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APPENDICES

Appendix A Life Cycle Inventory (LCI)

Table A1 Results of the inventory analysis of one kilogram PLA resin production in USA 2007

Input inventory			**Output inventory**	
Type	**Unit**		**Type**	**Unit**
Energy	**MJ**		***Product***	**kg**
Energy, from coal	0.55		PLA resin	1
Energy, from oil	5.27			
Energy, from gas, natural	22.04		***Emission to Air***	**mg**
Energy, from hydro power	0.02		CO	5800
Energy, from uranium	0.56		CO_2	-100,000
Energy, from coal, brown	0.01		SO_x as SO_2	2465.0266
Energy, from sulfur	0.12		NO_x as NO_2	7700
Energy, from biomass	24.6		Hydrocarbons	1300
Energy, from hydrogen	0.09		CH_4	13848.3026
Energy, recovered	-1.5		H_2	142.7353
Energy, from wind	6.68		HCl	9.5562
Resources	**mg**		HF	0.4142
Water, process, drinking	31603108		NMVOC	317.5822
Water, cooling, drinking	12153903		VOC	0.2449
Water, process, ocean	1788			
Water, cooling, ocean	1072007		***Emission to Water***	**mg**
Water, process, surface	1034		Phosphate	182
Water, cooling, surface	11376		COD	5900
Water, process, well	357459		BOD	1100
Water,process,unspecified	20548104		Cl^-	1628
Water,cooling,unspecified	3272351		Acid	0.5688
			Ammonium compounds	0.882
			Calcium compounds	127.3089
			Calcium ion	247.7508
			CO_3^-	0.2613
			Detergent, oil	0.059
			TOC	1568
			Sodium, ion	730.3292
			SO_4^-	138.6267
			Suspended solids	3094
			Solid Waste	**mg**
			Mineral waste	18,425
			Regulated Chemicals	4,365

Table A2 Results of the inventory analysis of one kilogram PLA resin production in Thailand based on NatureWorks 2007

Input inventory			**Output inventory**	
Type	**Unit**		**Type**	**Unit**
Energy	**MJ**		***Product***	**kg**
Energy, from coal	0.55		PLA resin	1
Energy, from oil	5.27			
Energy, from gas, natural	22.04		***Emission to Air***	**mg**
Energy, from hydro power	0.02		CO	5,778.15
Energy, from uranium	0.56		CO_2	1,715,000
Energy, from coal, brown	0.01		SO_x as SO_2	2,465.03
Energy, from sulfur	0.12		NO_x as NO_2	3,137.50
Energy, from biomass	111.4		Hydrocarbons	1,261.86
Energy, from hydrogen	0.09		CH_4	13,848.30
Energy, recovered	-1.5		H_2	142.7353
Energy, from wind	6.68		HCl	9.5562
Energy, unspecified	-5.12		HF	0.4142
Resources	**mg**		Organic substances	75.0725
Water, process, drinking	31603108		NMVOC	314.5822
Water, cooling, drinking	12153903		VOC	0.2449
Water, process, ocean	1788			
Water, cooling, ocean	1072007		***Emission to Water***	**mg**
Water, process, surface	1034		Phosphate	182
Water, cooling, surface	11376		COD	5,904.87
Water, process, well	357459		BOD	1,076.67
Water,cooling,unspecified	3272351		Cl^-	1,628.09
			Acid	0.5688
Materials/Fuels	**kg**		Ammonium compounds	0.882
Fertilizer (N)	-0.027		Calcium compounds	127.3089
Fertilizer (P)	-0.00476		Calcium ion	247.7508
Fertilizer (K)	-0.012		CO_3^-	0.2613
Lime ($CaCO_3$)	-0.0573		Detergent, oil	0.059
Pesticide	-0.000476		TOC	1568.4164
Shipping (tkm)	-0.833		Sodium, ion	730.3292
Truck (tkm)	-0.930163		SO_4^-	138.6267
Rail (tkm)	-0.0932		Suspended solids	3,094.28
Cassava root	17.4167		Pesticides, runoff	-7.122
Cassava chip	6.67		***Solid Waste***	**mg**
			Mineral waste	18,425
			Regulated Chemicals	4,365

Table A3 Results of the inventory analysis of one kilogram Ingeo resin production in USA 2009

Input inventory	
Type	**Unit**
Energy	**MJ**
Energy, from coal	16.6366
Energy, from oil	2.7406
Energy, from gas, natural	19.9791
Energy, from hydro power	0.6568
Energy, from uranium	3.8774
Energy, from coal, brown	0.0004
Energy, from sulfur	0.0718
Energy, from biomass	24.9681
Energy, from hydrogen	0.0477
Energy, recovered	-1.1547
Energy, from biomass(liq/gas)	0.0005
Industrial waste	0.0043
Municipal waste	0.0032
Energy, from wind	0.0024
Resources	**mg**
Water, process, drinking	16495064
Water, cooling, drinking	7205585
Water, process, ocean	1831
Water, cooling, ocean	461049
Water, process, surface	1062
Water, cooling, surface	12149
Water, process, well	48240
Water,process,unspecified	21341920
Water,cooling,unspecified	3220774

Output inventory	
Type	**Unit**
Product	**kg**
PLA resin	1
Emission to Air	**mg**
CO	5167.3905
CO_2	937733.7867
SO_x as SO_2	7401.4775
NO_x as NO_2	12311.2529
Hydrocarbons	1163.9528
CH_4	15207.342
H_2	15207.342
HCl	348.1994
HF	12.8964
NMVOC	43.2388
VOC	0.0318
Emission to Water	**mg**
Phosphate	0.0316
COD	4895.4074
BOD	2.7461
Cl^-	1254.1985
Acid	0.6349
Ammonium compounds	0.6997
Calcium ion	128.3772
CO_3^-	0.2652
Detergent, oil	0.0658
TOC	11.178
Sodium, ion	616.2524
SO_4^-	137.24
Suspended solids	3043.0238
Solid Waste	**mg**
Mineral waste	18751
Slags and ashes	60735
Waste, from drilling, un-specified	113119
Waste in inert landfill	68374

Table A4 Results of the inventory analysis of one kilogram Cassava-based PLA resin production in Thailand based on NatureWorks 2009

Input inventory		Output inventory	
Type	**Unit**	**Type**	**Unit**
Energy	MJ	***Product***	kg
Energy, from coal	16.6	PLA resin	1
Energy, from oil	2.6		
Energy, from gas, natural	19.7	***Emission to Air***	mg
Energy, from hydro power	0.659	CO	4,859.22
Energy, from uranium	3.89	CO_2	2,442,201
Energy, from coal, brown	0.014	SO_x as SO_2	7,576.57
Energy, from sulfur	0.0718	NO_x as NO_2	12,311
Energy, from biomass	111.4	Hydrocarbons	1,186.89
Energy, from hydrogen	0.0477	CH_4	15,068.30
Energy, recovered	-1.15	H_2	90.4235
Energy, from wind	0.0024	HCl	346.934
Resources	mg	HF	12.954
Water, process, drinking	16,495,064	VOC	0.2449
Water, cooling, drinking	7,205,585		
Water, process, ocean	1,831	***Emission to Water***	mg
Water, cooling, ocean	461,000	COD	4,920
Water, process, surface	1,062	BOD	27.419
Water, cooling, surface	12,149	NO_3^-	0.114
Water, process, well	48,240	Cl^-	1,353
Water,cooling,unspecified	3,220,774	Acid	0.634
		Ammonium compounds	0.719
		Calcium compounds	146.2739
		Calcium ion	251.8245
		CO_3^-	0.269
		Detergent, oil	0.0658
		PO_4^{3-}	0.314
		TOC	19.18037
		Sodium, ion	655.9894
		SO_4^-	171.3073
		Suspended solids	3,044
		Solid Waste	mg
		Carbon	0.195
		Calcium	0.293
		Phosphorous	0.004
		Potassium	0.029

Table A5 Results of the inventory analysis of one kilogram saccharide production in USA

Input Inventory				**Output Inventory**		
Type	**Unit**	**Amount**		**Type**	**Unit**	**Amount**
Material				**Product**		
Harvested crop	kg	1.5		Saccharide	kg	1
Energy				Corn gluten feed	kg	0.268
Electricity	MJ	0.934		Corn gluten meal	kg	0.08
Natural gas	MJ	2.181		Corn oil	kg	0.027
Chemical				**Air emission**		
Lime(CaO)	kg	0.0003		Particulate (PM10)	g	0.0007
Sulfuric acid (100%)	kg	0.00045		**Water emission**		
Sulphur dioxide	kg	0.00306		BOD5	g	0.0002
Urea	g	0.208		Chlorides	g	0.1188
Sodium hydroxide (50%)	g	0.282		Sulphate	g	0.0002
Sodium chloride	g	0.065		Suspended matter	g	0.0007
Cyclohexane	g	0.055				
Chlorine	g	0.012				
Water	m^3	0.0049				

Table A6 Results of the inventory analysis of cassava plantation in Thailand

Input inventory		
Type	**Unit**	**Amount**
Fuel		
Diesel	liter	0.016
Chemical		
Fertilizer (N)	kg	0.017
Fertilizer (P)	kg	0.016
Fertilizer (K)	kg	0.020
Paraquat	kg	0.001
Glyphosate	kg	0.001
Output inventory		
Type	**Unit**	**Amount**
Product		
Cassava root	kg	8.207
Emission to air		
Type	**unit**	**Amount**
Product		
CO_2	g/ton chip	-188,614

Table A7 Results of the inventory analysis of cassava chip processing in Thailand

Input inventory		
Type	**Unit**	**Amount**
Raw material		
Cassava root	kg	8.207
Energy		
Diesel	liter	0.010
Output inventory		
Type	**Unit**	**Amount**
Product		
Cassava chip	kg	3.143

Table A8 Results of the inventory analysis of cassava flour production in Thailand

Input Inventory		
Type	**Unit**	**Amount**
Water	m^3	15.24
Sulfur solution	m^3	10.476
Cassava root	ton	4.762
Fuel oil C grade	liter	30.95
Electricity	kwh	166.67
Output Inventory		
Waste water	liter	27,619
Cassava flour	ton	1
Cassava residue	ton	0.476
Water Emission		
Type	**Unit**	**Amount**
BOD5	kg	442
COD	kg	884
TSS	kg	414
Sulfate	kg	8.3

