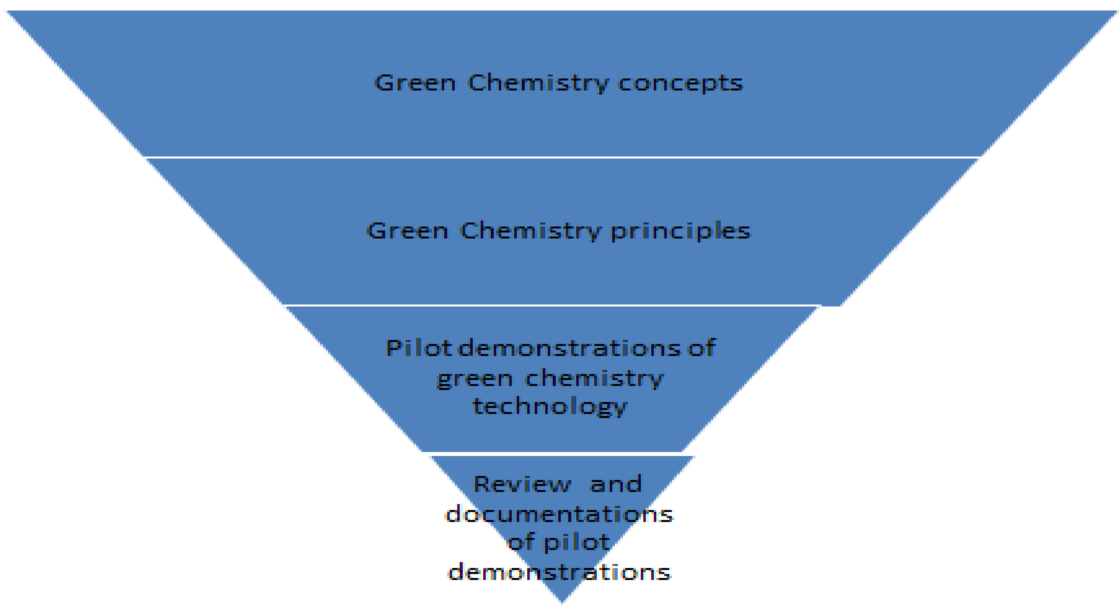
52. The documentation of the pilot demonstration will also highlight global environmental benefits which can be achieved through the application of green chemistry approaches and use of green chemistry technologies.
53. For the documentation of Braskem’s case study, the two green chemistry principles 1 (prevention of

hazardous chemicals and waste) and 2 (atom economy) will be highlighted to show full alliance with the 12 Green Chemistry Principles.

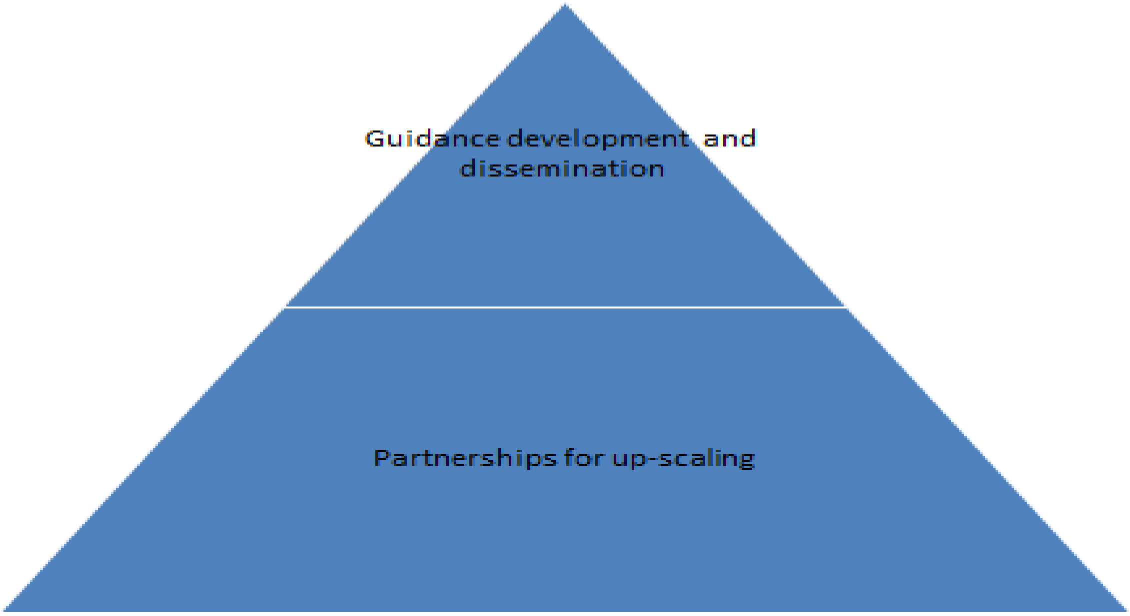
54. The documentation of the Green Chemistry case study will also include the assessment and documentation of required policy framework conditions to ensure that pre-conditions and legislation framework is set for the technology. Lessons learned from this assessment will be documented and shared as aspect during dissemination and trainings.

55. Output 2.2. Partnerships and business models (e.g. incentives) set up to further promote green chemistry

56. As outlined in the figure, this project aims to achieve i) the illustration and analysis of the existing green chemistry concepts and principles, which provide the basis for additional up-scaling of green chemistry and ii) creating opportunities and application areas to enhance green chemistry partnerships.



The following can only be achieved once the above skill sets are established:



57. This outputs aims at defining partnerships and applicable business models to support the promotion of green chemistry on the national, regional and global level. Global experts from the governmental, private sector and academic level will be part of drafting the guidance documents or the peer review and especially will be involved in the review of the green chemistry documentations. The knowledge, experience and lessons learned gathered will be used by the RECP network and NCPCs to receive and provide national, regional and global training and awareness raising programmes to ensure the most outreach as possible. The RECP network will be used as platform to distribute relevant green chemistry information and to initiate relevant stakeholders, including technical, academic and financial, discussions. A mechanism for information dissemination will also be set at the national level (mainly through the NCPCs) with selected African and Latin American NCPCs countries allowing the dissemination of knowledge and assistance for future projects.

58. The integration of Innovative Business Models (IBM) into project activities can provide a powerful solution to overcome barriers of further promoting the green chemistry concept among stakeholders. For example, Chemical Leasing as a service-oriented business model that shifts the focus from increasing sales volume of chemicals towards a value-added approach addresses several of the green chemistry principles, such as waste prevention and the use of less hazardous chemicals due to process optimization and the coupled reduction in chemical quantities.

Component 3. Monitoring and Evaluation

59. Outcome 3. Monitoring and evaluation mechanism implemented in accordance with UNIDO and GEF guidelines

60. Monitoring of project progress is essential for the adequate and timely delivery of results. This project component covers project monitoring and oversight by UNIDO in close coordination with the NCPCs, as well as the terminal evaluation of the Project. See Monitoring and Evaluation Part 12.

d) incremental/ additional cost reasoning and expected contributions from the baseline, the GEFTF, LDCF/SCCF and co-financing

61. Green Chemistry approaches and technologies save resources, although, initial capital investment is needed for

the transition from conventional chemistry to Green Chemistry approaches and technologies. The RECP's is already an existing and active global network which will be used for training and as executing partners for the pilot demonstrations and to utilize the outcomes for further stakeholder and partnership consultations. NCPCs will provide co-financing for the administrative availability and the GEF grant will be used for technical training, awareness raising and guidances on green chemistry, its replicability and up-scaling in the countries. Thus, without the financial support from GEF and technical support from UNIDO, the existing Green Chemistry knowledge and practical expertise will not be appropriate documented and will unlikely be shared among the wide field of stakeholder involved in this project.

62. The pilot demonstration will be co-financed by the company whereas the GEF grant will be utilized for a detailed documentation of the technology, its applicability and environmental benefits agains the Green Chemistry principles. The project will ensure that green chemistry and technologies are documented using the best scientific and technical knowledge possible and will bring together scientists with the private sector. It is unlikely that a detailed green chemistry documentation would be made available within this short time frame without this project.

63. Only a few companies have acknowledged the potential for Green Chemistry and have the interest to ensure that environmental, economic and social sustainability criteria are met. Without GEF support, this scenario would remain and Green Chemistry will not or very slowly be promoted and introduced at the national, regional and global level because of the limited guidance and practical documentations available. GEF grant will be utilized to develop the guidances, including a methodology on POPs savings, and will document the pilot project in line with Green Chemistry Principles. Thus, under the GEF alternative, Green Chemistry approaches and technologies would be properly documented and promoted through the RECP and NCPC network and opportunities to achieve global environmental benefits through green chemistry would be shared among national, regional and international relevant stakeholders. The project fits into CW1, programm and its initiaive to promote Green Chemistry with special emphasis on SAICM.

e) <u>global environmental benefits (GEFTF), and adaptation benefits (LDCF/SCCF)</u>

64. By completing the project objectives , the developed guidance and case studies will enable the detailed state-of-art anaylis of Green Chemistry, its technologies, applicability and global environmental benefit savings. Especially a methodology for POPs saving under Green Chemistry approaches and technologies will be developed and tested within selected countries (and support from the NCPCs). Priority areas for future GEF prioritize projects associated with a wide range of holistic environmental benefits, including POPs, SAICM, climate change, water and other benefits, will be another output from this project. In the following is an overview of potential environmental benefits to be achieved through green chemistry and through the pilot projects under this project:

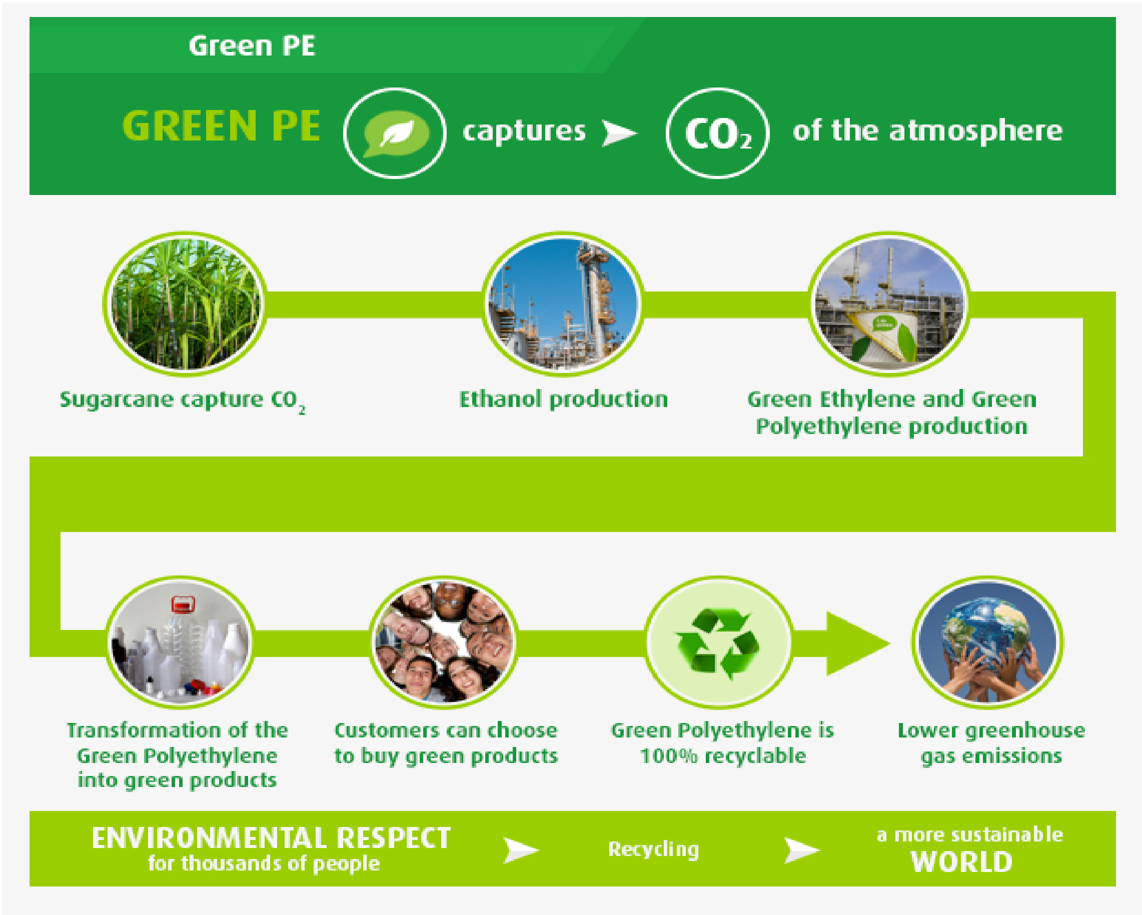
65. Replication of Green Chemistry demonstration projects will be achieved through up-scaling, awareness and networking of achieved project results and established partnerships. The following table summarized the widespread global environmental benefits which can be achieved through the application of green chemistry approaches.