Table A9 Results of the inventory analysis of HDPE T-shirt bag production from company A and B based on one kg of bioplastic product

Transportation of HDPE Resin							
Input Inventory				**Output Inventory**			
Descriptioin	**Unit**	**Amount**		**Description**	**Unit**	**Amount**	
Resource		**A**	B	***Product***		A	B
Diesel	kg	0.000851	0.001195	HDPE	kg	1.0783	1.513
				Emission to air			
				NO_x	g	0.1766	0.2479
				CO	g	0.3065	0.4301
				CO_2	g	16.9428	23.7731
				PM	g	0.0469	0.0659
Blowing							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**		**Description**	**Unit**	**Amount**	
Resources		**A**	**B**	***Products***		**A**	***B***
Virgin HDPE resin	g	1078.3	1513	Unprinted bag	g	1042	1344
Recycle HDPE resin	g	190.3	227	***Solid Waste***			
Utilities				Scrap	g	226.7	169
Electricity	kWh	0.907	1.082				
Printing							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**		**Description**	**Unit**	**Amount**	
Resources		**A**	B	***Products***		**A**	**B**
Unprinted bag	g	1042	1344	Uncut bag	g	935.3	1329
Printing color	g	1.3	1.3	***Solid Waste***			
Toluene	g	38.1	38.1	Scrap	g	106.7	14
Isopropanol	g	19	19				
Ethanol 99.7%	g	6.3	6.3				
Utilities							
Electricity	kWh	0.4047	0.448				

Recycling							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**		**Description**	**Unit**	**Amount**	
Resources		**A**	**B**	***Products***		**A**	**B**
Scrap	g	190.3	227	Recycle PLA resin	g	190.3	227
Utilities							
Electricity	kWh	0.1003	0.1196				

Transportation of HDPE Product							
Input Inventory				**Output Inventory**			
Descriptioin	**Unit**	**Amount**		**Description**	**Unit**	**Amount**	
Resource		**A**	**B**	***Product***		**A**	**B**
Diesel	kg	0.000403	0.0004	T-shirt bag	kg	1	1
				Emission to air			
				NO_x	g	0.0836	0.0831
				CO	g	0.1451	0.1441
				CO_2	g	8.0184	7.9672
				PM	g	0.0222	0.0221

Table A10 Results of the inventory analysis of PET water bottle production from company D based on one kg of bioplastic product

Transport PET resin							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
Diesel	kg	0.000737		PET resin	g	933.933	
				Emission to air			
				NO_X	g	0.1528	
				CO	g	0.2652	
				CO_2	g	14.6598	
				PM	g	0.0406	

Transport PP resin							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
Diesel	kg	0.000054		PP resin	g	67.933	
				Emission to air			
				NO_X	g	0.0111	
				CO	g	0.0193	
				CO_2	g	1.0674	
				PM	g	0.003	

Injection Stretch Blow Molding							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
Virgin PET resin	g	933.933		PET bottle	g	933	
Utilities				***Solid Waste***			
Electricity	kWh	2.643		Scrap	g	0.933	
Injection							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
Virgin PP resin	g	67.335		Cap	g	67	
Utilities				***Solid Waste***			
Electricity	kWh	0.266		Scrap	g	0.335	
Transport PET product							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
Diesel	kg	0.000488		PET bottle	g	1000	
				Emission to air			
				NO_X	g	0.1012	
				CO	g	0.1755	
				CO_2	g	9.7022	
				PM	g	0.0269	

Table A11 Results of the inventory analysis of PS food container production from company C based on one kg of bioplastic product

Transportation of PS resin							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
Diesel	kg	0.000897		PS resin	kg	1.1354	
				Emission to air			
				NO_x	g	0.1859	
				CO	g	0.3227	
				CO_2	g	17.84	
				PM	g	0.0494	
Drying							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
Virgin PS resin	g	1135.4		Dried resin	g	1135.4	
Utilities							
Electricity	kWh						
Thermoforming							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
Dried resin	g	1135.4		Food container	kg	1	
Utilities				***Solid Waste***			
Electricity	kWh			Scrap	g	135.4	
Transportation of PS product							
Input Inventory				**Output Inventory**			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
Diesel	kg	0.000594		Food container	kg	1	
				Emission to air			
				NO_x	g	0.1231	
				CO	g	0.2137	
				CO_2	g	11.8116	
				PM	g	0.0327	

Table A12 Results of the inventory analysis of option 2: increase cassava yield from 3.5 to 5 ton/rai

Input inventory		
Type	**Unit**	**Amount**
Fuel		
Diesel	g	1.1463
Chemical		
Fertilizer (N)	g	1.4499
Fertilizer (P)	g	1.3647
Fertilizer (K)	g	1.7059
Paraquat	g	0.0512
Glyphosate	g	0.0597
Output inventory		
Type	**Unit**	**Amount**
Product		
Cassava root	kg	1
Emission to air		
Type	**unit**	**Amount**
Product		
CO_2 uptake	g	-72.2327

Table A13 Results of the inventory analysis of conventional landfill based on one kg of bioplastic waste

Landfill scenario							
Input Inventory				Output Inventory			
Description	Unit	Amount	Remark	Description	Unit	Amount	Remark
Bioplastic waste collection							
Resources				***Emission to Air***			
Distance	km	35		CO	g	315	
Fuel consumption	Km/L	3.3		CO_2	g	26,950	
				CH_4	g	2.1	
				NO_x	g	350	
				N_2O	g	1.05	
				NMVOC	g	66.5	
Landfill							
Resources				***Emission to Air***			
plastic waste	kg	1		CO	g	0.09	
Diesel	kg	0.00513		CO_2 (fossil)	g	16.34	
Electricity	kWh	0.00225		CH_4	g	0.02	
Tap water	kg	0.00493		NO_x	g	0.32	
Wire	kg	0.00164		N_2O	g	0.0004	
				SO_x	g	0.02	
				Emission to Water			
				BOD	g	0.0658	
				COD	g	0.1088	

Table A14 Results of the inventory analysis of incineration scenario based on one kg of HDPE product

Incineration scenario							
Input Inventory				Output Inventory			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
HDPE	kg	1		Electricity	kW	1.5	
HCl 35%	L	3.60E-05					
NaOH 50%	L	3.70E-05		***Emission to Air***			
Lime	kg	4.66E-03		NO_x	kg	8.03E-04	
Electricity	kWh	4.29E-02		CO	kg	2.54E-04	
Diesel	L	2.18E-04		SO_x	kg	1.60E-05	
				CH_4	kg	1.98E-03	
				Emission to Soil			
				Ash	kg	1.00E-02	
				Emission to Water			
				Wastewater	L	2.54E-04	

Table A15 Results of the inventory analysis of incineration scenario based on one kg of PET product

Incineration scenario							
Input Inventory				Output Inventory			
Description	**Unit**	**Amount**	**Remark**	**Description**	**Unit**	**Amount**	**Remark**
Resources				***Products***			
PET	kg	1		Electricity	kW	1.5	
HCl 35%	L	3.60E-05					
NaOH 50%	L	3.70E-05		***Emission to Air***			
Lime	kg	4.66E-03		NO_x	kg	8.03E-04	
Electricity	kWh	4.29E-02		CO	kg	2.54E-04	
Diesel	L	2.18E-04		SO_x	kg	1.60E-05	
				CH_4	kg	1.98E-03	
				Emission to Soil			
				Ash	kg	1.00E-02	
				Emission to Water			
				Wastewater	L	2.54E-04	

Table A16 Results of the inventory analysis of incineration scenario based on one kg of PS product

Incineration scenario							
Input Inventory				Output Inventory			
Description	Unit	Amount	Remark	Description	Unit	Amount	Remark
Resources				*Products*			
PS	kg	1		Electricity	kW	1.5	
HCl 35%	L	3.60E-05					
NaOH 50%	L	3.70E-05		*Emission to Air*			
Lime	kg	4.66E-03		NO_x	kg	8.03E-04	
Electricity	kWh	4.29E-02		CO	kg	2.54E-04	
Diesel	L	2.18E-04		SO_x	kg	1.60E-05	
				CH_4	kg	1.98E-03	
				Emission to Soil			
				Ash	kg	1.00E-02	
				Emission to Water			
				Wastewater	L	2.54E-04	

Appendix B Life Cycle Impact Assessment (LCIA)

Table B1 Results of the impact assessment 1 kg PLA resin production in USA 2007 by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	0.014614344
Global warming (GWP100)	kg CO2 eq	0.22738496
Ozone layer depletion (ODP)	kg CFC-11 eq	0
Human toxicity	kg 1,4-DB eq	0.010662383
Fresh water aquatic ecotox.	kg 1,4-DB eq	1.92189E-06
Marine aquatic ecotoxicity	kg 1,4-DB eq	16.85794
Terrestrial ecotoxicity	kg 1,4-DB eq	1.22189E-09
Photochemical oxidation	kg C2H4	0.000358011
Acidification	kg SO2 eq	0.006815903
Eutrophication	kg PO4--- eq	0.001471291

Table B2 Results of the impact assessment 1 kg PLA resin production in USA by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Total
Greenhouse	kg CO2	0.052331329
Ozone layer	kg CFC11	0
Acidification	kg SO2	0.007873347
Eutrophication	kg PO4	0.001471192
Heavy metals	kg Pb	0
Carcinogens	kg B(a)P	0
Winter smog	kg SPM	0.002465027
Summer smog	kg C2H4	0.00074655
Pesticides	kg act.subst	0
Energy resources	MJ LHV	58.44
Solid waste	kg	0

Table B3 Results of the impact assessment 1 kg PLA resin production in Thailand based on NatureWorks 2007 by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	0.014619503
Global warming (GWP100)	kg CO2 eq	1.5317924
Ozone layer depletion (ODP)	kg CFC-11 eq	1.60E-09
Human toxicity	kg 1,4-DB eq	0.012105734
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.000788938
Marine aquatic ecotoxicity	kg 1,4-DB eq	23.078908
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000341358
Photochemical oxidation	kg C2H4	0.000355115
Acidification	kg SO2 eq	0.004283349
Eutrophication	kg PO4--- eq	0.000664023

Table B4 Results of the impact assessment 1 kg PLA resin production in Thailand based on NatureWorks 2007 by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Total
Greenhouse	kg CO2	1.3653421
Ozone layer	kg CFC11	1.85E-09
Acidification	kg SO2	0.004283616
Eutrophication	kg PO4	0.000665756
Heavy metals	kg Pb	7.42E-07
Carcinogens	kg B(a)P	7.82E-10
Winter smog	kg SPM	0.002270784
Summer smog	kg C2H4	0.000693799
Pesticides	kg act.subst	-7.12E-06
Energy resources	MJ LHV	140.21466
Solid waste	kg	0.041869877

Table B5 Results of the impact assessment 1 kg Ingeo resin production in USA 2009 by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	0.019617717
Global warming (GWP100)	kg CO2 eq	1.2954088
Ozone layer depletion (ODP)	kg CFC-11 eq	0
Human toxicity	kg 1,4-DB eq	0.053448091
Fresh water aquatic ecotox.	kg 1,4-DB eq	8.28E-05
Marine aquatic ecotoxicity	kg 1,4-DB eq	525.0456
Terrestrial ecotoxicity	kg 1,4-DB eq	3.86E-05
Photochemical oxidation	kg C2H4	0.00093075
Acidification	kg SO2 eq	0.015043727
Eutrophication	kg PO4--- eq	0.001803022

Table B6 Results of the impact assessment 1 kg Ingeo resin production in USA 2009 by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Total
Greenhouse	kg CO2	1.1050145
Ozone layer	kg CFC11	0
Acidification	kg SO2	0.016353848
Eutrophication	kg PO4	0.001802943
Heavy metals	kg Pb	2.66E-08
Carcinogens	kg B(a)P	1.21E-10
Winter smog	kg SPM	0.007263467
Summer smog	kg C2H4	0.000587705
Pesticides	kg act.subst	0
Energy resources	MJ LHV	67.8262
Solid waste	kg	0.267509

Table B7 Results of the impact assessment 1 kg Cassava root in Thailand by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	0.0001653
Global warming (GWP100)	kg CO2 eq	-0.029993
Ozone layer depletion (ODP)	kg CFC-11 eq	3.595E-10
Human toxicity	kg 1,4-DB eq	0.0013106
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.0001553
Marine aquatic ecotoxicity	kg 1,4-DB eq	1.1604925
Terrestrial ecotoxicity	kg 1,4-DB eq	3.862E-05
Photochemical oxidation	kg C2H4	4.785E-06
Acidification	kg SO2 eq	0.0001617
Eutrophication	kg PO4--- eq	1.609E-05

Table B8 Results of the impact assessment 1 kg Cassava root in Thailand by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Total
Greenhouse	kg CO2	-0.03164398
Ozone layer	kg CFC11	4.19433E-10
Acidification	kg SO2	0.000167068
Eutrophication	kg PO4	1.58156E-05
Heavy metals	kg Pb	3.02715E-08
Carcinogens	kg B(a)P	1.33912E-10
Winter smog	kg SPM	8.23535E-05
Summer smog	kg C2H4	4.41541E-06
Pesticides	kg act.subst	0
Energy resources	MJ LHV	0.34617726
Solid waste	kg	0.000007708

Table B9 Results of the impact assessment 1 kg Cassava chip in Thailand by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	2.253E-05
Global warming (GWP100)	kg CO2 eq	0.0002886
Ozone layer depletion (ODP)	kg CFC-11 eq	0
Human toxicity	kg 1,4-DB eq	5.39E-06
Fresh water aquatic ecotox.	kg 1,4-DB eq	4.035E-08
Marine aquatic ecotoxicity	kg 1,4-DB eq	0.0001807
Terrestrial ecotoxicity	kg 1,4-DB eq	4.97E-08
Photochemical oxidation	kg C2H4	8.995E-08
Acidification	kg SO2 eq	3.667E-06
Eutrophication	kg PO4--- eq	3.836E-07

Table B10 Results of the impact assessment 1 kg Cassava chip in Thailand by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Total
Greenhouse	kg CO2	0.0002885
Ozone layer	kg CFC11	0
Acidification	kg SO2	3.895E-06
Eutrophication	kg PO4	3.836E-07
Heavy metals	kg Pb	5.057E-11
Carcinogens	kg B(a)P	1.814E-13
Winter smog	kg SPM	2.174E-06
Summer smog	kg C2H4	1.172E-06
Pesticides	kg act.subst	0
Energy resources	MJ LHV	0.046772
Solid waste	kg	4.774E-06

Table B11 Results of the impact assessment 1 kg Cassava-based PLA resin production in Thailand based on NatureWorks 2009 by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	0.019604441
Global warming (GWP100)	kg CO2 eq	2.72008
Ozone layer depletion (ODP)	kg CFC-11 eq	1.59E-09
Human toxicity	kg 1,4-DB eq	0.052610691
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.000804056
Marine aquatic ecotoxicity	kg 1,4-DB eq	530.65342
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000237094
Photochemical oxidation	kg C2H4	0.000927289
Acidification	kg SO2 eq	0.012454642
Eutrophication	kg PO4--- eq	0.001066877

Table B12 Results of the impact assessment 1 kg Cassava-based PLA resin production in Thailand based on NatureWorks 2009 by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Total
Greenhouse	kg CO2	2.5386188
Ozone layer	kg CFC11	1.83E-09
Acidification	kg SO2	0.012690418
Eutrophication	kg PO4	0.00106867
Heavy metals	kg Pb	1.58E-07
Carcinogens	kg B(a)P	7.10E-10
Winter smog	kg SPM	0.007310995
Summer smog	kg C2H4	0.000533523
Pesticides	kg act.subst	-7.08E-06
Energy resources	MJ LHV	149.11853
Solid waste	kg	0.26736875

Table B13 Results of the impact assessment 1 kg cassava flour in Thailand by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	0.0061485
Global warming (GWP100)	kg CO2 eq	0.0802295
Ozone layer depletion (ODP)	kg CFC-11 eq	5.779E-11
Human toxicity	kg 1,4-DB eq	0.0006361
Fresh water aquatic ecotox.	kg 1,4-DB eq	1.186E-05
Marine aquatic ecotoxicity	kg 1,4-DB eq	0.3797278
Terrestrial ecotoxicity	kg 1,4-DB eq	4.633E-06
Photochemical oxidation	kg C2H4	8.46E-06
Acidification	kg SO2 eq	0.0002955
Eutrophication	kg PO4--- eq	0.0132018

Table B14 Results of the impact assessment 1 kg cassava flour in Thailand by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Total
Greenhouse	kg CO2	0.0800008
Ozone layer	kg CFC11	5.222E-11
Acidification	kg SO2	0.0003023
Eutrophication	kg PO4	0.0132018
Heavy metals	kg Pb	3.278E-08
Carcinogens	kg B(a)P	8.395E-11
Winter smog	kg SPM	0.0001823
Summer smog	kg C2H4	5.732E-05
Pesticides	kg act.subst	0
Energy resources	MJ LHV	1.912771
Solid waste	kg	0.0004255

Table B15 Results of the impact assessment 1 kg Cassava-based PLA resin production by using cassava flour as raw material in Thailand based on NatureWorks 2009 following CML 2 baseline 2000 V2.03 / World, 1995

Impact category	**Unit**	**Total**
Abiotic depletion	kg Sb eq	0.027290106
Global warming (GWP100)	kg CO2 eq	2.8275565
Ozone layer depletion (ODP)	kg CFC-11 eq	1.51E-09
Human toxicity	kg 1,4-DB eq	0.052320669
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.000662605
Marine aquatic ecotoxicity	kg 1,4-DB eq	530.39538
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000231259
Photochemical oxidation	kg C2H4	0.000931502
Acidification	kg SO2 eq	0.012675445
Eutrophication	kg PO4--- eq	0.019547661

Table B16 Results of the impact assessment 1 kg Cassava-based PLA resin production by using cassava flour as raw material in Thailand based on NatureWorks 2009 following Eco-indicator 95 V2.03 / Europe g

Impact category	**Unit**	**Total**
Greenhouse	kg CO2	2.645837
Ozone layer	kg CFC11	1.71E-09
Acidification	kg SO2	0.012949411
Eutrophication	kg PO4	0.019549462
Heavy metals	kg Pb	1.73E-07
Carcinogens	kg B(a)P	5.95E-10
Winter smog	kg SPM	0.007408857
Summer smog	kg C2H4	0.000610303
Pesticides	kg act.subst	-7.08E-06
Energy resources	MJ LHV	150.05063
Solid waste	kg	0.26747223

Table B17 Results of the impact assessment 1 kg PBS resin production by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	0.06629587
Global warming (GWP100)	kg CO2 eq	0.02669846
Ozone layer depletion (ODP)	kg CFC-11 eq	0.00160897
Human toxicity	kg 1,4-DB eq	5.38349068
Fresh water aquatic ecotox.	kg 1,4-DB eq	5.65E-07
Marine aquatic ecotoxicity	kg 1,4-DB eq	1.70210886
Terrestrial ecotoxicity	kg 1,4-DB eq	0.23751727
Photochemical oxidation	kg C2H4	767.945146
Acidification	kg SO2 eq	0.02388117
Eutrophication	kg PO4--- eq	0.00145935

Table B18 Results of the impact assessment 1 kg PBS resin production by Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Total
Greenhouse	kg CO2	5.205679
Ozone layer	kg CFC11	5.43E-07
Acidification	kg SO2	0.025039
Eutrophication	kg PO4	0.001607
Heavy metals	kg Pb	4.07E-05
Carcinogens	kg B(a)P	3.92E-07
Winter smog	kg SPM	0
Summer smog	kg C2H4	0.001652
Pesticides	kg act.subst	0.019795
Energy resources	MJ LHV	130.3679
Solid waste	kg	0.056528

Table B19 Results of the impact assessment 1 kg HDPE resin production by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	HDPE resin
Abiotic depletion	kg Sb eq	0.033282667
Global warming (GWP100)	kg CO2 eq	1.921212
Ozone layer depletion (ODP)	kg CFC-11 eq	1.98E-10
Human toxicity	kg 1,4-DB eq	0.07747427
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.02409699
Marine aquatic ecotoxicity	kg 1,4-DB eq	92.473122
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000114479
Photochemical oxidation	kg C2H4	0.000618446
Acidification	kg SO2 eq	0.006516918
Eutrophication	kg PO4--- eq	0.000515856