Area	Description
Human Health	
Cleaner air	Less release of hazardous chemicals, including u-POPs, leading to reduced air pollution and potential effects to human and environmental health
Cleaner water	Less release of hazardous chemicals, including POPs and SAICM chemicals, and chemical wastes to water leading to cleaner drinking
Occupational Health and Safety	Increased environmentally sound management of chemicals and thus more safety for workers in the chemical industry; less use of toxic chemicals, including POPs and SAICM; less personal protective equipment required; less potential for accidents (e.g., fires or explosions)

Safer consumer products of all types	New, safer products will become available for purchase; some products (e.g., drugs) will be made with less waste; some products (i.e., pesticides, cleaning products) will be replacements for less safe products
Safer food	Elimination of POP-chemicals that can enter the food chain; safer pesticides that are toxic only to specific pests and degrade rapidly after use
General	Less exposure to such toxic chemicals as endocrine disruptors (SAICM)
Environment	
Emissions/disposal	Many chemicals end up in the environment by intentional release during use (e.g., POP-pesticides), by unintended releases (including U-POPs emissions during manufacturing), or by disposal. Green chemicals either degrade to innocuous products or are recovered for further use
Flora and Fauna	Plants and animals suffer less harm from toxic chemicals in the environment
Atmosphere	Lower potential for global warming, ozone depletion, and smog formation
Ecosystem	Less chemical disruption of ecosystems
Resource Efficiency	Higher yields for chemical reactions, consuming smaller amounts of feedstock to obtain the same amount of product
	Fewer synthetic steps, often allowing faster manufacturing of products, increasing plant capacity, and saving energy and water
	Less use of landfills, especially hazardous waste landfills

Indirect global environmental benefits through the pilot projects

66. In the case of Braskem, a detailed environmental assessment of Braskem's biobased PE resin investigate different aspects of cradle-to-(factory) gate life cycle impacts of the production of linear-low density polyethylene (LLDPE) and high-density polyethylene (HDPE) resins has already been developed. The LLDPE, the green PE, production is a result of technology, innovation and sustainability and because of its benefits such as versatility (large range of density, molecular weight and molecular weight distribution) can be tailored and used in many application covering rigid packaging applications, flexible, caps and closures, bags, applications of packaging and films among other. The scope of the green LLDPE project is to replace an existing catalyst and use it to produce a new grade of green LLDPE which is currently not available. Thus, clients are forced to use petrochemical LLDPE in their products for now. Once green LLDPE becomes available, as a consequence of the project, they are expected to replace the petrochemical LLDPE and use green LLDPE. The benefits of the project then include both [a] the improvements in sustainability, such as the higher conversion, brought about by the new catalyst in the polymer plant and [b] the improvements in sustainability that arise from using the green PE. In addition the following environmental benefits could be achieved:



67. Potential environmental benefits: Through the substitution of fossil feedstock (gas or naphta) by renewable one (ethanol from sugar cane), the Braskem's Green PE biopolymer made from ethanol, captures 2.15 metric ton of CO2 equivalent for every metric ton of green plastic produced. If it is considered that the plant is running at 100%, 200,000 t Green PE per year will be produced which corresponds to a reduction of 800,000 t of CO2 per year (considering the substitution of petrochemical PE by Green PE). In addition, Green PE has the same technical properties, appearance and versatility of applications of polyethylene from fossil source; thus, the replacement of fossil source polyethylene for Green PE does not require investment in new plastic converter machines. By substituting fossil feedstock by ethanol, the eco-toxicity will be reduced: emission of some 600 t of 2,4-dichlorophenoace eq. will be avoided as a result of less energy needed to process the crude oil. In this category, the general causative factors are emissions of metals, nonmetals (arsenic) and organic chemicals (such as polychlorinated biphenyls-PCBs) into the atmosphere.

68. Reduction of raw materials: Green PE is produced from Brazilian sugarcane ethanol, which is a renewable source. The optimization process carried out will ensure a reduction of raw material: The current polymerization process requires 1.01 ton of raw material (ethylene + co-monomers) to produce 1 ton of polyethylene, where the 0.01 ton of raw material can be considered the non-reacted raw material. The new process will be able to decrease in 10% the non-reacted raw material, which means 0.01 ton* 10% = 1 kg reduction of non-reacted raw material compared to the previous process.

69. Recyclable: Green PE is recyclable in the same chain used for recycling traditional polyethylene because it does not contain hazardous waste components. Green PE is not biodegradable, however, the CO2 is captured by the product and thus remains fixed throughout the life cycle of the plastic. Braskem is supporting the increase of the recycling rates of (bio) plastics in Brazil through several initiatives such as the wecycle platform, Edukatu (which is the first Brazilian Online Learning Network that encourages the exchange of knowledge and practices about conscious consumption and sustainability among elementary school teachers and students in the country) and Ser+realizador (to promote the social and economic insertion of recyclable

materials laborers as entrepreneurs).

b) Innovation, sustainability and potential for scaling up.

70. As defined by the United States Environmental Protection Agency (US EPA), Green Chemistry refers to "environmentally friendly, sustainable chemicals and processes whose use results in reduced waste, safer outputs, and reduced or eliminated pollution and environmental damage. Green Chemistry encourages innovation and promotes the creation of products that are both environmentally and economically sustainable".

71. Green Chemistry is not about setting universal standards for industry, but much rather, more about encouraging innovation (rather than limiting it). The main purpose is to establish a favorable climate to achieve faster innovation in the design of value-added products and processes. This can be achieved by training, capacity building and awareness raising. The establishment of drivers and concepts, specific principles, illustrations and examples, and the analysis of these examples are needed in order to create opportunities, applications and partnerships to leverage the industrial Green Chemistry base and accelerate developments globally.

72. The promotion of Green Chemistry is lacking on the global level. This project would be the first UN project provide to promote Green Chemistry by accumulating existing green chemistry knowledge and to document the practical application of green chemistry technologies. The guidance will be avaible for global distribution and it could provide the basis for the development of national research and university programmes, involving industry, academia and research institutions for the development of new green chemistry applications that could be used to prevent hazardous chemicals, waste and eliminate other threats to the environment and human health.

73. The cooperation with the private sector is the first of this kind. The green chemistry pilot demonstrations and case studies to be developed under this project can be scaled up to many other different sectors, especially when comprehensive guidelines become available and the international community acknowledges and promotes the approach. The potential to interlink Green Chemistry with Innovative Business Models such as Chemical Leasing will be explored for the first time, highlighting channels for better market access for green chemistry technologies. Through the documentation of the mentioned case studies environmental and economic benefits will be clearly shown which may stimulate other companies to follow the examples.

74. In addition, the project will ensure wide-spread awareness, training and information dissemination on the national, regional and global level to ensure wide spread involvement of the private sector. This will also led to the developmemt of follow-up priority projects, replication of demonstrated approaches in different countries, industrial sectors and companies and further up-scaling of other outlined Green Chemistry approaches and technologies.

2. *Child Project?* If this is a child project under a program, describe how the components contribute to the overall program impact.
N/A

3. *Stakeholders.* Will project design include the participation of relevant stakeholders from civil society organizations (yes ☒ /no☐) and indigenous peoples (yes ☐ /no☒)? If yes, elaborate on how the key stakeholders engagement is incorporated in the preparation and implementation of the project.

75. Yale University will be the lead executing partner to develop the technical guidances and the NCPCs in Colombia and Uganda and Brazil's SENAI Institute for Innovation on Green Chemistry will support the pilot countries and/or are involved in dissemination, training and awareness raising activities. For the latter, the NCPCs in Egypt and Sri Lanka will play a major role.

76. For national, regional and global dissemination, UNIDO-UNEP's Resource Efficient and Cleaner Production Network (RECPs) will be used. Selected National Cleaner Production Centres (NCPCs) will operate within the frame of this programme and will be the core stakeholders of the national training and

networking activities.

77. The private sector is the key stakeholder involved in this project because they are the key player of the green chemistry pilot demonstrations. The companies in the countries will be the technical investment of the Green Chemistry approaches and together with UNIDO and NCPCs will document the results along with the 12 Green Chemistry Principles.

78. A project strategic committee (PSC) consisting of UNIDO, STAP, Yale, US-EPA, German Federal Environmental Agency, Brazil's SENAI Centre of Innovation on Green Chemistry and other selected stakeholders will be set-up with the aim to provide strategic and consultation advice for the project and future green chemistry implementation.

4. Gender Equality and Women's Empowerment. Are gender equality and women's empowerment taken into account (yes ☒ /no☐)? If yes, elaborate how it will be mainstreamed into project implementation and monitoring, taking into account the differences, needs, roles and priorities of women and men.

79. UNIDO's Environment Branch gender guidance will be used to support gender mainstreaming into stages of the project cycle. Initial assessments showed that this green chemistry intervention is expected to have overall limited direct influence over gender equality and/or women's empowerment in the countries and therefore could be classified as a project with "limited gender dimensions" according to the UNIDO Project Gender Categorization Tool. Nevertheless this project to be gender responsive and to demonstrate good practices in mainstreaming gender aspects (e.g. through specific trainings) into the project cycle, wherever possible, and avoid negative impacts on women or men due to their gender, ethnicity, social status or age.

80. Guiding principle of the project will be to ensure that both women and men are provided equal opportunities to access, participate in, and benefit from the project, without compromising the technical quality of the project results. In practical terms,

- Gender-sensitive recruitment will be practiced at all levels where possible, especially in selection of project staff. Gender responsive TORs will be used to mainstream gender in the activities of consultants and experts. In cases where the project does not have direct influence, gender-sensitive recruitment will be encouraged. Furthermore, whenever possible existing staff will be trained and their awareness raised regarding gender issues.
- All decision-making processes will consider gender dimensions. At project management level, Project Steering Committee meetings will invite observers to ensure that gender dimensions are represented. Also at the level of project activity implementation, effort will be made to consult with stakeholders focusing on gender equality and women's empowerment issues. This is especially relevant in policy review and formulation.
- To the extent possible, efforts will be made to promote participation of women in training activities, both at managerial and technical levels. This can include advertising of the events to women's technical associations, encouraging companies to send women employees, etc.

5. Benefits. Describe the socioeconomic benefits to be delivered by the project at the national and local levels. Do any of these benefits support the achievement of global environment benefits (GEF Trust Fund) and/or adaptation to climate change?