Table B20 Results of the impact assessment 1 kg HDPE resin production by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	HDPE resin
Greenhouse	kg CO2	1.73E+00
Ozone layer	kg CFC11	2.54E-10
Acidification	kg SO2	0.006406157
Eutrophication	kg PO4	0.000515852
Heavy metals	kg Pb	2.43E-05
Carcinogens	kg B(a)P	4.00E-09
Winter smog	kg SPM	0.004520741
Summer smog	kg C2H4	0.001957833
Pesticides	kg act.subst	0
Energy resources	MJ LHV	76.673994
Solid waste	kg	0

Table B21 Results of the impact assessment 1 kg PET resin production by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	PET resin
Abiotic depletion	kg Sb eq	0.03615649
Global warming (GWP100)	kg CO2 eq	2.9386789
Ozone layer depletion (ODP)	kg CFC-11 eq	1.33E-07
Human toxicity	kg 1,4-DB eq	1.4806079
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.22436906
Marine aquatic ecotoxicity	kg 1,4-DB eq	1018.8666
Terrestrial ecotoxicity	kg 1,4-DB eq	0.012950718
Photochemical oxidation	kg C2H4	0.000678865
Acidification	kg SO2 eq	0.010894288
Eutrophication	kg PO4--- eq	0.003139666

Table B22 Results of the impact assessment 1 kg PET resin production by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	PET resin
Greenhouse	kg CO2	2.7740608
Ozone layer	kg CFC11	1.39E-07
Acidification	kg SO2	0.010618691
Eutrophication	kg PO4	0.003138851
Heavy metals	kg Pb	6.02E-05
Carcinogens	kg B(a)P	2.77E-07
Winter smog	kg SPM	0.008135474
Summer smog	kg C2H4	0.001432686
Pesticides	kg act.subst	0
Energy resources	MJ LHV	82.41989
Solid waste	kg	0

Table B23 Results of the impact assessment 1 kg PS resin production by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	PS resin
Abiotic depletion	kg Sb eq	0.039422796
Global warming (GWP100)	kg CO2 eq	3.4611024
Ozone layer depletion (ODP)	kg CFC-11 eq	8.33E-10
Human toxicity	kg 1,4-DB eq	0.25584927
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.080551537
Marine aquatic ecotoxicity	kg 1,4-DB eq	131.18349
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000478921
Photochemical oxidation	kg C2H4	0.000746565
Acidification	kg SO2 eq	0.011464553
Eutrophication	kg PO4--- eq	0.000840047

Table B24 Results of the impact assessment 1 kg PS resin production by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	PS resin
Greenhouse	kg CO2	3.0875943
Ozone layer	kg CFC11	1.23E-09
Acidification	kg SO2	0.01111623
Eutrophication	kg PO4	0.000840037
Heavy metals	kg Pb	4.00E-05
Carcinogens	kg B(a)P	1.76E-08
Winter smog	kg SPM	0.007943416
Summer smog	kg C2H4	0.001586496
Pesticides	kg act.subst	0
Energy resources	MJ LHV	87.653071
Solid waste	kg	0

Table B25 Results of the impact assessment 1 kg cassava root from option 2: increase cassava yield from 3.5 to 5 ton/rai by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	0.000115641
Global warming (GWP100)	kg CO2 eq	-0.052131721
Ozone layer depletion (ODP)	kg CFC-11 eq	2.52E-10
Human toxicity	kg 1,4-DB eq	0.000917538
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.000108718
Marine aquatic ecotoxicity	kg 1,4-DB eq	0.81247417
Terrestrial ecotoxicity	kg 1,4-DB eq	2.70E-05
Photochemical oxidation	kg C2H4	3.35E-06
Acidification	kg SO2 eq	0.000113207
Eutrophication	kg PO4--- eq	1.13E-05

Table B26 Results of the impact assessment 1 kg cassava root from option 2: increase cassava yield from 3.5 to 5 ton/rai by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Total
Greenhouse	kg CO2	-0.053287188
Ozone layer	kg CFC11	2.94E-10
Acidification	kg SO2	0.000116943
Eutrophication	kg PO4	1.11E-05
Heavy metals	kg Pb	2.12E-08
Carcinogens	kg B(a)P	9.38E-11
Winter smog	kg SPM	5.76E-05
Summer smog	kg C2H4	3.09E-06
Pesticides	kg act.subst	0
Energy resources	MJ LHV	0.24225129
Solid waste	kg	5.39E-06

Table B27 Results of the impact assessment 1 kg Cassava-based PLA resin production in Thailand compare with 1 kg Cassava-based PLA resin production in Thailand with option 1 by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Cassava-based PLA resin without option	Cassava-based PLA resin with option 1
Abiotic depletion	kg Sb eq	0.027290106	0.027290106
Global warming (GWP100)	kg CO2 eq	2.8275565	0.77755646
Ozone layer depletion (ODP)	kg CFC-11 eq	1.51E-09	1.51E-09
Human toxicity	kg 1,4-DB eq	0.052320669	0.052320669
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.000662605	0.000662605
Marine aquatic ecotoxicity	kg 1,4-DB eq	530.39538	530.39538
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000231259	0.000231259
Photochemical oxidation	kg C2H4	0.000931502	0.000931502
Acidification	kg SO2 eq	0.012675445	0.012675445
Eutrophication	kg PO4--- eq	0.019547661	0.001187121

Table B28 Results of the impact assessment 1 kg Cassava-based PLA resin production in Thailand compare with 1 kg PLA resin production in Thailand with option 1 by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Cassava-based PLA resin without option	Cassava-based PLA resin with option 1
Greenhouse	kg CO2	2.645837	0.595837
Ozone layer	kg CFC11	1.71E-09	1.71E-09
Acidification	kg SO2	0.012949411	0.012949411
Eutrophication	kg PO4	0.019549462	0.001188922
Heavy metals	kg Pb	1.73E-07	1.73E-07
Carcinogens	kg B(a)P	5.95E-10	5.95E-10
Winter smog	kg SPM	0.007408857	0.007408857
Summer smog	kg C2H4	0.000610303	0.000610303
Pesticides	kg act.subst	-7.08E-06	-7.08E-06
Energy resources	MJ LHV	150.05063	150.05063
Solid waste	kg	0.26747223	0.26747223

Table B29 Results of the impact assessment 1 kg Cassava-based PLA resin production in Thailand compare with 1 kg PLA resin production in Thailand with option 2 by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Cassava-based PLA resin without option	Cassava-based PLA resin with option 2
Abiotic depletion	kg Sb eq	0.027290106	0.0269592
Global warming (GWP100)	kg CO2 eq	2.8275565	2.6798929
Ozone layer depletion (ODP)	kg CFC-11 eq	1.51E-09	7.93E-10
Human toxicity	kg 1,4-DB eq	0.052320669	0.049699231
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.000662605	0.000352003
Marine aquatic ecotoxicity	kg 1,4-DB eq	530.39538	528.0741
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000231259	0.000154015
Photochemical oxidation	kg C2H4	0.000931502	0.000921926
Acidification	kg SO2 eq	0.012675445	0.012351794
Eutrophication	kg PO4--- eq	0.019547661	0.01951546

Table B30 Results of the impact assessment 1 kg Cassava-based PLA resin production in Thailand compare with 1 kg PLA resin production in Thailand with option 2 by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Cassava-based PLA resin without option	Cassava-based PLA resin with option 2
Greenhouse	kg CO2	2.645837	2.5014768
Ozone layer	kg CFC11	1.71E-09	8.73E-10
Acidification	kg SO2	0.012949411	0.012615072
Eutrophication	kg PO4	0.019549462	0.01951781
Heavy metals	kg Pb	1.73E-07	1.12E-07
Carcinogens	kg B(a)P	5.95E-10	3.28E-10
Winter smog	kg SPM	0.007408857	0.007244059
Summer smog	kg C2H4	0.000610303	0.000601455
Pesticides	kg act.subst	-7.08E-06	-7.08E-06
Energy resources	MJ LHV	150.05063	149.35745
Solid waste	kg	0.26747223	0.26745676

Table B31 Results of the impact assessment 1 kg Cassava-based PLA resin production in Thailand compare with 1 kg PLA resin production in Thailand with all options by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Cassava-based PLA resin without option	Cassava-based PLA resin with all options
Abiotic depletion	kg Sb eq	0.027290106	0.0269592
Global warming (GWP100)	kg CO2 eq	2.8275565	0.62989288
Ozone layer depletion (ODP)	kg CFC-11 eq	1.51E-09	7.93E-10
Human toxicity	kg 1,4-DB eq	0.052320669	0.049699231
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.000662605	0.000352003
Marine aquatic ecotoxicity	kg 1,4-DB eq	530.39538	528.0741
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000231259	0.000154015
Photochemical oxidation	kg C2H4	0.000931502	0.000921926
Acidification	kg SO2 eq	0.012675445	0.012351794
Eutrophication	kg PO4--- eq	0.019547661	0.00115492

Table B32 Results of the impact assessment 1 kg Cassava-based PLA resin production in Thailand compare with 1 kg PLA resin production in Thailand with all options by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Cassava-based PLA resin without option	Cassava-based PLA resin with all options
Greenhouse	kg CO2	2.645837	0.45147683
Ozone layer	kg CFC11	1.71E-09	8.73E-10
Acidification	kg SO2	0.012949411	0.012615072
Eutrophication	kg PO4	0.019549462	0.00115727
Heavy metals	kg Pb	1.73E-07	1.12E-07
Carcinogens	kg B(a)P	5.95E-10	3.28E-10
Winter smog	kg SPM	0.007408857	0.007244059
Summer smog	kg C2H4	0.000610303	0.000601455
Pesticides	kg act.subst	-7.08E-06	-7.08E-06
Energy resources	MJ LHV	150.05063	149.35745
Solid waste	kg	0.26747223	0.26745676

Table B33 Results of the impact assessment 1 kg PLA T-shirt bag from Company A without disposal phase by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Best	Worst
Abiotic depletion	kg Sb eq	0.04140	0.07320
Global warming (GWP100)	kg CO2 eq	1.58796	4.92909
Ozone layer depletion (ODP)	kg CFC-11 eq	0	0
Human toxicity	kg 1,4-DB eq	0.07269	0.08583
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.00112	0.00117
Marine aquatic ecotoxicity	kg 1,4-DB eq	671.75941	672.22487
Terrestrial ecotoxicity	kg 1,4-DB eq	0.00022	0.00030
Photochemical oxidation	kg C2H4	0.00123	0.00145
Acidification	kg SO2 eq	0.01794	0.02737
Eutrophication	kg PO4--- eq	0.00174	0.00279

Table B34 Results of the impact assessment 1 kg PLA T-shirt bag from Company A without disposal phase by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Best	Worst
Greenhouse	kg CO2	1.36024	4.69764
Ozone layer	kg CFC11	0	0
Acidification	kg SO2	0.01849	0.02862
Eutrophication	kg PO4	0.00175	0.00279
Heavy metals	kg Pb	0	0
Carcinogens	kg B(a)P	0	0
Winter smog	kg SPM	0.01040	0.01575
Summer smog	kg C2H4	0.00081	0.00101
Pesticides	kg act.subst	0	0
Energy resources	MJ LHV	199.83064	246.87448
Solid waste	kg	0.33975	0.34391

Table B35 Results of the impact assessment 1 kg PLA T-shirt bag from Company B without disposal phase by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Best	Worst
Abiotic depletion	kg Sb eq	0.04387	0.08429
Global warming (GWP100)	kg CO2 eq	1.78087	6.02795
Ozone layer depletion (ODP)	kg CFC-11 eq	0	0
Human toxicity	kg 1,4-DB eq	0.07565	0.09235
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.00119	0.00127
Marine aquatic ecotoxicity	kg 1,4-DB eq	688.30690	688.89856
Terrestrial ecotoxicity	kg 1,4-DB eq	0.00023	0.00032
Photochemical oxidation	kg C2H4	0.00127	0.00155
Acidification	kg SO2 eq	0.01881	0.03079
Eutrophication	kg PO4--- eq	0.00183	0.00316

Table B36 Results of the impact assessment 1 kg PLA T-shirt bag from Company B without disposal phase by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Best	Worst
Greenhouse	kg CO2	1.54746	5.78979
Ozone layer	kg CFC11	0	0
Acidification	kg SO2	0.01940	0.03228
Eutrophication	kg PO4	0.00184	0.00316
Heavy metals	kg Pb	0	0
Carcinogens	kg B(a)P	0	0
Winter smog	kg SPM	0.01090	0.01770
Summer smog	kg C2H4	0.0008413	0.0010878
Pesticides	kg act.subst	0	0
Energy resources	MJ LHV	206.84596	266.64569
Solid waste	kg	0.3481971	0.3534841

Table B37 Results of the impact assessment 1 kg HDPE T-shirt bag from Company A compare with 1 kg HDPE T-shirt bag from Company B by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	HDPE_A	HDPE_B
Abiotic depletion	kg Sb eq	0.045780721	0.062529395
Global warming (GWP100)	kg CO2 eq	3.0475525	4.120636
Ozone layer depletion (ODP)	kg CFC-11 eq	7.31E-09	9.44E-09
Human toxicity	kg 1,4-DB eq	0.10327132	0.13975848
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.031027154	0.042070745
Marine aquatic ecotoxicity	kg 1,4-DB eq	110.10342	151.56928
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000369607	0.000448255
Photochemical oxidation	kg C2H4	0.000781034	0.001072678
Acidification	kg SO2 eq	0.009937845	0.013469539
Eutrophication	kg PO4--- eq	0.001002915	0.001320973

Table B38 Results of the impact assessment 1 kg HDPE T-shirt bag from Company a compare with 1 kg HDPE T-shirt bag from Company B by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	HDPE_A	HDPE_B
Greenhouse	kg CO2	2.8338845	3.8233795
Ozone layer	kg CFC11	9.04E-09	1.18E-08
Acidification	kg SO2	0.010039745	0.013583915
Eutrophication	kg PO4	0.001002553	0.001320588
Heavy metals	kg Pb	2.70E-05	3.76E-05
Carcinogens	kg B(a)P	8.07E-09	1.03E-08
Winter smog	kg SPM	0.006492231	0.008836203
Summer smog	kg C2H4	0.024888845	0.02808312
Pesticides	kg act.subst	0	0
Energy resources	MJ LHV	98.7854	135.64402
Solid waste	kg	0.001089068	0.001365497

Table B39 Results of the impact assessment 1 kg PLA water bottle from Company D without disposal phase by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Best	Worst
Abiotic depletion	kg Sb eq	0.045967156	0.061271053
Global warming (GWP100)	kg CO2 eq	4.8127409	6.4112597
Ozone layer depletion (ODP)	kg CFC-11 eq	1.56E-09	2.13E-09
Human toxicity	kg 1,4-DB eq	0.061434607	0.083147933
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.000711878	0.00096824
Marine aquatic ecotoxicity	kg 1,4-DB eq	544.60745	742.62589
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000277602	0.000375384
Photochemical oxidation	kg C2H4	0.00109345	0.00147954
Acidification	kg SO2 eq	0.018463765	0.02474158
Eutrophication	kg PO4--- eq	0.020684747	0.028155514

Table B40 Results of the impact assessment 1 kg PLA water bottle from Company D without disposal phase by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Best	Worst
Greenhouse	kg CO2	4.6234217	6.1533601
Ozone layer	kg CFC11	1.77E-09	2.42E-09
Acidification	kg SO2	0.019193972	0.025698933
Eutrophication	kg PO4	0.020686797	0.028158294
Heavy metals	kg Pb	2.47E-07	3.31E-07
Carcinogens	kg B(a)P	2.03E-09	2.66E-09
Winter smog	kg SPM	0.01062431	0.014250416
Summer smog	kg C2H4	0.000737202	0.000996492
Pesticides	kg act.subst	-7.27E-06	-9.91E-06
Energy resources	MJ LHV	180.58255	244.15864
Solid waste	kg	0.27685806	0.3773488

Table B41 Results of the impact assessment 1 kg PET water bottle from Company D without disposal phase by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	PET
Abiotic depletion	kg Sb eq	0.053980549
Global warming (GWP100)	kg CO2 eq	4.7936696
Ozone layer depletion (ODP)	kg CFC-11 eq	1.24E-07
Human toxicity	kg 1,4-DB eq	1.3949866
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.21103361
Marine aquatic ecotoxicity	kg 1,4-DB eq	957.03203
Terrestrial ecotoxicity	kg 1,4-DB eq	0.012141624
Photochemical oxidation	kg C2H4	0.000800247
Acidification	kg SO2 eq	0.016063903
Eutrophication	kg PO4--- eq	0.003600654

Table B42 Results of the impact assessment 1 kg PET water bottle from Company D without disposal phase by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	PET
Greenhouse	kg CO2	4.6268265
Ozone layer	kg CFC11	1.30E-07
Acidification	kg SO2	0.016252461
Eutrophication	kg PO4	0.003600094
Heavy metals	kg Pb	5.77E-05
Carcinogens	kg B(a)P	2.61E-07
Winter smog	kg SPM	0.010912389
Summer smog	kg C2H4	0.001561074
Pesticides	kg act.subst	0
Energy resources	MJ LHV	108.71937
Solid waste	kg	0.002358196

Table B43 Results of the impact assessment 1 kg PBS T-shirt bag from Company A without disposal phase by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Best	Worst
Abiotic depletion	kg Sb eq	0.09117	0.12116
Global warming (GWP100)	kg CO2 eq	7.60316	10.75441
Ozone layer depletion (ODP)	kg CFC-11 eq	0	0
Human toxicity	kg 1,4-DB eq	2.16366	2.17605
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.30123	0.30128
Marine aquatic ecotoxicity	kg 1,4-DB eq	975.29225	975.73125
Terrestrial ecotoxicity	kg 1,4-DB eq	0.03025	0.03031
Photochemical oxidation	kg C2H4	0.00191	0.00212
Acidification	kg SO2 eq	0.03608	0.04497
Eutrophication	kg PO4--- eq	0.00232	0.0033

Table B44 Results of the impact assessment 1 kg PBS T-shirt bag from Company A without disposal phase by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Best	Worst
Greenhouse	kg CO2	7.38E+00	10.52393661
Ozone layer	kg CFC11	6.98E-07	6.98E-07
Acidification	kg SO2	3.42E-02	4.38E-02
Eutrophication	kg PO4	0.002316035	3.30E-03
Heavy metals	kg Pb	5.16E-05	5.17E-05
Carcinogens	kg B(a)P	4.97E-07	4.99E-07
Winter smog	kg SPM	0.001229046	6.28E-03
Summer smog	kg C2H4	2.14E-03	2.32E-03
Pesticides	kg act.subst	0.025048593	0.025048593
Energy resources	MJ LHV	175.8012687	220.1714837
Solid waste	kg	0.072841774	0.076764643

Table B45 Results of the impact assessment 1 kg PBS food container from Company C without disposal phase by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Best	Worst
Abiotic depletion	kg Sb eq	6.16E-02	7.20E-02
Global warming (GWP100)	kg CO2 eq	5.841882564	6.939604364
Ozone layer depletion (ODP)	kg CFC-11 eq	1.13E-09	1.13E-09
Human toxicity	kg 1,4-DB eq	0.721625394	0.725941828
Fresh water aquatic ecotox.	kg 1,4-DB eq	9.49E-02	9.49E-02
Marine aquatic ecotoxicity	kg 1,4-DB eq	696.8318714	696.9847947
Terrestrial ecotoxicity	kg 1,4-DB eq	9.69E-03	9.72E-03
Photochemical oxidation	kg C2H4	0.001387186	0.001459858
Acidification	kg SO2 eq	0.024592702	0.027690025
Eutrophication	kg PO4--- eq	0.015601132	0.015943449

Table B46 Results of the impact assessment 1 kg PBS food container from Company C without disposal phase by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Best	Worst
Greenhouse	kg CO2	6.7579677	7.8544627
Ozone layer	kg CFC11	1.4204E-09	1.43022E-09
Acidification	kg SO2	0.022752317	0.026079733
Eutrophication	kg PO4	0.002032152	0.002374586
Heavy metals	kg Pb	4.55635E-05	4.56038E-05
Carcinogens	kg B(a)P	2.23708E-08	2.31982E-08
Winter smog	kg SPM	0.014144567	0.015903002
Summer smog	kg C2H4	0.001990243	0.002053959
Pesticides	kg act.subst	0	0
Energy resources	MJ LHV	144.65522	160.111373
Solid waste	kg	0.003992266	0.005358778