81. Inadequate use of hazardous chemicals and resources might cause significant global environmental impacts and health effects. There are knowledge gaps, technological and financial gaps that prevent the proper use and management of chemicals in an efficient and resource-efficient way. Green Chemistry is an approach for more efficient, design, use and management of hazardous chemicals and resources, and this project will address the needs to achieve global awareness and scale-up of the approach. To achieve this, leading global project partners, e.g. Yale University and an international scientific and technical consortium, will be involved to tackle the existing obstacles.

82. The guidance development and technical demonstration will create the foundation for Green Chemistry application and thus the reduction of exposure of hazardous chemicals, inefficient use of resources and ultimately global environmental benefits to human and environmental health.

83. New Green Chemistry approaches and technologies will also create jobs at the scientific, technical, administrative and managerial level to establish and manage Green Technology applications.
84. The project includes an output on business models and stakeholder networking to overcome potential shortages for follow-up projects, sustainability and up-scaling.
85. The project also promotes up-scaling activities so that potential socio-economic benefits from Green Chemistry can be achieved in the long run.

Potential socio-economic benefits from Green Chemistry	
Resource Efficiency	Reduced waste, eliminating costly remediation, hazardous waste disposal, and end-of-the-pipe treatments
	Allow replacement of a purchased feedstock by a waste product
	Better performance so that less product is needed to achieve the same function
	Reduced manufacturing plant size or footprint through increased throughput
Conservation of Non-renewable resources	Reduced use of petroleum products, slowing their depletion and avoiding their hazards and price fluctuations
Commercial competitiveness	Increased consumer sales by earning and displaying a safer-product label
	Improved competitiveness of chemical manufacturers and their customers
Job creation	Through application of Green Chemistry projects

6. *Risks.* Indicate risks, including climate change, potential social and environmental future risks that might prevent the project objectives from being achieved, and if possible, propose measures that address these risks:

86.

RISK	LIKELIHOOD	MITIGATION MEASURES
Persistent barriers to the deployment of green chemistry technologies in the selected companies	Low	Limitations in terms of technical, financial, operational and managerial capacities will affect the application of green chemistry approaches. A selection of pilot demonstration took place prior project implementation to ensure that the intervention will be in line with green chemistry principles. The company is ready for this intervention and is willing to provide co-financing.
Environmnetal threats and negative social impacts due to pilot demonstrations	Low	Environmental and social risks are part of the companies Environmental Management Plans and will be fully mitigated.
The sustainability of the green chemistry approaches deployed under the project is not ensured	Low	Sustainability of the pilot demonstrations will be ensured through verified technical intervention in line with managerial and financial planning of operation beyond the project. In addition, awareness raising and training is planned to enchange awareness and visibility of Green Chemistry.
Risk of climate change to the project	Low	Not applicable for guidance development.

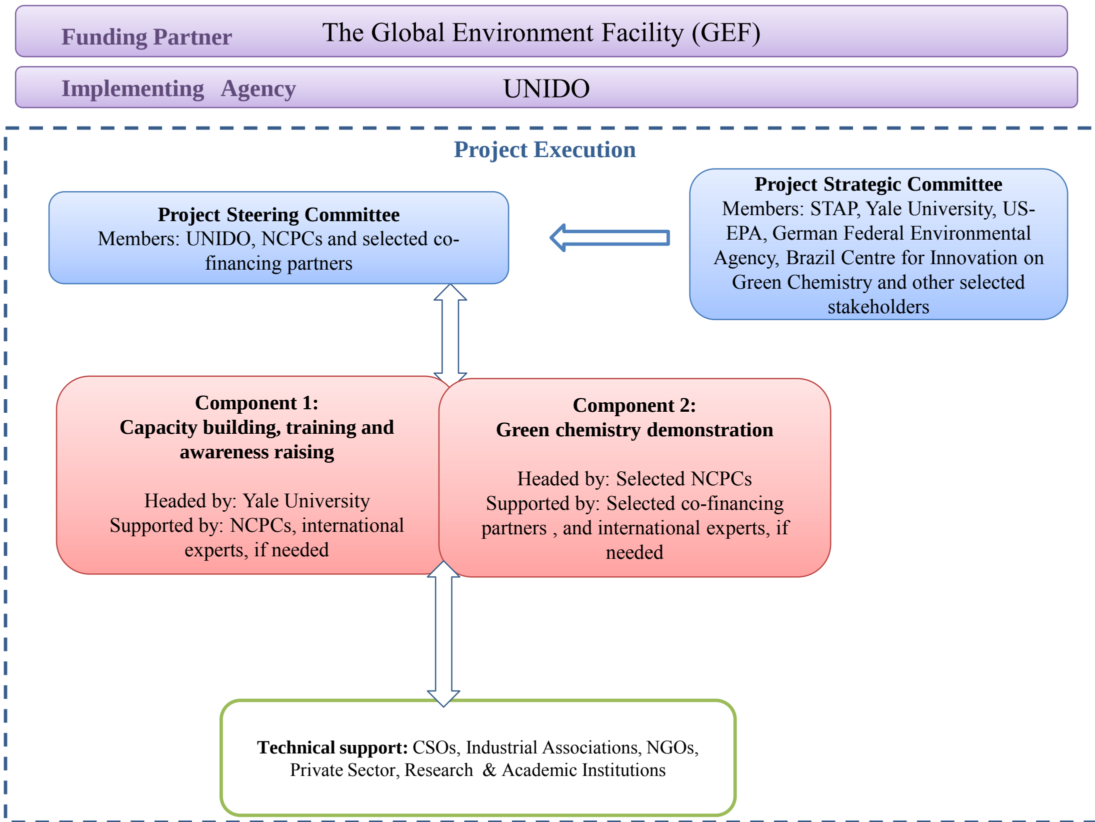
7. *Cost Effectiveness.* Explain how cost-effectiveness is reflected in the project design:

87. Cost-effectiveness will be ensured through the global networking and training activities of the project, in which numerous stakeholders from government, academia, research, private sector and the public will participate. The demonstration projects will ensure that the project will have tangible and measurable results and that from the lessons learned new projects can be designed and up-scaled.

8. *Coordination.* Outline the coordination with other relevant GEF-financed projects and other initiatives [not

mentioned in 1]: 88. Coordination with GEF-financing will be seeked, if gets applicable.

9. *Institutional Arrangement.* Describe the institutional arrangement for project implementation:
89.



90.The GEF Implementation Agency (IA) for the Project will be UNIDO, with headquarters in Vienna, Austria. UNIDO's Headquarter-based Project Manager will oversee project implementation and will oversee that all activities will be in accordance with UNIDO and GEF rules as well as with the approved project document. UNIDO's project manager will be responsible for tracking overall project milestones and progress towards the attainment of the set project outputs and will be also responsible for reporting to the GEF. The annual workplan will be further detailed by each activtity and changes to the WP will be done in accordance with the approved project document and GEF document C 39.Inf 04.

91. Upon inception, a dedicated Project Steering Committee (PSC) will be constituted. The PSC should at least include (a) UNIDO; (b) directors of the participating NCPs and (c) representatives from the pilot demonstration countries. The responsibilities of the Steering Committee include: (i) review and approval for annual work plans; (ii) review and approval of annual GEF reporting (PIRs); (iii) review and approval of annual budgets; (iv) monitoring of Project progress; and (v) guidance on strategic issues and activities. Changes/amendments proposed by the Project Steering Committee ought to be in accordance with the approved project document and the GEF policy C.39.09 and UNIDO rules and regulation. The Project Manager will be responsible for conveying meetings, preparing the agenda, including issues requiring decision, and issuing minutes of meeting. The PSC will meet 2 times per year in person or through videoconference.

92. The Project will establish a Project Strategic Committee (PSC) for advice and review of project activities. The PSC will consits of UNIDO, STAP, Yale University, US-EPA, the German Federal Environmental Agency,

Brazil's Centre for Innovation on Green Chemistry and other selected stakeholders to provide overall strategic guidance for project implmentation and beyond. Meetings (in-person or online) of the PSC will be held at least once in a year or more frequently upon request. Other stakeholders and experts can be invited to the meetings depending on the specific needs or topics of a meeting agenda. The PSC will ensure that all project partners are informed and updated about the status of the project implementation and developments on national and regional level. Further the PSC will be involved in the review of the guidance documents and other technical documentation made available during the project as well as future strategic advice to prioritize Green Chemistry projects and its global up-scaling. All the PSC activities will be conducted, in line with the project approved objectives, goals, outcomes, outputs, activities, indicators and budgets, and in adherence to the GEF and UNIDO requirements.

93. UNIDO will issue contractial arrangement for the development of the guidelines to Yale University as executing partner. The main task of Yale University will include inter alia, but not limited to the coordination of guidance development and peer review; and the communication with national, regional and international stakeholder.

94. UNIDO will work in close cooperation with the existing NCPCs, which are experienced in the consultation with national industrial priority sectors and with the implementation of sound chemicals management. Specifically they build national capacity for the implementation of projects in RECP and sustainable chemicals management and provide technical assistance to their clients in the implementation of practical sustainable chemicals management activities. The assistance provided includes sound waste management through the minimization of waste generation and resource-efficiency, and the promotion of environmentally sound technologies. These activities are carried out taking into consideration all international chemicals-related conventions, agreements and initiatives.

95.The global network for Resource Efficient and Cleaner Production (RECPnet) has been officially established, with the support of UNIDO and UNEP, in November 2010 by 41 inaugural signatories to its Charter. The global RECPnet is a not-for-profit initiative to bundle and utilize existing capacities of NCPCs and RECP service providers, which objective is to contribute to the effective promotion and implementation of RECP and to foster North-South and South-South collaboration and transfer of methods, policies and technologies.

96. Contractual arrangements for NCPCs will be issued in accordance with UNIDO's procurement procedures for the facilitation of national training modules.

97.The NCPCs will be engaged through sub-contracts in two different types: Type I Participation in training and awareness raising activities and Type II as National Executing Agency for the pilot demonstration projects. Sub-contracts will be issued to the NCPCs which will include at least the following activities:

98. Type I) - Organize and participate in training activities
- Organize and participate in awareness raising activities

99. Type II) – Act as national focal point and assign project coordination team (day-to-day activities)
- Provide administrative and technical support to pilot demonstration projects
- Organize and participate in relevant trainings
- Organize and participate in relevant trainings
- Document and disseminate project achievements and lessons learned

100. UNIDO may also enter into other contractual agreements with selected institutions within the region to support the execution of specific project outputs.

101.Additional international and national consultants will be recruited based on project requirements drafted by UNIDO's project manager. Terms of Reference (ToRs) will be prepared by UNIDO in collaboration with the national project coordinators, if required.

102. Procurement contracts for larger, centralized procurement requirements will be managed exclusively by UNIDO.

103. As provider of the fund for this project, the GEF logo will appear on all project publications and outreach materials.

10. Knowledge Management. Outline the knowledge management approach for the project, including, if any, plans for the project to learn from other relevant projects and initiatives, to assess and document in a user-friendly form, and share these experiences and expertise with relevant stakeholders.

104. The Knowledge Management strategy focuses on different levels such as governmental bodies, national experts, academia and industry. The objectives of the strategy lie in three main areas – strengthening local and national institutions to apply Green Chemistry through better knowledge management, establishing green chemistry applications in industries, and enabling UNIDO and all involved project partners and other stakeholders to learn how Green Chemistry can be applied at the global level and in particular in developing countries and economies in transition. The following strategic directions were defined: 1. Improving global access to state-of-the-art information on Green Chemistry; 2. Sharing and reapplying experiential knowledge; 3. Fostering an enabling environment to effectively use knowledge on Green Chemistry in local, national and regional conditions; 4. Translating knowledge into policy and action.