Table B47 Results of the impact assessment 1 kg PS food container from Company C without disposal phase by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	PS
Abiotic depletion	kg Sb eq	0.060125428
Global warming (GWP100)	kg CO2 eq	5.5714897
Ozone layer depletion (ODP)	kg CFC-11 eq	9.57E-10
Human toxicity	kg 1,4-DB eq	0.29720415
Fresh water aquatic ecotox.	kg 1,4-DB eq	0.091485461
Marine aquatic ecotoxicity	kg 1,4-DB eq	149.17041
Terrestrial ecotoxicity	kg 1,4-DB eq	0.000578211
Photochemical oxidation	kg C2H4	0.000968909
Acidification	kg SO2 eq	0.017721921
Eutrophication	kg PO4--- eq	0.001496857

Table B48 Results of the impact assessment 1 kg PS food container from Company C without disposal phase by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	PS
Greenhouse	kg CO2	5.1447874
Ozone layer	kg CFC11	1.41E-09
Acidification	kg SO2	0.01772622
Eutrophication	kg PO4	0.001497017
Heavy metals	kg Pb	4.55E-05
Carcinogens	kg B(a)P	2.12E-08
Winter smog	kg SPM	0.011602571
Summer smog	kg C2H4	0.001896529
Pesticides	kg act.subst	0
Energy resources	MJ LHV	122.27117
Solid waste	kg	0.002012305

Table B49 LCIA results of PLA landfill (without energy recovery) based on one kg of bioplastic waste by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	1.49E-04
Global warming (GWP100)	kg CO2 eq	1.82
Ozone layer depletion (ODP)	kg CFC-11 eq	5.42E-12
Human toxicity	kg 1,4-DB eq	8.39E-04
Fresh water aquatic ecotox.	kg 1,4-DB eq	7.17E-06
Marine aquatic ecotoxicity	kg 1,4-DB eq	0.065
Terrestrial ecotoxicity	kg 1,4-DB eq	3.58E-06
Photochemical oxidation	kg C2H4	1.61E-05
Acidification	kg SO2 eq	2.41E-04
Eutrophication	kg PO4--- eq	5.01E-05

Table B50 LCIA results of PLA landfill (without energy recovery) based on one kg of bioplastic waste by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Amount
Greenhouse	kg CO2	1.82
Ozone layer	kg CFC11	7.22E-12
Acidification	kg SO2	3.04E-04
Eutrophication	kg PO4	5.02E-05
Heavy metals	kg Pb	2.98E-08
Carcinogens	kg B(a)P	9.59E-10
Winter smog	kg SPM	1.20E-04
Summer smog	kg C2H4	7.91E-06
Pesticides	kg act.subst	0
Energy resources	MJ LHV	0.3
Solid waste	kg	4.34E-05

Table B51 LCIA results of PLA landfill (with energy recovery) based on one kg of bioplastic waste by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	2.25E-04
Global warming (GWP100)	kg CO2 eq	0.064
Ozone layer depletion (ODP)	kg CFC-11 eq	6.34E-12
Human toxicity	kg 1,4-DB eq	8.81E-04
Fresh water aquatic ecotox.	kg 1,4-DB eq	8.15E-06
Marine aquatic ecotoxicity	kg 1,4-DB eq	0.075
Terrestrial ecotoxicity	kg 1,4-DB eq	3.70E-06
Photochemical oxidation	kg C2H4	1.66E-05
Acidification	kg SO2 eq	2.63E-04
Eutrophication	kg PO4--- eq	5.34E-05

Table B52 LCIA results of PLA landfill (with energy recovery) based on one kg of bioplastic waste by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Amount
Greenhouse	kg CO2	0.064
Ozone layer	kg CFC11	8.45E-12
Acidification	kg SO2	3.31E-04
Eutrophication	kg PO4	5.35E-05
Heavy metals	kg Pb	3.01E-08
Carcinogens	kg B(a)P	9.66E-10
Winter smog	kg SPM	5.59E-04
Summer smog	kg C2H4	8.32E-06
Pesticides	kg act.subst	0
Energy resources	MJ LHV	0.413418
Solid waste	kg	5.39E-05

Table B53 LCIA results of PLA recycling based on one kg of bioplastic waste by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	0.025
Global warming (GWP100)	kg CO2 eq	3.25
Ozone layer depletion (ODP)	kg CFC-11 eq	6.64E-09
Human toxicity	kg 1,4-DB eq	0.498
Fresh water aquatic ecotox.	kg 1,4-DB eq	8.55E-03
Marine aquatic ecotoxicity	kg 1,4-DB eq	78.63
Terrestrial ecotoxicity	kg 1,4-DB eq	4.13E-03
Photochemical oxidation	kg C2H4	2.14E-03
Acidification	kg SO2 eq	0.02
Eutrophication	kg PO4--- eq	1.68E-03

Table B54 LCIA results of PLA recycling based on one kg of bioplastic waste by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Amount
Greenhouse	kg CO2	3.16
Ozone layer	kg CFC11	8.85E-09
Acidification	kg SO2	0.021
Eutrophication	kg PO4	1.87E-03
Heavy metals	kg Pb	3.69E-05
Carcinogens	kg B(a)P	1.20E-06
Winter smog	kg SPM	0.036
Summer smog	kg C2H4	8.69E-04
Pesticides	kg act.subst	0
Energy resources	MJ LHV	49.69
Solid waste	kg	0.255

Table B55 LCIA results of PLA composting based on one kg of bioplastic waste by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	5.73E-03
Global warming (GWP100)	kg CO2 eq	-9.29E-02
Ozone layer depletion (ODP)	kg CFC-11 eq	-3.59E-10
Human toxicity	kg 1,4-DB eq	1.37E-02
Fresh water aquatic ecotox.	kg 1,4-DB eq	-1.24E-05
Marine aquatic ecotoxicity	kg 1,4-DB eq	-2.16E-02
Terrestrial ecotoxicity	kg 1,4-DB eq	1.65E-05
Photochemical oxidation	kg C2H4	5.42E-04
Acidification	kg SO2 eq	5.73E-03
Eutrophication	kg PO4--- eq	1.35E-03

Table B56 LCIA results of PLA composting based on one kg of bioplastic waste by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Amount
Greenhouse	kg CO2	-9.25E-02
Ozone layer	kg CFC11	-4.71E-10
Acidification	kg SO2	7.74E-03
Eutrophication	kg PO4	1.35E-03
Heavy metals	kg Pb	5.68E-08
Carcinogens	kg B(a)P	1.61E-09
Winter smog	kg SPM	5.86E-04
Summer smog	kg C2H4	1.08E-03
Pesticides	kg act.subst	0.00E+00
Energy resources	MJ LHV	1.19E+01
Solid waste	kg	1.24E-03

Table B57 LCIA results of PLA incineration based on one kg of bioplastic waste waste by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	5.73E-03
Global warming (GWP100)	kg CO2 eq	9.07E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	9.81E-12
Human toxicity	kg 1,4-DB eq	1.37E-02
Fresh water aquatic ecotox.	kg 1,4-DB eq	-4.98E-05
Marine aquatic ecotoxicity	kg 1,4-DB eq	-6.17E-01
Terrestrial ecotoxicity	kg 1,4-DB eq	7.01E-06
Photochemical oxidation	kg C2H4	7.53E-04
Acidification	kg SO2 eq	8.56E-03
Eutrophication	kg PO4--- eq	2.21E-03

Table B58 LCIA results of PLA Incineration based on one kg of bioplastic waste by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Amount
Greenhouse	kg CO2	8.92E-01
Ozone layer	kg CFC11	-8.76E-12
Acidification	kg SO2	1.20E-02
Eutrophication	kg PO4	2.21E-03
Heavy metals	kg Pb	4.20E-09
Carcinogens	kg B(a)P	5.14E-11
Winter smog	kg SPM	-2.96E-02
Summer smog	kg C2H4	1.06E-03
Pesticides	kg act.subst	0.00E+00
Energy resources	MJ LHV	4.12E+00
Solid waste	kg	1.49E-03

Table B59 LCIA results of PBS landfill (without energy recovery) based on one kg of bioplastic waste by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	1.49E-04
Global warming (GWP100)	kg CO2 eq	1.28
Ozone layer depletion (ODP)	kg CFC-11 eq	5.42E-12
Human toxicity	kg 1,4-DB eq	8.39E-04
Fresh water aquatic ecotox.	kg 1,4-DB eq	7.17E-06
Marine aquatic ecotoxicity	kg 1,4-DB eq	0.065
Terrestrial ecotoxicity	kg 1,4-DB eq	3.58E-06
Photochemical oxidation	kg C2H4	1.61E-05
Acidification	kg SO2 eq	2.41E-04
Eutrophication	kg PO4--- eq	5.01E-05

Table B60 LCIA results of PBS landfill (without energy recovery) based on one kg of bioplastic waste by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Amount
Greenhouse	kg CO2	1.28
Ozone layer	kg CFC11	7.22E-12
Acidification	kg SO2	3.04E-04
Eutrophication	kg PO4	5.02E-05
Heavy metals	kg Pb	2.98E-08
Carcinogens	kg B(a)P	9.59E-10
Winter smog	kg SPM	1.20E-04
Summer smog	kg C2H4	7.91E-06
Pesticides	kg act.subst	0
Energy resources	MJ LHV	0.3
Solid waste	kg	4.34E-05

Table B61 LCIA results of PBS landfill (with energy recovery) based on one kg of bioplastic waste by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	2.25E-04
Global warming (GWP100)	kg CO2 eq	-0.204
Ozone layer depletion (ODP)	kg CFC-11 eq	6.34E-12
Human toxicity	kg 1,4-DB eq	8.81E-04
Fresh water aquatic ecotox.	kg 1,4-DB eq	8.15E-06
Marine aquatic ecotoxicity	kg 1,4-DB eq	0.075
Terrestrial ecotoxicity	kg 1,4-DB eq	3.70E-06
Photochemical oxidation	kg C2H4	1.66E-05
Acidification	kg SO2 eq	2.63E-04
Eutrophication	kg PO4--- eq	5.34E-05

Table B62 LCIA results of PBS landfill (with energy recovery) based on one kg of bioplastic waste by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Amount
Greenhouse	kg CO2	-0.204
Ozone layer	kg CFC11	8.45E-12
Acidification	kg SO2	3.31E-04
Eutrophication	kg PO4	5.35E-05
Heavy metals	kg Pb	3.01E-08
Carcinogens	kg B(a)P	9.66E-10
Winter smog	kg SPM	5.59E-04
Summer smog	kg C2H4	8.32E-06
Pesticides	kg act.subst	0
Energy resources	MJ LHV	0.413418
Solid waste	kg	5.39E-05

Table B63 LCIA results of PBS composting based on one kg of bioplastic waste by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	5.71E-03
Global warming (GWP100)	kg CO2 eq	-1.00E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	-3.59E-13
Human toxicity	kg 1,4-DB eq	1.34E-02
Fresh water aquatic ecotox.	kg 1,4-DB eq	1.02E-05
Marine aquatic ecotoxicity	kg 1,4-DB eq	4.57E-02
Terrestrial ecotoxicity	kg 1,4-DB eq	1.26E-05
Photochemical oxidation	kg C2H4	5.46E-04
Acidification	kg SO2 eq	5.93E-03
Eutrophication	kg PO4--- eq	1.40E-03

Table B64 LCIA results of PBS composting based on one kg of bioplastic waste by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Amount
Greenhouse	kg CO2	-8.47E-02
Ozone layer	kg CFC11	-4.71E-13
Acidification	kg SO2	7.99E-03
Eutrophication	kg PO4	1.40E-03
Heavy metals	kg Pb	1.29E-08
Carcinogens	kg B(a)P	4.75E-11
Winter smog	kg SPM	5.51E-04
Summer smog	kg C2H4	1.09E-03
Pesticides	kg act.subst	0.00E+00
Energy resources	MJ LHV	1.19E+01
Solid waste	kg	1.21E-03

Table B65 LCIA results of PBS incineration based on one kg of bioplastic waste by using CML 2 baseline 2000 V2.03 / World, 1995

Impact category	Unit	Total
Abiotic depletion	kg Sb eq	5.71E-03
Global warming (GWP100)	kg CO2 eq	8.67E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	9.81E-15
Human toxicity	kg 1,4-DB eq	1.34E-02
Fresh water aquatic ecotox.	kg 1,4-DB eq	1.02E-05
Marine aquatic ecotoxicity	kg 1,4-DB eq	4.51E-02
Terrestrial ecotoxicity	kg 1,4-DB eq	1.26E-05
Photochemical oxidation	kg C2H4	5.46E-04
Acidification	kg SO2 eq	5.93E-03
Eutrophication	kg PO4--- eq	1.40E-03

Table B66 LCIA results of PBS Incineration based on one kg of bioplastic waste by using Eco-indicator 95 V2.03 / Europe g

Impact category	Unit	Amount
Greenhouse	kg CO2	8.52E-01
Ozone layer	kg CFC11	-8.76E-15
Acidification	kg SO2	7.99E-03
Eutrophication	kg PO4	1.40E-03
Heavy metals	kg Pb	1.28E-08
Carcinogens	kg B(a)P	4.60E-11
Winter smog	kg SPM	5.21E-04
Summer smog	kg C2H4	1.09E-03
Pesticides	kg act.subst	0.00E+00
Energy resources	MJ LHV	1.18E+01
Solid waste	kg	1.21E-03

Appendix C Calculation

C1. Transportation product by volume

Assumption of transportation

- Distance of PLA resin transportation: Rayong to Nakhon Pathom about 235 km

By trailer 25 tons.

- Distance of PLA product transportation: Nakhon Pathom to Bangkok about 56 km

By track 12 tons.

- Use the same size of box for packing the products.

Truck Specification

L container = 6.5 m

W container = 2.30 m

H container = 2 m

A container = L container x W container = 6.5m x 2.30 m = 14.95 m^2

V container = 6.5m x 2.30 m x 2 m = 29.9 m^3

Paper Board Specification

$V_{\text{paper board}}$ = 45 cm x 55 cm x 40 cm = 0.099 m^3

How many paper boards are in a container?

$V_{\text{container}}$ / $V_{\text{paper board}}$ = 29.9 m^3 / 0.099 m^3

= 302 boxes

So the total paper board weight = 302 x 0.655 = 197.82 kg

- T-shirt bag A = 10,000 bags/box
- T-shirt bag B = 7,500 bags/box

- Food container = 176 sets/box
- Water bottle = 24 bottle/pack

* Size of bottle pack 22 cm x 33 cm x 14.5 cm

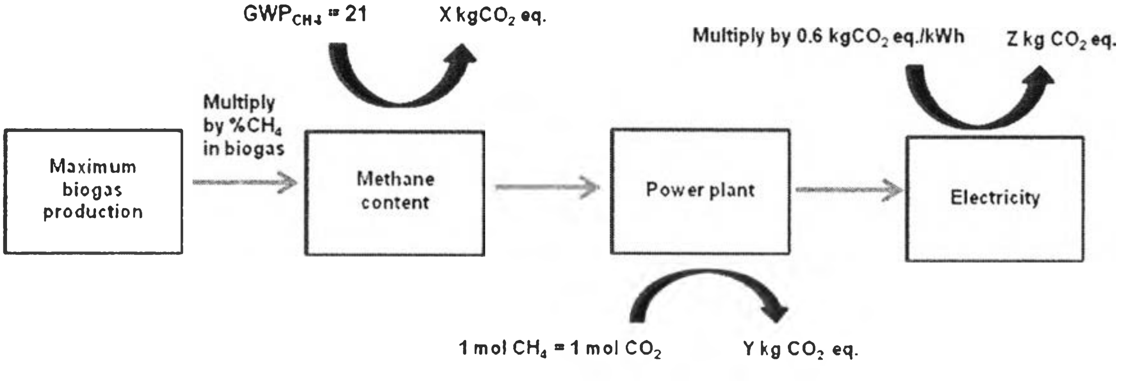
Calculation of Total weight

T-shirt bag = 8,500 x 302 = 2,567,000 bags
= 0.0045 kg/bag x 2,567,000 = 11,551 kg
Total weight = 11,551+198 = 11,749 kg

Food container = 176 x 302 = 53,152 sets
= 0.1491 kg/set x 53,152 = 7,925 kg
Total weight = 7,925+198 = 8123 kg

Water bottle = 24 x 1,500 = 36,000 bottles
= 0.268 kg/bottle x 36,000 = 9,648 kg

C2. GHG emission reduction from option 1: utilization of biogas from wastewater treatment



Formula : X-(Y+Z) = GHG emission reductions

C3. Calculation of Methane Content from Landfill (45%)

Calculate methane emission rate from landfill by using First-order decay reaction

$$Q = L_0 R (e^{kc} - e^{-kt})$$

เมื่อ Q = Methane content in the present (m^3/year)

L_0 = Methane generation potential of the waste (m^3/ton of waste) (170)

R = A certain amount of waste (ton/year) (2,431)

K = the rate constant of biodegradation (per year) (0.02)

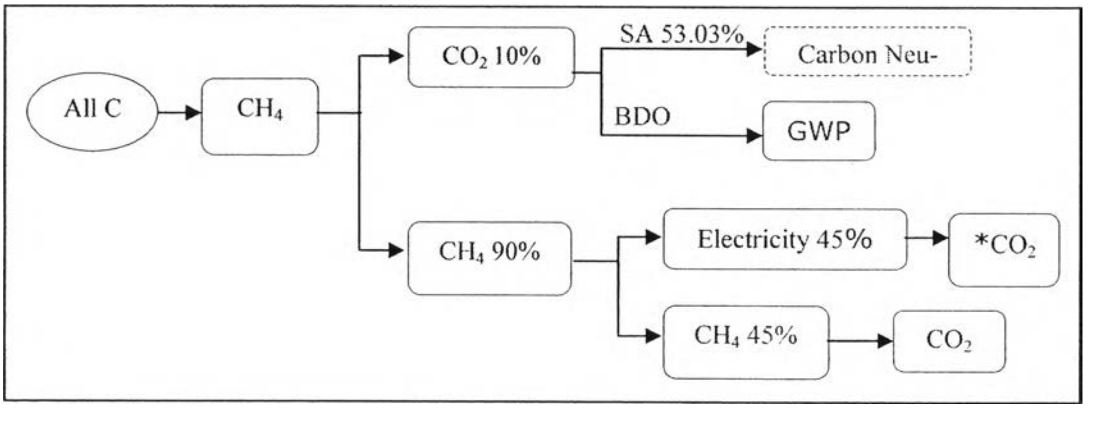
C = Time (year) (1)

T = The time elapsed since landfilling of the waste (year) (6)

Source:The default parameters are provided by US.EPA. For regulations under the Clean Air Act (CAA), a k of 0.02 yr^{-1} for dry landfill and an L_0 of 170 m^3/kg are used (Reinhart and et. al., 2005).

From this equation, methane content can be calculated 14,058,618.86 m^3/yr but it can be collected only 700 m^3/hr. When it is expressed in term of annual, it shows 6,132,000 m^3/yr. Therefore, it is calculated for being percentage about 45%.