Knowledge will be captured on different levels (1. industry; 2. national experts; 3. academia and 4. government) through the "Green Chemistry Guidance Document and Technology Compendium", University curricula, train-the-trainers curriculum, the development of the on-line Green Chemistry platform, Project workshops, information sharing and knowhow exchange meetings with leading scientists on Green Chemistry as well as other partners such as the International Sustainable Chemistry Collaborative Center ISC3 and the German Federal Environmental Foundation, and by creating synergies with other existing knowledge management systems (e.g. ACS-Green Chemistry Institute and UNIDO-UNEP KMS). The knowledge management approach is summarized in the table below

Strategic directions of Knowledge Management	Levels of interaction
- Improving global access to state-of-the-art information on Green Chemistry	- Industry
- Sharing and reapplying experiential knowledge	- National Experts
- Fostering an enabling environment to effective use knowledge on	- Academia
- Green Chemistry in local, national and regional conditions	- Government
- Translating knowledge into policy and action	

Actors/ distributors of knowhow	Means of the Knowledge Management System
- University Consortium (led by Yale University)	- Guidance Document and Technology Compendium
- International Green Chemistry Experts	- Green Chemistry On-line Platform
- National Cleaner Production Centres	- Project Workshops/ Train-the-trainer courses
- Green Chemistry Institutes (e.g. in Brazil)	- Curricular Development
- Other Project Partners	- Knowhow exchange with other project partners

11. Consistency with National Priorities. Is the project consistent with the National strategies and plans or reports and assessements under relevant conventions? (yes ☐ /no X). If yes, which ones and how: NAPAs, NAPs, NBSAPs, ASGM NAPs, MIAs, NCs, TNAs, NCSA, NIPs, PRSPs, NPFE, BURs, etc.

105. The Project falls under the Strategic Approach to International Chemicals Management (SAICM) which is a policy framework to promote chemical safety around the world. SAICM has as its overall objective the achievement of the sound management of chemicals throughout their life cycle so that, by 2020, chemicals are

produced and used in ways that minimize significant adverse impacts on human health and the environment.

12. M & E Plan. Describe the budgeted monitoring and evaluation plan.

106. Project monitoring and evaluation (M&E) will be conducted in accordance with UNIDO's established guidelines for conducting terminal evaluations of GEF-funded projects and GEF procedures. The M&E activities are defined under project component 4 and the M&E budget is in the Table below. Monitoring will be based on indicators defined within the project results framework and complemented by the annual work plans. The GEF tracking tool will also be used as a monitoring and evaluation tool, and will be submitted three times during the duration of the project (CEO approval and project closure).

107. UNIDO as Implementing Agency will involve the GEF Operational Focal Points, national executing counterparts and project stakeholders at all stages of the project monitoring and evaluation to ensure that the results lead to improved current and future project design and implementation.

108. According to the GEF and UNIDO Monitoring and Evaluation policies, follow-up studies like country portfolio evaluations and thematic evaluations can be conducted. All project partners and contractors are obliged to (i) make studies available, and provide reports or other project- related documents, and (ii) facilitate interviews with staff involved in the project activities.

M&E Activity Categories	**Feeds Into**	**Time Frame**	**GEF Grant Budget ($US)**	**Co-financing Budget ($US)**	**Responsible Parties**
Monitoring of project impact indicators (as per Log Frame)	Project management; Semi-annual progress report; Annual GEF PIR	To be agreed between executing partners and UNIDO PM	5,000	20,000	• NCPCs provide inputs and submits drafts for approval by project steering committee (PSC); • PSC submits final inputs/reports to UNIDO PM
Periodic Progress Reports	Project management; Annual GEF PIR	To be agreed between executing partners and UNIDO PM	20,000	60,000	
Independent terminal evaluation	Terminal Evaluation Review (TER) conducted by UNIDO EVA	Project completion	45,000	120,000	
Total indicative cost			**70,000**	**200,000**	Independent evaluator, for submission to UNIDO PM and UNIDO ODG/EVA

109. Monitoring responsibilities: Day to day monitoring of the national project implementation will be the responsibility of the NCPCs (for pilot, training and awareness) and Yale University for the guidance development as executing partners. Reporting will be done to UNIDO's project manager on a regular basis.

110. UNIDO, through meetings or exchanges with project counterparts, or as frequently as deemed necessary, but not less than semi-annually, will undertake periodic monitoring of the project

implementation progress. This will allow parties to troubleshoot any problems pertaining to the project timely, to ensure the smooth implementation of project activities.

111. UNIDO will conduct periodic visits based on agreed schedules, to be detailed in the Annual Work Plan to assess project progress. Other members of the PSC and the PAC may also accompany these visits. A Field Visit Report will be prepared by UNIDO and will be circulated to the project team and the Steering Committee members one month after the visit.

112. Annual Monitoring will occur through PSC meetings, which will take place at least once a year (through visits or telecommunication).

113. Independent evaluation responsibilities: The project will undergo at least one independent external evaluations as follows:

114. Terminal evaluation: An independent final evaluation will be performed by an independent consultant after project completion, and will consider the outcomes of the mid-term review. It will focus on project results and impacts (e.g. in terms of global environmental benefits), sustainability and recommendations for follow-up projects. The TORs for this evaluation by UNIDO in accordance with the generic TORs developed by the UNIDO and GEF Evaluation Offices.

115. Inception workshop: A Project Inception Workshop (IW) will be conducted with the full project team, relevant government counterparts, co-financing partners, UNIDO, and other partners as appropriate. The IW is expected to inter alia define annual work plan, set clear targets for each country, define and agree on the role of each stakeholder, agree on a meeting schedule for the PSC and PSC, define activities that will be implemented in cooperation with the co-financing partners. Measurement of impact indicators related to global benefits will be done according to the schedules defined in the IW. These will be undertaken through subcontracts or agreements with relevant institutions, or through specific studies that are part of the projects activities.

116. Inception report: The inception report will be prepared after the inception workshop and will include at least the following: Annual workplan, including tentative dates for the PSC meeting, UNIDO field missions, project budget for the first year and M&E requirements for the first year.

117. Project implementation report (PIR): is an annual progress document mandated by the GEF. The PIR includes the following (a) analysis of the achievement of project objectives, (b) analysis of project performance over the reporting period, including the resulting outputs and outcomes, (c) risk management, (d) accounting of co-financing. The PIR shall also constitute the annual project report, which is a UNIDO requirement for monitoring project management.

118. A terminal project workshop will be conducted in the last month of project duration. A final report will be prepared, including project achievements, further actions needed if any, project sustainability, replicability and up-scaling options.

119. Prior obligations and prerequisites: GEF grant assistance will be provided to the counterparts subject to UNIDO being satisfied that obligations and pre-requisites have been fulfilled or are likely to be fulfilled. When fulfilment of one or more of these prerequisites fails to materialize, UNIDO may, at its discretion, either suspend or terminate its assistance.

120. During project implementation, progress reports and PIR reports should be prepared according to the project monitoring plan.

PART III: APPROVAL/ENDORSEMENT BY GEF OPERATIONAL FOCAL POINT(S) AND GEF AGENCY(IES)

A. Record of Endorsement[9] of GEF Operational Focal Point (S) on Behalf of the Government(S): (Please attach the *Operational Focal Point endorsement letter(s)* with this template. For SGP, use this SGP OFP endorsement letter).

NAME	POSITION	MINISTRY	DATE *(MM/dd/yyyy)*

B. GEF Agency(ies) Certification

This request has been prepared in accordance with GEF policies[10] and procedures and meets the GEF criteria for a medium-sized project approval under GEF-6.					
Agency Coordinator, Agency name	**Signature**	**DATE** *(MM/dd/yyyy)*	**Project Contact Person**	**Telephone**	**Email Address**
Philippe R. Scholtès, Managing Director Programme Development and Technical Cooperation (PTC), UNIDO GEF Focal Point		5/02/2016	Petra Schwager	+0043 1 26026 3749	P.Schwager@unido.org

C. ADDITIONAL GEF PROJECT AGENCY CERTIFICATION *(Applicable only to newly accredited GEF Project Agencies)*

For newly accredited GEF Project Agencies, please download and fill up the required **GEF Project Agency Certification of Ceiling Information Template** to be attached as an annex to this project template.

[9] For regional and/or global projects in which participating countries are identified, OFP endorsement letters from these countries are required even though there may not be a STAR allocation associated with the project.
[10] GEF policies encompass all managed trust funds, namely: GEFTF, LDCF, and SCCF

ANNEX A: PROJECT RESULTS FRAMEWORK (either copy and paste here the framework from the Agency document, or provide reference to the page in the project document where the framework could be found).

Interventions	Indicators	Baseline	Target	Sources of Verification	Assumptions
Project Objective	**To increase global awareness, and technical capacities on deployable Green Chemistry approaches for the design of products and processes that advance global environmental benefits throughout their life cycles**				
Outcome 1: Guidance development , training and awareness for green chemistry build	# guidance document developed	Comprehensive green chemistry guidance training not available	One guidance document, including case studies, and NCPC	Guidance document	Yale University and private stakeholders are committed to disseminate green chemistry
Output 1.1: Training on green chemistry and technology, including policy aspects, provided	# of comprehensive trainings to disseminate green chemistry, including policy aspects and gender considerations	Trainings on green chemistry through NCPCs not carried out	At least eight NCPCs have received and provided trainings on green chemistry; # 20 training participants (male/female)	Meeting minutes; List of training participants	
Output 1.2: Guidance document on green chemistry approach and technologies developed and globally promoted	# of green chemistry guidance documents on green chemistry approaches and trainings	Comprehensive green chemistry guidance not available	One guidance document, including case studies, drafted and peer reviewed	Guidance document	

Outcome 2: Documentation of green chemistry case study	# of green chemistry case studies documented # partnerships to further promote green chemistry established	Lack of green chemistry documentation	At least 1 green chemistry documentations, and 10 additional Green Chemistry examples At least 2 partnerships on green chemistry promotion established	Documentation reports	Governments of all participating countries are committed to strengthen the e-waste knowledge and proper management in their countries and within the region
Output 2.1. Green chemistry case studies, including policy framework conditions, in selected countries documented	# of green chemistry case studies documented	Lack of technical green chemistry documentations	At least 1 green chemistry cases documented, and 10 additional Green Chemistry examples	Green chemistry documentation	
Output 2.2. Partnerships and business models (e.g. incentives) set up to further promote green chemistry	# of partnerships to further promote green chemistry established	Lack of green chemistry promotion partnerships	At least 2 partnerships on green chemistry promotion established	Draft MOUs	

ANNEX B: CALENDAR OF EXPECTED REFLOWS (if non-grant instrument is used**)**

Provide a calendar of expected reflows to the GEF/LDCF/SCCF Trust Funds or to your Agency (and/or revolving fund that will be set up)

ANNEX C: GEF budget

Output Based Budget for the GEF Grant					
		GEF Grant Budget Component 1			
Outcome 1	**Type of Expense**	**Yr 1**	**Yr 2**	**Yr 3**	**Output Total**
Outcome 1	International Expertise (BL 11-00)				0
Training on green chemistry and technology including policy aspects, provided	Local Travel (BL 15-00)				0
	National Expertise (BL 17-00)				0
	Contractual Arrangement (BL 21-00)	500,000			500000
	Training/Workshops (BL 30-00)				0
	International Meetings/Workshops (BL 35-00)	60,000	50,000	60,000	170000
	Equipment (BL 45-00)				0
	Miscellaneous (BL 51-00)				0
	Output sub-total	560,000	50,000	60,000	670000
Output 1.2	International Expertise (BL 11-00)				0
Guidance document on green chemistry approach and technologies developed	Local Travel (BL 15-00)				0
	National Expertise (BL 17-00)				0
	Contractual Arrangement (BL 21-00)	300,000			300000
	Training/Workshops (BL 30-00)				0
	International Meetings/Workshops (BL 35-00)				0
	Equipment (BL 45-00)				0

	Miscellaneous (BL 51-00)				0
	Output sub-total	300,000	0	0	300000
TOTAL Outcome 1		860,000	50,000	60,000	970,000

		GEF Grant Budget Component 2			
Outcome 2	**Type of Expense**	**Yr 1**	**Yr 2**	**Yr 3**	**Output Total**
Output 2.1	International Expertise (BL 11-00)	30,000	30,000	10,000	70,000
Green chemistry documentations, including policy framework conditions, in selected countries piloted	Local Travel (BL 15-00)				0
	National Expertise (BL 17-00)				0
	Contractual Arrangement (BL 21-00)	300,000	100000	100000	500,000
	Training/Workshops (BL 30-00)				0
	International Meetings/Workshops (BL 35-00)				0
	Equipment (BL 45-00)				0
	Miscellaneous (BL 51-00)				0
	Output sub-total	330,000	130,000	110,000	570,000
Output 2.2	International Expertise (BL 11-00)				0
Partnerships and business models (e.g. incentives) set up to further promote green chemistry	Local Travel (BL 15-00)				0
	National Expertise (BL 17-00)				0
	Contractual Arrangement (BL 21-00)		50,000	50000	100,000

	Training/Workshops (BL 30-00)				0
	International Meetings/Workshops (BL 35-00)				0
	Equipment (BL 45-00)				0
	Miscellaneous (BL 51-00)				0
	Output sub-total	0	50,000	50,000	100,000
TOTAL Outcome 2		330,000	180,000	160,000	670,000

		GEF Grant Budget Component 2			
Outcome 3	**Type of Expense**	**Yr 1**	**Yr 2**	**Yr 3**	**Output Total**
Output 3	International Expertise (BL 11-00)			50,000	50000
Monitoring and Evaluation	Local Travel (BL 15-00)				0
	National Expertise (BL 17-00)				0
	Contractual Arrangement (BL 21-00)				0
	Training/Workshops (BL 30-00)				0
	International Meetings/Workshops (BL 35-00)				0
	Equipment (BL 45-00)				0
	Miscellaneous (BL 51-00)				0
	Output sub-total	0	0	50000	50000
TOTAL Outcome 3		0	0	50000	50000

Sub-total		1,190,000	230,000	270,000	1,690,000
Project Management Costs		30,000	25,000	25,000	80,000
Total GEF Project Financing		1,220,000	255,000	295,000	1,770,000

ANNEX D: Workplan

Project workplan																																				
	PROJECT MONTHS																																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Outcome 1: Guidance document developed, training and awareness for green chemistry build																																				
Output 1.1: Training on green chemistry and technology including policy aspects, provided																																				
Output 1.2: Guidance document on green chemistry approach and technologies developed																																				
Outcome 2: Documentation of selected green chemistry case studies and up-scaling																																				
Output 2.1. Green chemistry documentations, including policy framework conditions, in selected countries																																				

Project workplan																																				
	PROJECT MONTHS																																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Outcome 1: Guidance document developed, training and awareness for green chemistry build																																				
Output 2.2. Partnerships and business models (e.g. incentives) set up to further promote green chemistry																																				

ANNEX E: 12 Principles of Green Chemistry and Green Engineering

No.	12 Principles of Green Chemistry	12 Principles of Green Engineering
1	**Prevention** It is better to prevent waste than to treat or clean up waste after it has been created.	**Inherent Rather Than Circumstantial** Designers need to strive to ensure that all materials and energy inputs and outputs are as inherently nonhazardous as possible.
2	**Atom Economy** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.	**Prevention Instead of Treatment** It is better to prevent waste than to treat or clean up waste after it is formed.
3	**Less Hazardous Chemical Syntheses** Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.	**Design for Separation** Separation and purification operations should be designed to minimize energy consumption and materials use.
4	**Designing Safer Chemicals** Chemical products should be designed to effect their desired function while minimizing their toxicity.	**Maximize Efficiency** Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency.
5	**Safer Solvents and Auxiliaries** The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.	**Output-Pulled Versus Input-Pushed** Products, processes, and systems should be "output pulled" rather than "input pushed" through the use of energy and materials.
6	**Design for Energy Efficiency** Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.	**Conserve Complexity** Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition.
7	**Use of Renewable Feedstocks** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.	**Durability Rather Than Immortality** Targeted durability, not immortality, should be a design goal.
8	**Reduce Derivatives** Unnecessary derivatization (use of blocking groups, protection/ de-protection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.	**Meet Need, Minimize Excess** Design for unnecessary capacity or capability (e.g., "one size fits all") solutions should be considered a design flaw.
9	**Catalysis** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.	**Minimize Material Diversity** Material diversity in multicomponent products should be minimized to promote disassembly and value retention.

10	**Design for Degradation** Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.	**Integrate Material and Energy Flows** Design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows.
11	**Real-time analysis for Pollution Prevention** Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.	**Design for Commercial "Afterlife"** Products, processes, and systems should be designed for performance in a commercial "afterlife."
12	**Inherently Safer Chemistry for Accident Prevention** Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.	**Renewable Rather Than Depleting** Material and energy inputs should be renewable rather than depleting.

ANNEX F: Pilot demonstration projects

i) Brazil: Production of linear low density green polyethylene

Introduction:

Since 2010 Braskem has been producing substantial amounts of polyethylene resins for a wide variety of applications and market segments, using ethylene obtained from sugar cane based-ethanol as feedstock by a dehydration process.

The total capacity of our green ethylene plant is 200 thousand metric tons yearly (kty), which makes Braskem the world leading player in this business. Current clients are mostly global brand-owner companies located worldwide, especially in Japan, Germany and Brazil.

"Green" ethylene from this plant can be fed by pipeline to three existing polymerization units to produce the green high density polyethylene, green low density polyethylene and green linear low density polyethylene.

What we observe in our existing linear low density polyethylene industrial plant is that the current polymerization technology, which is predominantly used in flexible food packaging, has shown not to fully meet highly demanding requirements set by the Market, especially with regard to the optical (transparency and gloss) and sealing (the ability to seal a packaging) properties. As a result of that, parts of LLDPE sales (which include both the petrochemical and green version) have been limited to some extent.

Project Description:

In order to overcome the aforementioned performance gaps, Braskem is planning to implement a new licensable and commercially proven Technology based on the use of novel type catalysts combined with some process optimization in one of its existing polymerization lines.

Preliminary results obtained at Braskem lab from the evaluation of commercial samples produced by the partner under this Technology showed significant improvements in the final performance in comparison to the current LLDPE grade produced by Braskem, which motivated Braskem to move forward in the feasibility study of licensing such Technology.

A few modifications in the existing industrial plant will be required to enable Braskem to implement the Technology. Over the implementation period, the Technology owner will provide Braskem with the process design package (PDP), which includes all the technical information related to the Project.

It should be pointed out that the Technology refers only to the polymerization stage after the green ethylene has been obtained from ethanol dehydration, however in order to produce the green LLDPE an extensive work should be conducted to avoid the possible effects that the contaminants presents in the green ethylene (ethanol, ethyl ether and acetaldehyde) in the polymerization process, which are not found in the ethylene obtained by fossil sources.

Due to improvements in the final performance, customers will be allowed to increase the amount of green PE in their formulations with noticeable gains over the value chain.

Project Duration:

The intended starting date is 1st quarter 2016 after a License Agreement has been signed. The total estimated period of time for completion is 1.5 – 2 years, broken down into the following milestones:

- 1st quarter 2016: Delivery of Process Design Package and main equipment ordering
- 2nd quarter 2016: Execution of Detailing Project
- From 3rd quarter 2016 to 1st 2017: Project execution (on-site construction)
- 2nd quarter 2017: Test Run and Project finalization

Project Size:

The required investment cost to implement the Project is estimated to be approximately U$ 6 MM over the entire period. In addition, Braskem will be charged in related to personnel training, support for Plant Test Run and post-implementation technical services.

Some performance guarantees, including minimum production rate, product quality criteria and maximum chemical and utilities unit consumption, will be agreed in advance between Braskem and the Technology owner, and included in the License Agreement. In addition, the Technology owner should provide a legal statement signed by an independent office that the use of Technology by Braskem does not infringe Intellectual Property of third parties.

Adherence to Green Chemistry principles

Table 1 shows some notes about the adherence to Green Chemistry. Since the project only involves a change in the catalyst and the required adaptations in the process, only principles 1 (prevention) and 2 (atom economy) are substantially improved. Other principles, such as 7 (renewable feedstocks) are already highlights of our current product and are maintained.

Table 1: Adherence to Green Chemistry principles

No.	**12 Principles of Green Chemistry**	**Green Chemistry in the Green PE project**
1	**Prevention** It is better to prevent waste than to treat or clean up waste after it has been created.	The novel catalysts are well known for their higher co-monomer incorporation and lower hydrogenation as compared to the current catalyst. Such catalyst change will thus reduce the monomer and co-monomer loss due to hydrogenation. Today, as 1-hexene and ethylene are to some extent converted to hexane and ethane respectively, we have to deal with higher purge rates to flare and liquid hexane/hexane purge to treatment plants. The new process will prevent these losses. Regarding the green ethylene production, waste is only generated by unwanted,

No.	12 Principles of Green Chemistry	Green Chemistry in the Green PE project
		secondary reactions, that are minimized by the technology. The production of green ethylene from ethanol involves the loss of one water molecule for each molecule of ethylene that is formed, so that water is the only significant "by-product", and it can be reused in the site.
2	**Atom Economy** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.	The novel catalysts have much better co-monomer incorporation and response as compared to the current catalysts, besides promoting less hydrogenation, there will be atom economy in the process as less hexane is loss due to solubility issues and hydrogenation of the co-monomer 1-hexene. In the end the plant will have an improved total monomer efficiency to produce the same amount of polyethylene. The production of green ethylene from ethanol involves a chemical reaction where all carbon the atoms in the reactant are maintained in the final product. The production of PE involves a polymerization reaction where all the atoms are conserved. This means that improvements in atom economy are limited to reducing the by-product formation (as mentioned above).
3	**Less Hazardous Chemical Syntheses** Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.	PE is not toxic.
4	**Designing Safer Chemicals** Chemical products should be designed to affect their desired function while minimizing their toxicity.	PE is not toxic.
5	**Safer Solvents and Auxiliaries** The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.	
6	**Design for Energy Efficiency** Energy requirements of chemical processes	

No.	12 Principles of Green Chemistry	Green Chemistry in the Green PE project
	should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.	
7	**Use of Renewable Feedstocks** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.	The raw material (green ethylene obtained from sugar cane alcohol) is 100% renewable.
8	**Reduce Derivatives** Unnecessary derivatization (use of blocking groups, protection/ deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.	No derivatives are used, the reactions are straightforward (dehydration and polymerization)
9	**Catalysis** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.	Both the dehydration and polymerization are catalytic reactions.
10	**Design for Degradation** Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.	Green PE can be re-used, is recyclable and can be simply added to existing recycling streams. PE is not biodegradable. In some countries, incineration is favored because of the high energy content (similar to most hydrocarbon fuels)
11	**Real-time analysis for Pollution Prevention** Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.	While there is no critical pollutant generation within the process, real time, online analysis is used to maintain the optimal operating conditions, minimizing the risk of unwanted secondary reactions.
12	**Inherently Safer Chemistry for Accident Prevention** Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.	The raw material and the products do not pose a health risk. Ethylene is inflammable, and the design takes this into consideration. The plant will be located inside an existing industrial site with health, environment and safety procedures already in place.

ANNEX G: Green Chemistry Training Needs Assessment

Green Chemistry Training Needs Assessments		
Num	**Country**	**Objective1: Green Chemistry Training**
		Universities/ Associations (Name/ City)
1	**Brazil**	UFRJ Rio de Janeiro
		SENAI-RS
		Painting Industry Union
		SENAI National Department and SENAI Network on Chemistry and Environment
2	**Colombia**	Uni Jorge Tadeo Lozano, Bogota
		Uni of Sabana, Bogota
		Uni of Antioquia, Medellín
		Uni Pontificia Bolivariana, Medellín
3	**Egypt**	Ain Shams University
		Cairo University
		Mansoura University
		Academy of Scientific Research
		Egyptian Japenese University
		Suez Canal University
4	**Mexico**	NCPC Mexico provided detailed information on national general stakeholders, ongoing national activities on Green chemistry and baseline data on relevant sectors, technologies and companies without mentioning project partners yet
5	**Peru**	8 universities with chemical and chemical engineering career that could be trained
		Relevant associations: National Society of Industry National Chemical Committee conducted by MINAM; The National Chemical Society (disseminates chemistry researchs)
6	**Russia**	Moscow State University
		Mendeleyev University of Chemical Technology of Russia
		Altai State University
		Kazan National Research Technological University
		Northern (Arctic) Federal University
		Novosibirsk State University

		Far Eastern Federal University
7	**Serbia**	University of Belgrade
		University of Nis
		University of Novi Sad
		State University of Novi Pazar
		Serbian Chemicals Society
8	**Uganda**	Makerere University Kampala, Department of Chemistry
		Kyambogo University
		Mbarara University of Science and Technology
		Uganda Industrial Research Institute
		Uganda Manufactures Association
		Uganda Sugar Manufacturers Association
		Uganda Small Scale Industries Association
		Uganda Tea Development Agency
9	**Ukraine**	Among others: Ukranian Chemists Union;
		Association of farmers and Landowners of Ukraine
		Association “Greenhouses of Ukraine”

ANNEX H: Environmental assessment of Braskem's biobased PE resin

Environmental assessment of Braskem's biobased PE resin

Summary of the life cycle assessment, land-use change and water footprint reports

November 2013

This is a summary of a report prepared by E4tech and LCAworks in collaboration with two expert reviewers, Professor Isaias Macedo and Professor Joaquim Seabra.

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Contents

Introduction

In order to better understand the environmental profile of its polyethylene resins derived from biobased feedstock (sugarcane ethanol), Braskem commissioned three separate, but related studies:

1. A complete life cycle assessment in line with ISO 14040/44
2. A location-specific land use change assessment in line with the EU Renewable Energy Directive
3. A location-specific water footprint based on the Water Footprint Network methodology

Practitioners

The studies were developed by E4tech, a technically informed strategic consultancy in sustainable energy and materials based in the UK and Switzerland, and LCAworks, an environmental consultancy based in the UK. They relied on data collected from a selection of Braskem's ethanol suppliers and on Braskem data for the polyethylene resins production processes, and benefited from close collaboration between the two firms and two independent Brazilian experts. The three studies investigate different aspects of the cradle-to-(factory) gate life cycle impacts of the production of Braskem's biobased high-density polyethylene (HDPE) and linear-low density polyethylene (LLDPE) resins.

Objectives

The main aims of the three studies were to:

- gain insight into the key impacts of biobased polyethylene resins production across a range of environmental impact categories
- consider the environmental profiles of novel biobased PEs, and in the case of the LCA compared with the environmental profiles of conventional petrochemical-based PEs (based on petrochemical PEs by Braskem from their production site at Triunfo, Rio Grande do Sul, Brazil).
- understand some of the wider environmental issues linked to the introduction of biobased PE manufacture
- evaluate opportunities to improve the environmental profile in the future.

Life cycle assessment - LCA

The LCA study was undertaken in accordance with ISO 14040/44, complemented by additional relevant parts of BS EN 16214 (Draft), BS EN 15804 (2012), PAS 2050 (2011), the Greenhouse Gas Protocol and the International Reference Life Cycle Data System (ILCD).

An ISO 14044 critical review process for this LCA study was carried out in 3 stages, with the Goal & Scope report issued to the Critical Review Panel (CRP) in January 2012, the review of the LCI raw data report completed in May 2013, and the final LCA report review and CRP statement in November 2013.

The CRP includes the following individuals:

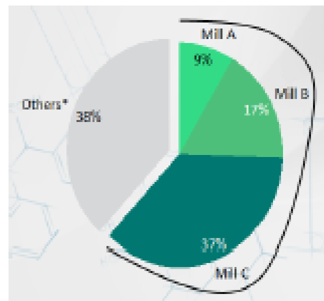
- Andreas Detzel, IFEU, Germany
- Prof Ramani Narayan, Michigan State University, USA
- Martina Krueger, IFEU, Germany (substituting Prof Masahiko Hirao, University of Tokyo, Japan, from October 2013)

Functional unit, data and methodological choices

The functional unit for the study is 1 kilogram of Braskem biobased PE resin, commercially known as *"I'm green™ Polyethylene"*.

Primarily, the study focusses on the potential emissions and removals[1] related to the production of biobased PE products. It aims to understand the wider implications of the new biobased PE system, rather than only attributional aspects of the environmental profile for what could be regulatory compliance (e.g. similar to the EC Renewable Energy Directive for biofuels regulation). Thus, the LCA here considers aspects linked to the introduction of biobased PE that may affect removals and emissions more widely than just within the product system itself. Particular attention was paid to the potential implications of co-products, carbon removals into the PE products and effects of direct and indirect Land Use Change (direct LUC and indirect LUC). The principle approach used for presentation of the LCA results for the biobased PE is a *substitution credit approach* for electricity co-produced with ethanol and supplied to the Brazil national grid.

The LCA, land-use change and water footprint results are based on data from three individual mills that supply more than 60% of the ethanol purchased by Braskem. Their data is representative of the 2011/12 harvest year, and has been averaged over a full 6-year sugarcane crop cycle. Making up the remaining ethanol is a "Centre-South Brazil" dataset, representing the average ethanol supply from this region (which produces >80% of Brazilian sugarcane ethanol). This gives the "Braskem weighted average ethanol" supply based on the volumes of ethanol supplied by these different sugarcane mills.



Data for Braskem's manufacturing of biobased PE refers to the 2012 production year, representing stable manufacture processes. This is considered to be a reasonable reflection of production expected over the time period 2011-2015. Since the biobased ethylene plant start-up commenced in 2011, 2012 production still included periods of improvement and process refinement.

The assessment includes biobased HDPE produced by either the slurry process (Hostalen) or HDPE or LLDPE produced by the gas-phase process (Spherilene) up to the Braskem factory gate in a form ready for compounding and packaging for distribution to users. The analysis revealed only small differences between the slurry and gas phase results for the manufacture of biobased PE in any impact categories with other factors constant. This is the reason why the gas-phase data is not presented in this summary report.

Conventional HDPE and LLDPE resins produced by Braskem from Naphtha are also assessed in the report as comparative benchmarks and these are referred to as petrochemical HDPE and petrochemical LLDPE respectively. Again, this summary report only presents the HDPE, as differences between the petrochemical PEs are relatively small.

Several sensitivity analyses were carried out to ensure the quality of the results and guarantee a transparent and robust study that best represent the Brazilian conditions and Braskem's reality.

This executive summary presents detailed results generated for the "Base case" as defined below:

1 kg of Green HDPE (slurry process, "Braskem weighted average" ethanol supply) when a substitution credits methodology (consequential LCA approach) is applied to the surplus

[1] The term "removals" is here used to express what is often referred to as "sequestration". Since this study is cradle to gate, the term "sequestration" is avoided in order not to imply a false sense of "permanent" storage of CO_2 from the atmosphere, when, in fact, this CO_2 could be released again depending on the fate of the PE product in the end of life phase of a full life cycle.

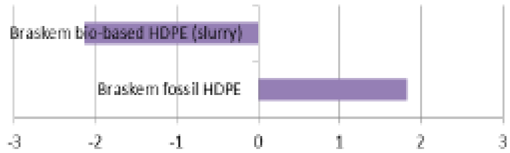
electricity co-product and when CO_2eq credits for direct LUC carbon storage on land and CO_2 removal into the polymer resin are accounted for in the model

Results

The graphs below present the comparison of the Braskem "Base Case" biobased PE produced via the slurry process and Braskem's petrochemical PE (a single site, like-for-like comparison). The results are expressed as LCIA results, primarily via midpoint assessment methods.

Note that these impact categories present "potential" impacts, and not impacts that have been directly measured in the environment. It is also not possible to simply derive the sustainability of these processes in the relevant locations from these results. This would require further detailed location-specific research.

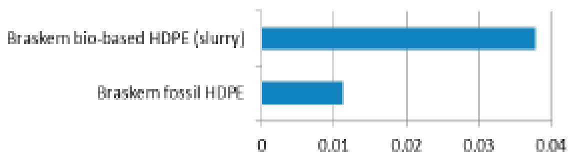
Global Warming Potential (kg CO_2eq/kg PE)



Calculation methodology: IPCC 2007

This presents the GHG emissions of the two PE products.
For the biobased PE, this figure is negative. The main reasons for this are carbon "removal" from the atmosphere and its incorporation as carbon atoms in the polymer (as "sequestered" CO2), but also a "substitution credit" for co-produced electricity at the sugarcane mills and for direct land-use change.

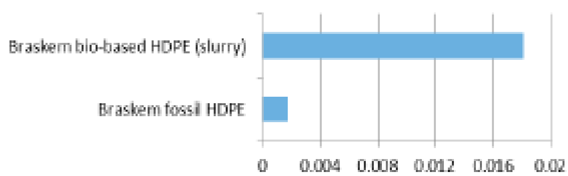
Acidification Potential (kg SO_2eq/kg PE)



Calculation methodology: CML 2001

This describes any potential chemical alteration of the environment (mainly rivers and lakes) resulting in hydrogen ions being produced more rapidly than they are dispersed or neutralised.
The main contributors to this impact category are SOx and NOx emissions. For biobased PE they result from bagasse combustion, fossil fuel combustion by agricultural machinery and in- field trash burning.

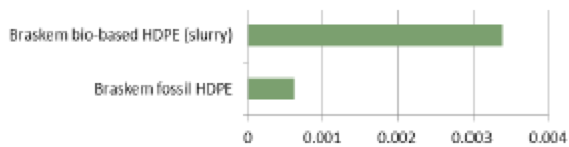
Eutrophication Potential (kg PO_4eq/kg PE)



Calculation methodology: CML 2001

This informs on the potential enrichment of land and water bodies by nitrogen and phosphorous compounds from emissions to air or surface run-off. Enrichment increases the growth of aquatic plants and can produce algal blooms that deoxygenate water and smother other aquatic life.
The emissions that drive the eutrophication category of the biobased PE are primarily from sugarcane cultivation and mainly phosphate and phosphorus emissions.

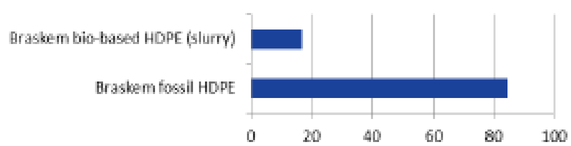
Photochemical Ozone Creation Potential (kg C_2H_4eq/kg PE)



Calculation methodology: CML 2001

Photochemical ozone formation is caused by degradation of organic compounds (VOCs) in the presence of light and nitrogen oxide (NOx), causing "summer smog" as a local impact and "tropospheric ozone" as a regional impact.
The main contributors to this impact category for biobased PE are the sugarcane cultivation, and green ethanol production, with sugarcane production the most significant driver due to the carbon monoxide from in-field trash burning.

Fossil Energy Demand (MJ/kg PE)



Fossil energy demand represents a depletion of these finite reserves. Petrochemical PE's fossil energy demand includes fossil feedstock that is converted into the PE polymer itself as well as fossil process energy usage for this conversion. Biobased PE's fossil energy demand is incurred in sugarcane cultivation, ethanol transport and green ethylene production and polymerisation into biobased PE. However, its feedstock is renewable (sugarcane ethanol) as is over 80% of the energy for its processing (sugarcane bagasse). Both types of PE share the same polymerisation process, i.e. they have the same fossil energy demand for that particular phase of production.

Exploration of scenarios

By working through different scenarios, insights can be gained on specific matters of interest, for example related to the possible improvements that can be achieved, or if impacts can be expected to change in the future.

An ***improvement analysis*** on the base case revealed that a series of near-term measures in sugar cane cultivation and cane mill operations, as well as in the green ethylene conversion process would yield a 10-20% improvement across all assessed impact categories.

Equally, an analysis of the longer-term ***future perspective 2020*** revealed that strong indications that substantial opportunity exists to continue improving the environmental performance for biobased PE over that timeframe and beyond.

Main conclusions

The main conclusions from this cradle-to-factory gate LCA study are:

Global Warming Potential (GWP_{100}) impacts

- The two types of Braskem's biobased PEs, for the "Base Case" modelled using the substitution credit approach and the Braskem average ethanol supply chain lead to a negative GWP_{100}

indicator. The biobased PE polymer resin leads to a net removal of CO_2 from the atmosphere, averaging -2.15 kg CO_2e/kg biobased HDPE (slurry). The emissions from biobased PE production (sugarcane production, ethanol production, Green Ethylene production and biobased PE production) are more than outweighed by the CO_2 removed from the atmosphere and embodied into the biobased PE resin.

- Under the substitution credit methodological approach, a credit is awarded to sugarcane ethanol for the emissions avoided from power generation in natural gas power plants due to the green electricity co-produced with sugarcane ethanol. This benefit is equivalent to offsetting approx. 25% of the GWP_{100} production emissions for biobased HDPE (slurry) for Braskem's average ethanol supply.
- Direct LUC for sugarcane cultivation, as calculated by the separate LUC study (see below for more information), also contributes beneficially to the overall GWP_{100} balance for biobased HDPE (slurry) by offsetting the equivalent of 40% of the GWP_{100} production emissions for biobased HDPE (slurry) for Braskem's average ethanol supply.
- When compared with Braskem's petrochemical PE comparator in this study, which has a GWP_{100} impact of +1.83 kg CO_2e/kg PE, the net GWP_{100} benefits of the base case Braskem average biobased HDPE (slurry) is -3.98 kg CO_{2e}/kg biobased PE.
- Care must be taken when quoting the GWP_{100} balance results, to be clear that they refer to the co-product substitution credit methodology applied and that this is a cradle-to-gate assessment. A significant fraction of the negative GWP_{100} emissions associated with Braskem biobased PE is due to the carbon bound in the biobased PE, and the LCA does not account for the ultimate release into the atmosphere of any of this bound carbon, which could potentially occur as part of the ultimate fate of a biobased PE product. Of course, the same will also apply to the end of life of a petrochemical PE product.

All categories

The performance of biobased PE compared with the petrochemical comparator is mixed across the other environmental impact categories. Biobased PE shows benefit for Global Warming Potential (GWP) and Abiotic Depletion, but the petrochemical comparator performs better or equally across the other impact categories.

Although GHG/GWP and Abiotic Depletion issues are the most important drivers of green materials uptake, it is important to maintain a balanced perspective across a range of important environmental impacts. The relative weighting of different environmental indicators has been a topic of academic debate for several years, and attempts have been made to create integrated assessments based on different weighting approaches. In practice, the relative importance of each impact category varies according to the specific local conditions and needs to be interpreted and weighted very carefully in that context. Also, the significance of the absolute impacts needs to be understood, though the lower the impact the better.

Sensitivity Analysis

The sensitivity analysis carried out gives significant comfort that the results are not critically altered around a small number of (possibly uncertain) assumptions or input data. Overall, the broad conclusions from the results are relatively insensitive to most critical data, boundary and assumptions.

Impacts of transport

A question is often asked in relation to the impacts of transport. The relative contributions of transport to the six main environmental impact categories for Braskem's biobased HDPE (slurry) are dominated by the transport of the ethanol by rail in Brazil, owing to the large distances involved compared with road transportation, and higher per unit distance impacts than for transport by sea. The international shipping of biobased HDPE from the factory in Brazil to representative international destination ports adds only 2-4% extra to the GWP_{100} emissions profile.

"Hotspots"

In an approximate order of importance in relation to impacts:

HOTSPOTS	Impact Categories
Trash and bagasse burning	GWP, Acidification Potential, Eutrophication Potential, Photochemical Ozone Creation Potential
Fertilizer and pesticide use and soil/field emissions	Eutrophication Potential
Diesel consumption	GWP, Abiotic Depletion Potential
Natural gas usage	GWP, Abiotic Depletion
Transportation	GWP, Abiotic Depletion Potential, Acidification Potential, Eutrophication Potential
Grid electricity use	GWP, Abiotic Depletion, Acidification Potential, Eutrophication potential

Main limitations of this study

A thorough and detailed LCA study underlies this summary. However, in common with most LCA studies, some important limitations are associated with methodology and data choices, data quality aspects and interpretations made.

- There are uncertainties (explored in the sensitivity analyses) associated with input data for some key substances and processes (e.g. phosphate leaching from fertilizer use, emissions to air from in-field, pre-harvest burning of sugarcane (being phased out) and from bagasse combustion). Further research would lead to more reliable values, and in several cases would require new measurements to be carried out. Sensitivity analysis showed that while the overall balance of results of the LCIA was relatively stable to a range of these values, some appreciable effects are observed for one or two individual impact categories. Overall these do not in themselves invert the trend in the findings.
- The methodologies used to analyse the inventory and to develop characterised results and their interpretation is still undergoing active development in the LCA community. At present, there is no universally agreed single 'consensus' approach. The LCA aimed to select impact categories and methodological approaches that are consistent with established European and International standards and guidance. The methodological choices used for this study are described explicitly in the full LCA report and a number of 'extra' impact categories beyond the six core ones were also explored in the work (e.g. terrestrial ecotoxicity). Sensitivity analysis using an alternative LCIA method (ReCiPE) was also undertaken and this supported the general direction of the results obtained.
- The choice of approach in relation to co-products, especially green electricity exported to the Brazilian national grid (co-product of sugarcane ethanol), is an important methodological aspect that affects the results. The study applies the substitution credit approach for co-product electricity, considering that it is a significant element in the Brazilian grid electricity supply and has been recognized and applied in similar studies both in Brazil and internationally. However, in order to ensure transparency and as a sensitivity analysis, results are also presented and discussed via the allocation approach in the full LCA report.

- The results and conclusions drawn from this study reflect the system and methodological choices made. Alternative methodological approaches, system boundaries and/or impact categories will lead to differences in the results.
- The cradle-to-gate perspective of this life cycle study properly reflects those phases of a product life cycle that are under Braskem's direct influence as manufacturer and supplier of biobased and petrochemical polyethylenes. As a cradle-to-gate study no account is taken of impacts associated with the use and end-of-life phases of a full product life cycle.

Land-use change assessment

Method

A separate, location-specific study on the land use change impacts of Braskem's demand for sugarcane ethanol for the production of biobased PE has been conducted. This study estimates the changes in soil organic carbon and carbon stocks of land directly and indirectly affected by Braskem's activities. An important objective of the study was not only to help Braskem better understand the land requirement fo biobased PE and the resulting impacts on the existing Brazilian agricultural system, but also to identify actions to mitigate land pressure and carbon emissions from such land use change.

Approach

The study is limited to changes in soil organic carbon and above and below ground carbon stocks, and quantifies the direct carbon emissions from conversion of land directly to sugarcane cultivation (direct LUC), as well as the indirect "knock-on" effects of displaced pasture and cropland to other regions in Brazil (indirect LUC). To understand impacts of future changes in sugarcane harvesting practices and intensification of the agricultural system, both a current case (2008 – 2011/12 harvest year) and a future case (2008 – 2020) were calculated and used in the appropriate scenarios in the LCA study. The direct LUC and indirect LUC impacts are calculated per kg biobased PE.

The direct LUC calculations follow the "European Commission Decision of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC". The calculations include changes in soil organic carbon, above/below ground carbon stocks and the effects of the burning of cane and trash on carbon stocks. It was taken into account that soil organic carbon stocks only reach their equilibrium after approximately 20 years of consistent land cover or land use.

It is important to note that disagreement over the modelling of indirect LUC exists among practitioners and policy makers. For the indirect LUC modelling in this study, E4tech's causal-descriptive modelling approach was used (E4tech, 2010[2]). This approach transparently models the local land use situation at the sugarcane plantations, and the knock-on impact of land required elsewhere. All assumptions were reviewed by local experts. However, the controversy and lack of consensus on indirect LUC representation means that, in common with many LCA studies it has not been implemented in the base-case. The potential effects of incorporating indirect LUC were examined in a specific scenario in the full LCA report.

Data – direct LUC

Analogous to the LCA study, the same three mills provided us with data regarding soil conditions and the mix of land types that were converted during expansion in 2010/11 and 2011/12 (for the "current" case), and which mix of land types they expect to continue to be converted in the future (2012-2020, "future" case), as well as the share of burned and unburned cane for both periods. A "São Paulo/Centre-South" data set was constructed based on literature data and local expert advice to determine LUC impacts of ethanol supply other than from the three mills. This was complemented with additional literature data in order to characterise soil organic carbon and above and below ground carbon stocks before conversion to sugarcane and after conversion.

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[2] E4tech (2010) "A Causal Descriptive Approach to Modelling the GHG Emissions Associated with the Indirect Land Use Impacts of Biofuels" Authors: Bauen, A., Chudziak, C., Vad, K., and Watson, P., Final Report, A study for the UK Department for Transport, Available at: http://www.apere.org/doc/1010_e4tech.pdf

The mills also provided us with the figures of their supply (or supply projections in the "future case") of ethanol to Braskem in the time periods considered. These figures were used to calculate the weighted average LUC of Braskem's ethanol consumption.

Data – indirect LUC

Since it is not possible to know exactly where the indirect LUC takes place and which land uses or land covers are displaced, for the indirect LUC modelling a regional dataset published by Winrock International (2011)[3] with estimates of historic proportions of different land cover changes and associated carbon stocks was used.

Results – direct LUC ("current case")

As presented in Figure 1, the weighted average across Braskem's current Green PE production equates to direct LUC emissions of -1.1 kgCO2e/kg PE, with a range of +0.7 to -2.4 kgCO2e/kg PE.

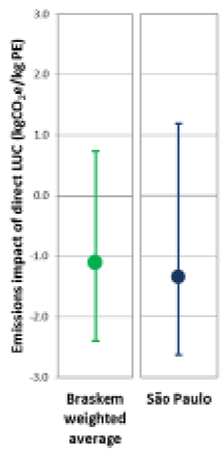

Figure 1: direct LUC results

We note that these "average" net CO_2 emissions for direct LUC are negative, i.e. the change to sugarcane has increased the carbon stocks in the soil and/or above and below-ground vegetation. The error bars in Figure 1 indicate uncertainty ranges that result from data sets with actual measurements lacking in many cases and the use of proxy data from literature. The error bars extend in the positive direction, i.e. it is not certain that Braskem's current Green PE production is leading to net CO_2 negative direct LUC.

Results – indirect LUC ("current case")

Given the methodological uncertainties, indirect LUC was not included in the "Base Case" scenario of the LCA study. Indirect LUC is found to result in +1.3 $kgCO_2e$/kg PE, but was not further used in LCA scenarios.

Results – "future case"

Both the direct and indirect LUC emissions show slight improvements in the future case. This is mainly due to the phase-out of the practice of burning of sugarcane during manual harvesting in the case of direct LUC, and due to further intensification and yield improvements in the case of indirect LUC.

[3] Winrock International (2011) "Land Use Change GHG Emissions Factors", pdf and excel available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2011-0542-0105

Conclusions and limitations of the study

Sufficient land is available to meet Braskem's demands. There are currently 9.75 million ha of sugarcane in Brazil. Brazil's Agro-Ecological Zoning policy identifies very large areas of land within Brazil that are suitable for the expansion of sugarcane production without environmental restrictions. Around 5-6 million ha of additional land is expected to be needed by 2020 for the sugarcane industry as a whole, based on current projected demands by Embrapa. The area modelled for Braskem's hypothetical 2020 production is only a very small fraction of this area.

The uncertainty of the data has to be taken into account whenever drawing inferences from the results of both the direct and indirect LUC impacts. More extensive and detailed data would reduce uncertainties, and improved data gathering at the sugarcane plantations would enable Braskem to model the impacts of LUC with greater precision in the future.

The key message from the available direct LUC data is to ensure that the soil types expanded onto are those that are likely to give the greatest gain in SOC, and that minimal above-ground vegetation is present. As the land types onto which a high proportion of sugarcane expansion is expected to occur are typically degraded pasture land, the resulting indirect LUC will also be relatively small.

Importantly, although the direct LUC results gave a spread of negative values (with uncertainties stretching into the positive), it is expected that the indirect LUC results will generally always be positive (due to conversion of higher carbon stock native vegetation), despite the large data uncertainties

Water footprint

A separate study on the water impacts of Braskem's demand for sugarcane ethanol for the production of biobased PE has been conducted, making use of data gathered for the LCA study and assuming the same system boundaries and temporal coverage.

Methodology

The assessment follows the methodology of the Water Footprint Network, thus calculating the direct and indirect water consumption of Braskem's biobased PE (for both the water consumed by sugarcane itself, the "green water footprint", and readily accessible water taken from aquifers and streams for process use the "blue water footprint"[4]) and an estimation of the water that would be needed to dilute any pollutants to legally acceptable levels (the "grey water footprint").

Figure 2 illustrates the calculation of the water footprint (WFP) for each of the production stages of biobased PE. The words "direct" and "indirect" highlighted in white indicate in which production stage either a direct or indirect green, blue, or grey WFP occurs. For example, only the plantation & mill (i.e. the ethanol production) stage has a direct green WFP generated by the uptake of rainwater by the sugarcane, while the indirect green WFP that occurs in the plantation & mill as well as in the transport stage comes from a very small amount of biodiesel used for machinery and trucks. Added up together, these components make up the total green WFP of Braskem's biobased PE. The figure also shows allocation to different co-products, which is done on an economic basis.

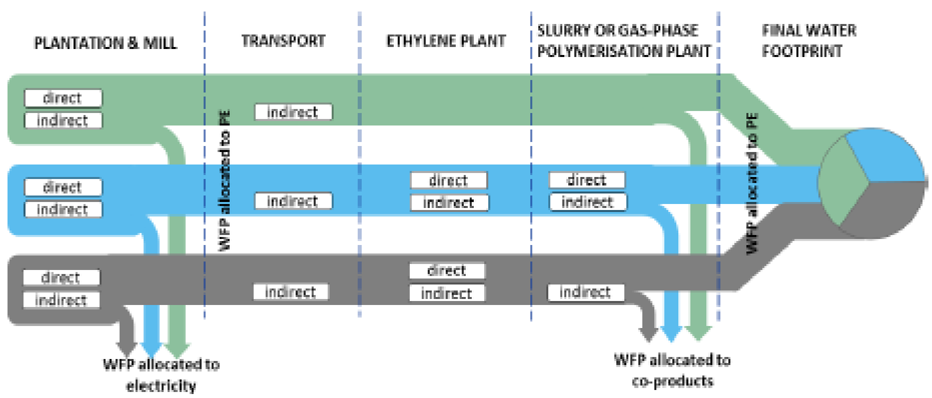

Figure 2: Illustration of the calculation of the overall WFP

The final results are then split up between the Parana River Basin, where all the sugarcane plantations and the ethanol mills are located, and the South Atlantic Basin, the location of Braskem's ethylene and polyethylene facilities.

In addition to this quantitative assessment, the study also gathers evidence of the underlying situation of these river basins: data is assembled about the availability of water as well as its quality using data published by governmental and international bodies. Based on these insights, we come to an initial understanding of the sustainability of the water impacts of Braskem's demand for sugarcane ethanol.

[4] It is important to note that the "blue" water footprint is defined as the "removal" (either through incorporation into a product and its transport or evaporation) from the river basin in which a particular process step takes place.

Results

Figure 3 shows the water footprint (split into the green, blue and grey components) of Braskem's biobased PE production for the river basins in which the activities are located.

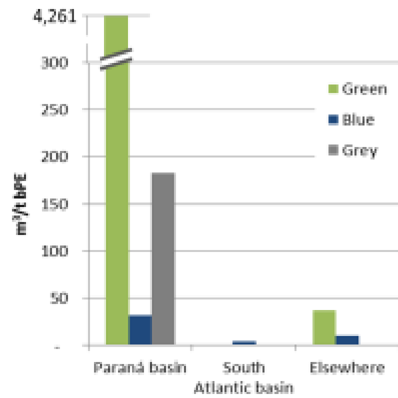

Figure 3: Water footprint of Braskem's biobased PE production in river basins where production is located

It is immediately evident that the green water footprint dwarfs both the blue and the grey water footprints. This result is the norm for products derived from plants, as they take up water through evapotranspiration during growth. There are no green and grey components in the South Atlantic Basin, as processing in this river basin does not involve the growing of sugarcane, and as Braskem's chemical plants only discharge treated liquid effluents.

The results have been compared to other water footprint studies of sugarcane and sugarcane ethanol, and were found to be slightly lower, with some sensitivity of the green water footprint to the underlying data for evapotranspiration.

For the sustainability assessment, both the availability and quality of water in both river basins was assessed:

According to data available for the Parana River Basin, even during the dry months water scarcity is considered to be low, and water supply sustainable throughout the year. In addition to this, sugarcane with its characteristically high green water footprint grows during the wet season, and is not irrigated in this area, making a negative impact on water availability unlikely.

Equally, water quality measurements attest an overall healthy situation. Overall in the Parana River Basin there is no immediate concern regarding water sustainability at this time, however, it is important to monitor the impact of the agricultural activities and their impact continuously.

In the South Atlantic Basin, data shows that the area is considered a hot spot both in terms of water availability and quality. From the data gathered for this study it is clear that Braskem's processes are water efficient, but it is vital that processes are reviewed and improved regularly, and that staff awareness around the issues of water is built and maintained.

Conclusions and limitations of the study

1. **Green water footprint** – determining the correct value of evapotranspiration is difficult as this parameter depends on rainfall, insolation and other general characteristics of the location of the field. Measurements of the same field in different years can also yield different values for

evapotranspiration. In addition, comparative green WFPs are needed in order to be able to assess the "net green WFP" when converting land from previous land uses to sugar cane plantations.

2. **Grey water footprint** – in the absence of a clearly agreed method for quantifying the dilution volumes for assimilation of pollutants, the estimation of the grey WFP is subjective. The authors suggest that issues such as eutrophication and ecotoxicity are more aptly assessed by LCA.
3. **Nutrient leaching from fields** – measurement of the leaching of nutrients such as nitrogen and phosphorus is difficult, and when conducted offer a range of values. In order to make the grey water footprint more specific to the actual mills' situation, it would be desirable to conduct measurements in the mills' plantations, and to assess related data that may become available from external studies (e.g. scientific publications and reports).
4. **Pesticides and herbicides leaching and impacts on water** – similar to nutrient leaching, the behaviour of pesticides and herbicides has to be investigated, and their impact on water established. It is important to keep in mind that the grey WFP of Braskem's biobased PE does currently not take any impacts from pesticides/herbicides into account because of a lack of available data.
5. **Precipitation monitoring** – even though blue water in the Paraná Basin currently is not scarce, and all sugar cane grows in completely rain-fed plantations, much of the future sustainability does depend on precipitation in the region. It is important to understand potential future changes to precipitation in order to assess the suitability of current plantations for future use, as well as to identify future expansion areas from a green water availability perspective.
6. **Water scarcity and quality in the South Atlantic Basin** – as soon as more detailed data describing the situation of water in the South Atlantic (and the Paraná River) Basin become available, a renewed assessment of the sustainability of the biobased PE water footprint should be made in light of the new data.
7. **Irrigation of sugar cane in Brazil** – most of the sugarcane plantations in Brazil are currently not irrigated. However, it is possible that irrigation may become necessary if sugar cane plantations expand onto drier soils, and it is recommended to further study both likelihood and timeline of this possibility.

Conclusion

Through these studies, Braskem taken important steps in understanding of the main potential environmental impacts of its biobased PE and has identified a number of points that will benefit from further work, continuous monitoring, and the prioritisation of future improvements.

In terms of the main results, biobased PE was identified as having a good performance in the GWP_{100} and Abiotic Depletion Potential impact categories. Comparative whole life cycle assessments on PE products will be a next step to indicate how these cradle-to-gate benefits contribute when appropriate use and end of life phases are brought into the assessment. Other impact categories show more heterogeneous results with petrochemical PE showing advantage over biobased PEs in some impact categories. To come to a conclusion on the relative importance of individual impact categories, it is necessary to understand their significance or weighting (essentially a value judgement) in any integration process to generate an overall indicator of absolute impact on the environment. Such 'integrated assessment' models are the subject of ongoing debate and discussion and, for the present time, we believe that the greatest clarity and understanding is obtained from evaluating the impacts of biobased PE on a category-by-category and individual issue basis.

The improvement analysis in the LCA has provided an understanding of areas for continuing improvement that can be integrated in Braskem's environmental management systems, and be further monitored.

It is also clear that the absolute values of the results vary depending on the choice of LCA methodology. We consider, however, that the substitution-based approach used is appropriate in relation to the study's goals, is transparent and qualified, and is a reasonable representation of the system impacts of Braskem's biobased PE production.

In terms of land use change, the impacts are relatively low, with possibly positive direct LUC and negative indirect LUC. Actively supporting national land use planning and identification of suppliers expanding onto degraded land will be important going forward in order to minimise indirect LUC impacts.

The water footprint study showed that there are no immediate significant water impacts, but that the local water situation requires continued monitoring to identify and prevent the development of new hotspots.

The results of these studies will now form the basis of further technical developments within Braskem and will inform discussions and collaboration with stakeholders.

ANNEX I: Legal context

It is expected that each set of activities to be implemented in the target countries will be governed by the provisions of the Standard Basic Cooperation Agreement concluded between the Government of the recipient country concerned and UNIDO or – in the absence of such an agreement – by one of the following: (i) the Standard Basic Assistance Agreement concluded between the recipient country and UNDP, (ii) the Technical Assistance Agreements concluded between the recipient country and the United Nations and specialized agencies, or (iii) the Basic Terms and Conditions Governing UNIDO Projects.

Brazil (Federative Republic of)

> "The Government of the Federative Republic of Brazil agrees to apply to the present project, mutatis mutandis, the provisions of the Revised Standard Technical Assistance Agreement between the United Nations and Specialized Agencies and the Government, signed on 29 December 1964 and entered into force on 5 May 1966."