C4. Emission Calculation of PBS Landfill



PBS compositions are divided into 2 major composition as following
- SA (Bio-base) 53.03%
- BDO (petroleum-base) 46.97%

Chemical formula: $C_8H_{12}O_4$ (MW = 172)

PBS 1 mol: 172 g
PBS 1 kg: (1000/172) = 5.81 mol

Assume PBS is biodegradable 100%

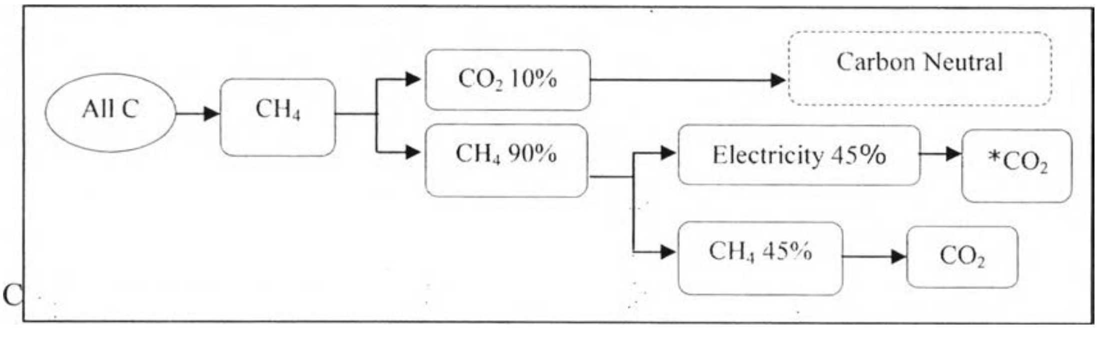
PBS 1 mol transforms to CH_4 100% = CH_4 8 mol

but assumption for Carbon content in PBS, which can be transformed to CH_4 90%

So PBS 1 mol has CH_4 7.2 mol

So PBS 5.81 mol can emit CH_4 (5.81 x 7.2) = 41.832 mol or (41.832 x 16) = 669.31 g
Conclusion: PBS 1 kg is biodegraded, it can emit CH_4 669.31 g

C5. Emission Calculation of PLA Landfill



Chemical formula: $C_3H_5O_2$ (MW = 73)
PLA 1 mol: 73 g
PLA 1 kg: (1000/73) = 13.69 mol

Assume PLA is biodegradable 100%

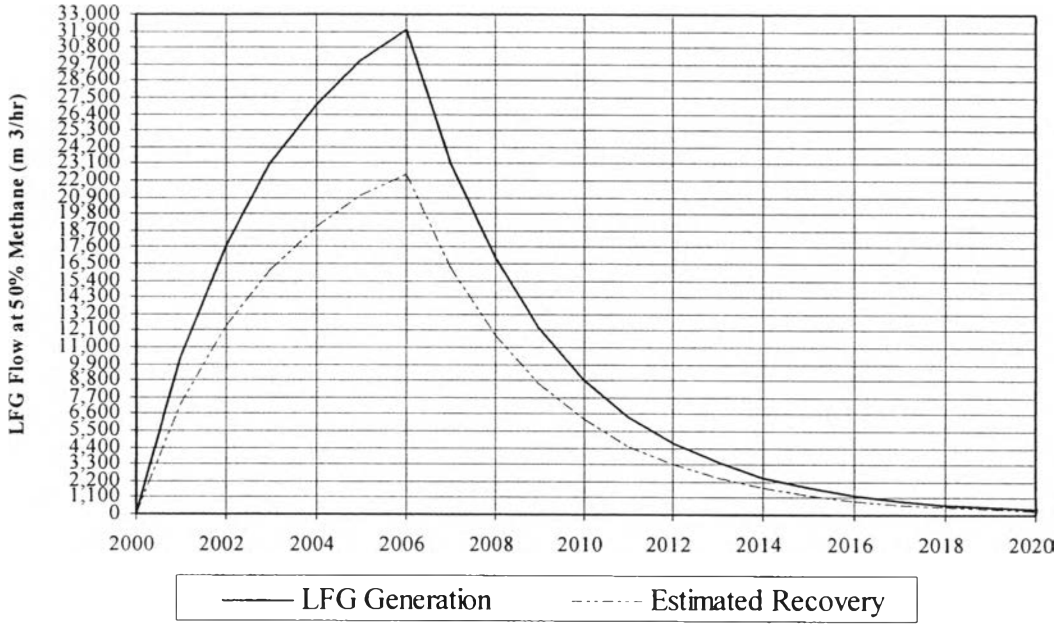
PLA 1 mol transforms to CH_4 100% = CH_4 3 mol

but assumption for Carbon content in PLA, which can be transformed to CH_4 90%

So PLA 1 mol has CH_4 2.7 mol

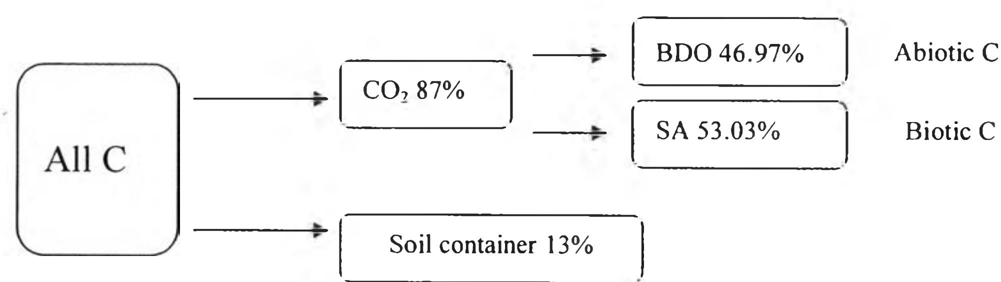
So PLA 13.69 mol can emit CH_4 (13.69 x 2.7) = 36.963 mol or (36.963 x 16) = 591.40 g
Conclusion: PLA 1 kg is biodegraded, it can emit CH_4 591.40 g

Table C1 Expectation graph of emitted gas content from landfill



C6. Emission calculation of PBS and PLA Composting

Assumption



PBS

Chemical formula: $C_8H_{12}O_4$ (MW = 172)

PBS 1 mol:172 g

PBS 1 kg: (1000/172) = 5.81 mol

Assume PBS is biodegradable 100%

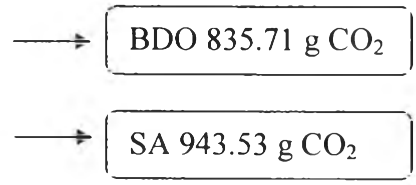
PBS 1 mol transforms to CO_2 100% = CO_2 8 mol

but assumption for Carbon content in PBS, which can be transformed to CO_2 87%

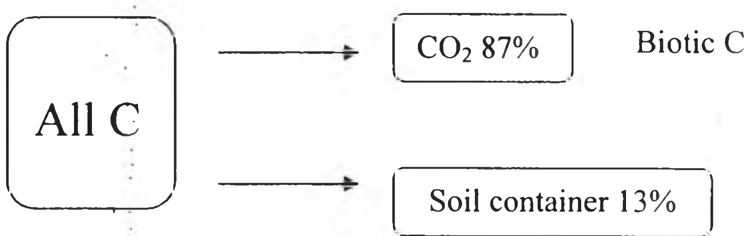
So PBS 1 mol has CO_2 6.96 mol

So PBS 5.81 mol can emit CO_2 (5.81 x 6.96) = 40.437 mol or (40.437 x 44) = 1,779.25 g

Conclusion: PBS 1 kg is biodegraded, it can emit CO_2 1,779.25 g



Assumption



PLA

Chemical formula: $C_3H_5O_2$ (MW = 73)

PLA 1 mol: 73 g

PLA 1 kg: (1000/73) = 13.69 mol

Assume PLA is biodegradable 100%

PLA 1 mol transforms to CO_2 100% = CO_2 3 mol

but assumption for Carbon content in PLA, which can be transformed to CO_2 87%

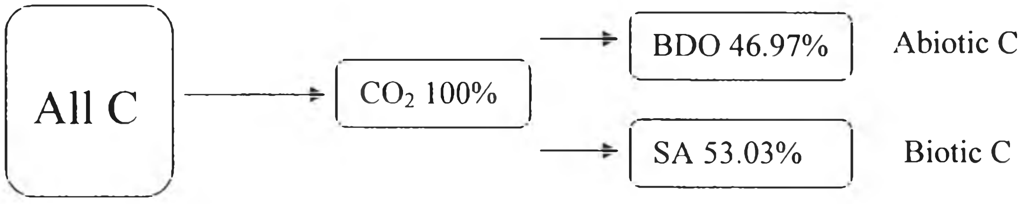
So PLA 1 mol has CO_2 2.349 mol

So PLA 13.69 mol can emit CO_2 (13.69 x 2.349) = 32.157 mol or (36.963 x 44) = 1,414.94 g

Conclusion: PLA 1 kg is biodegraded, it can emit CO_2 1,414.94 g

C7. Emission Calculation of PBS and PLA Incineration

Assumption



PBS

Chemical formula: $C_8H_{12}O_4$ (MW = 172)

PBS 1 mol:172 g

PBS 1 kg: (1000/172) = 5.81 mol

Assume PBS is biodegradable 100%

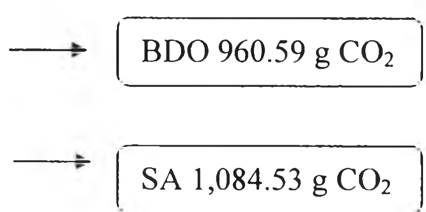
PBS 1 mol transforms to CH_4 100% = CO_2 8 mol

but assumption for Carbon content in PBS, which can be transformed to CO_2 100%

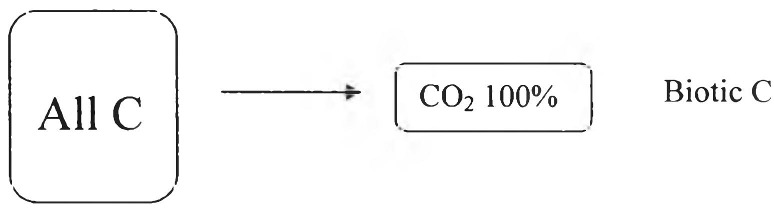
So PBS 1 mol has CO_2 8 mol

So PBS 5.81 mol can emit CO_2 (5.81 x 8) = 46.48 mol or (46.48 x 44) = 2,045.12 g

Conclusion: PBS 1 kg is biodegraded,
it can emit CO_2 2,045.12 g



Assumption



PLA

Chemical formula: $C_3H_5O_2$ (MW = 73)

PLA 1 mol: 73 g

PLA 1 kg: (1000/73) = 13.69 mol

Assume PLA is biodegradable 100%

PLA 1 mol transforms to CO_2 100% = CO_2 3 mol

but assumption for Carbon content in PLA, which can be transformed to CO_2 100%

So PLA 1 mol has CO_2 3 mol

So PLA 13.69 mol can emit CO_2 (13.69 x 3) = 41.07 mol or (41.07 x 44) = 1,807.08 g

Conclusion: PLA 1 kg is biodegraded, it can emit CO_2 1,807.08 g

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Proceedings:

1. Promnigorn, P., Malakul, P., Nithitanakul, M., Chatchupong, T, Thammongkol, V., and Kaabbuathong, N. (2011, April 26) Life Cycle Environmental Evaluation of PLA- and PBS-based Bioplastic Products. Proceedings of The 2^{nd} Research Symposium on Petroleum, Petrochemicals, and Advanced Materials and The 17^{th} PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand