TAMPERE UNIVERSITY OF APPLIED SCIENCES

Ostfalia Hochschule für angewandte Wissenschaften

CREATION OF A SUSTAINABILITY MONITORING TOOL FOR A RETAIL STORE

Gaëlle THOMAS

Bachelor’s thesis
July 2018
Energy and environmental engineering

ABSTRACT

Tampere University of Applied Sciences
Ostfalia University of Applied Sciences
Bachelor's Degree in Environmental Engineering

GAELLE THOMAS
Creation of a sustainability monitoring tool for a retail store

Bachelor's thesis 42 pages, appendices 32 pages
July 2018

This bachelor thesis had three goals: assessing the current environmental situation of the grocery store Super U Chatou along with the costs associated with the sectors causing environmental impacts, finding out possible ameliorations to the current situation and creating an sustainability performance monitoring tool that could help the managing team to track their environmental impacts and target the areas that trigger the biggest impacts. As grocery stores generate a lot of waste and need a big energy, water and chemical consumption to suit the marketing needs, an environmental impact analysis and monitoring procedure is necessary to help reducing their environmental footprint to the maximum.

Two methods were used to research the current situation: theoretical researches from various Internet resources and practical in-situ researches – through asking the workers and analyzing the store receipts and documents. The possible ameliorations were researched by comparing theoretical data with the current situation. The tool was created with Microsoft Excel® by broadening the current and ameliorated situations information through the design of specific formulas. The sustainability indicator was also created with specific formulas derived from the current and ameliorated situations' data.

Key words: environmental impact, monitoring, retail store

CERTIFICATE OF AUTHENTICITY

I, Gaëlle Thomas, student of fourth year in the Bachelor of Environmental Engineering at the Tampere University of Applied Sciences and Ostfalia University of Applied Sciences, declare that this report contains only work completed by me except for the information obtained in a legitimate way from literature, company or university sources which is properly marked as reference and annexed in appendices, in accordance with the norms of Tampere University of Applied Sciences and Ostfalia University of Applied Sciences on plagiarism.

.

Gaëlle THOMAS

CONTENTS

ABBREVIATIONS AND TERMS

BTU	British thermal unit
CtD	Close to date products
GHG	greenhouse gas
h	hour
kcal	kilocalorie
kgCO2eq	kilogram carbon dioxide equivalent
kg	kilogram
kWh	kilowatt per hour
lb	pounds
m	meter
m3	cubic meter
m^2	square meter
OM	other mixed waste
tCO2eq	ton carbon dioxide equivalent

1 INTRODUCTION

1.1 Material flow and sustainability

1.1.1 Sustainability in a grocery store

According to the US Environmental Protection Agency (What is Sustainability?, n.d.), sustainability consists in maintaining conditions to ensure a harmony between human life and nature, on short and long terms. It is done by balancing together three parameters: economy, environment and society.

A grocery store is an example of challenging area when it comes to sustainability, as the main aim is to make profit. This economy-oriented mindset implies that everything in the store aims at appealing the customer to products. This is done through constantly full shelves, attractive packaging and an optimal highlight of the products. Along with the administrative matters, high amounts of waste are triggered, the energy consumption can reach big values and the chemicals used to fit into the sanitary chart often result in the use of products that are hazardous for the environment. In addition, a large volume of water can be consumed in the case where the fridge installation requires a water-based cold-generating back-up system.
Increasing the sustainability of a grocery store means to implement changes that take into account the environmental impacts as well.

1.1.2 Types of waste

The different types of waste generated by a retail store are plastic, cardboard, close-to-date products (referred to as CtD), tallows, office paper, catalogue paper, polystyrene, glass and other types of waste like dirty cleaning paper, out-of-date non-consumable products, etc. (referred to as OM). The treatment options available (ADEME Database, n.d.) for those different types of waste and their source(s) are detailed in TABLE 1.

TABLE 1. Source and different treatment options per type of waste

Type of waste	Source	Treatment options (Y/N)			
		Inc[(1)]	Comp[(2)]	Lf[(3)]	Rec[(4)]
Plastic	Packaging	Y	N	Y	Y
Cardboard	Packaging	Y	Y	Y	Y
CtD	Products that need to be taken away from the shelves according to the sanitation chart but proper to human consumption*	Y	Y	Y	Y
Tallows	Animal tissues and fats (meat sale) improper to human consumption	Y	N	N	Y
Office paper	Administration (management sector, orders, receipts, etc.)	Y	Y	Y	Y
Catalogue paper	Advertisement	Y	Y	Y	Y
Polystyrene	Fish packaging	Y	N	Y	Y
Glass	Jars, bottles	Y	N	Y	Y
OM	All of the waste that cannot be recycled	Y	N	Y	N

* The products are still proper to human consumption until they reach their shelf life labeled ”Use by” or three months after their shelf life labeled ”Best before”;

(1) Inc refers to incineration with or without energy recovery;

(2) Comp refers to composting;

(3) Lf refers to landfilling;

(4) Rec refers to recycling.

1.1.3 Energy consumption

The energy consumption of a grocery store is separated into three main sectors: the lighting system, the heating system and the cold system.

1.1.4 Water consumption

The water consumption is triggered by the sanitary water (toilets, sinks) and, in the case of a water-based cold-generating back-up system, mostly by the cold generation system.

1.2 Current situation

1.2.1 Structure, activity and temperature

The store is at the floor level of an apartment building situated in Chatou, in France. It is built on three levels: the bottom-most level is the storage area; the middle level is the sales area in addition to the management team's offices and the top-most level are the employee's lockers, offices and break room. At the back of the store is the waste management hall. The total sales area is 1700 m², and the height of the walls of the sales area is 4 meters.

The ideal inside temperature of the store can be estimated at approximately 17°C, while the inside temperature with no other influence than the cold system taken into account is approximately 10°C.

From Monday to Saturday, the store is open to customers from 8.30 to 20.45, which, including the maintenance of the shelves, the orders, and all the other daily activities that need to be done before opening and after the closing, amounts to activity hours from 4.00 to 21.00. On Sundays, the store is open from 9.00 to 12.30, which results in activity hours from 4.00 to 13.00. The total yearly activity hours are 5790 hours.

1.2.2 Waste volume and treatment

On average, around 1400 m3 of waste is incinerated as mixed waste per year at the store by the company Veolia, which results in a yearly renting amount of 81 containers. This amount of waste generates a yearly cost of around 22700 €. The bills are shown in Appendix 1. The disposal of mixed waste is done by every employee in the store that is actively working (around 50 employees affected) during a total of 15 minutes every day of the week. According to the manager of the store, the personnel cost was of 66840€ per year as the minimal hourly wage paid per employee was 14.64€ as of January 2017.

In addition, three types of waste are fully recycled: plastic, cardboard and CtD.

Plastic and cardboard are recycled through compression in bales that are sent to back to the warehouse for free. According to the warehouse receipts shown in Appendix 2, 428 kg of plastic are thrown and recycled per month on average. According to the warehouse receipts shown in Appendix 3, 8716 kg of cardboard are recycled on average per month. Around 30 employees are in charge of the disposal, which takes approximately 30 minutes in each employee's workday for each of the two types of waste. The total personnel cost of this process is of 80 208€ in total per year for each type.

CtD products are recycled by being donated to charity from Monday to Saturday, all year long. Based on the amount of products given, a percentage of the value of the products is returned to the store and deduced from the store's taxes. Currently, 70% of the CtD value is returned to the store, but 18% is kept by Phenix ®, the logistics company in charge of the system. The final value deduced is therefore 42% of the CtD value. The disposal is organized by all of the employees taking care of filling up the shelves (25 on average). They currently dedicate around 20 minutes to that process per day from Monday to Saturday, which amounts to a yearly 34375€.

1.2.3 Energy and water consumption

In Super U Chatou currently, natural gas heating is used for a yearly consumption of around 81300 kWh, which costs a total of around 3000€, from which 38% comes from the routing of the gas and 62% from the consumption cost itself. The gas is supplied by Gaz Pro energy. The bills are shown in Appendix 4. In addition, around 790€ is paid yearly for maintenance of the equipment.

The electricity accounts for the cold system and the lighting system. The total electricity consumption is of around 834120 kWh. The total cost for electricity is of around 28470 € for the electricity supply and 15300 € for the maintenance of the electric circuit. As displayed on the EDF electricity bills, peak hours represent a total of 66% of the total hours and off-peak 34%. The bills are shown in Appendix 5.

The total yearly water consumption due to this system was 7351 m3 for 2015-2016 provided by the supplier Suez Environnement, for a cost of 18 850 €.

At the store, all of the lightbulbs were recently replaced by LED lightbulbs.

1.2.4 Chemicals usage

The supplier of all of the products used in Super U Chatou is Laboratoires Anios, situated in Lilles-Hellemmes, in France.

2 SCOPE

2.1 Calculations related to the store

Prior to the creation of the environmental monitoring tool, information related to the current situation at the store needed to be calculated: firstly, the amount of waste per waste type; secondly, the energy-related information: the energy consumptions of the heating system, lighting system and cold system as well as the number and temperatures of the fridge; then, the water consumption per chosen unit of time; and lastly, the number of chemicals used as well as their hazard level through the R-phrases featured in their MSDSs. In addition, the corresponding costs and carbon footprints were needed.

The possible alternatives possible for the waste treatments and the energy consumption areas needed to be researched.

2.2 Creation of the tool

The results obtained from the above-mentioned calculations needed to be broadened to create a tool that would fit the retailing sector in general.

3 THEORY

3.1 Waste management

The carbon footprint for the different treatments per type of waste can be seen in TABLE 2 below.

TABLE 2. Carbon footprint of the different treatments per type of waste (ADEME Database, n.d.)

Waste type	**Incineration**		**Composting**	**Landfilling**	**Recycling** [(2)]
	Without energy recovery	**With energy recovery** [(1)]			
Plastic, polystyrene	2680.6	2614.38	-	33	2037.1
Cardboard	1436.6	1413.71	626.8	1541	18
CtD	805.6	778.49	626.77	681	0.4614 [(3)]
Tallows[(4)]	706.7	652.35	-	-	180
Paper	1436.6	1410.09	626.8	1597	18
Glass	46.6	46.45	-	33	28
OM	805.6	778.49	-	681	-

(1) See Appendix 6.

(2) See Appendix 7.

(3) The recycling values are those of the carbon footprint of a 12 tons transportation truck (kgCO2eq/ton/km)

(4) Special Industrial Waste values

The average treatment cost worldwide per treatment option are shown in TABLE 3. The details of the recycling cost per waste type are shown in TABLE 4.

TABLE 3. Average treatment costs worldwide (Annex E “Estimated Solid Waste Management Costs”, n.d.)

Treatment		Average cost (€/ton)
Incineration	*Without energy recovery*	149.60
	With energy recovery	120.10
Composting		62.50
Landfilling		55.80
Recycling		Depends on the waste type

TABLE 4. Average recycling cost per waste type

Waste type		Average recycling cost (€/ton)	Source
Plastic		193.70	”Plastic 2017”, June 2017.
Cardboard		106.40	”Waste paper 2017”, June 2017.
CtD		Depends on the contractor	
Tallows		No information found	
Paper	*Office paper*	211	”Waste paper 2017”, June 2017.
	Catalogue paper	193.70	”Waste paper 2017”, June 2017.
Glass		10	”Glass prices 2017”, June 2017.

3.2 Energy consumption

3.2.1 Theoretical heating consumption

The theoretical heating consumption of a room can be calculated by applying Formula (1). Depending on the heating system, it calculates the theoretical consumption from the theoretical heating needs.

$$C_Q = \frac{c_p * \rho_p * V * \Delta T * HP}{\eta} \quad (1)$$

With:

C_Q the total theoretical heating consumption (kWh)

c_p the specific heat capacity of air (0.000279 kWh/kg°C)

ρ_p the density of air (1.25 kg/m3)

V the volume of the room to heat (m3)

ΔT the temperature difference between the ideal inside temperature and the outside temperature (°C)

HP the peak hours of the heating system (h)

η the efficiency of the heating system

3.2.2 Electricity carbon footprint

The carbon footprint of electricity depends on the source of the electricity. In TABLE 5 below, the different carbon footprint per source are displayed. In addition, the source distribution of EDF France, the most common supplier of electricity supplier in France and the average source distribution of French electricity are shown.

TABLE 5. Carbon footprints and electricity distributions of EDF France and the French average per source.

		Distribution	
Source	**Carbon footprint (1)**	**EDF France (%) (2)**	**Average France (%) (2)**
Nuclear	0.006	89.7	72.3
Petroleum	0.73	1.5	0.6
Coal	1.06	1.1	1.4
Gas	0.418	0.8	6.6
Hydraulic	0.006	6.3	12
Wind	0.007	0.2	3.9
Solar	0.0055	0.2	1.6
Earth	0.0045	0.2	1.6

(1) ADEME database

(2) Information sur l’origine de l’électricité fournie par EDF, n.d.

(3) Eco2Mix database, n.d.

3.2.3 Cold system

The cold system is powered by electricity; therefore the carbon footprint depends on the consumption. In addition, most systems use a refrigerant as an intermediary cold-transferring tool (Le froid alimentaire commercial, 2014).. In the food industry, the most commonly known refrigerant is R-404A, although some new systems have implemented the R-134A, R-407C and R-410A (Le froid alimentaire commercial, 2014).The carbon footprints of the different refrigerants as well as their cost are shown in TABLE 6.

TABLE 6. Carbon footprint and average cost of refrigerants

Refrigerant option	**Carbon footprint (kgCO2eq/kg)**	**Average cost (5)**
R-134a	1430 (1)	8.96€
R-404A	3922 (2)	18.08€
R-407C	1722 (3)	18.08€
R-410A	2088 (4)	16.84€

(1) Source: Industrial gases – R-134a, n.d.
(2) Source: Industrial gases – R-404A, n.d.
(3) Source: Industrial gases – R-407C, n.d.
(4) Source: Industrial gases – R-410A, n.d.
(5) Source: Amazon.com

The amount of refrigerant in the cold system and the annual leaking rate depend on the sales area, as shown in TABLE 7. In addition, the percentage of the energy consumption represented by the cold system also depends on the sales area and is displayed in TABLE 7 below.

TABLE 7. Information concerning the cold system depending on the sales area.

Sales area	Percentage of the energy consumption taken by the cold system (1)	Amount of refrigerant (2)	Leaking rate annually (2)
120-400m²	70%	132 kg	10%
400-2500m²	35%-50%	0.21 kg/m²	20%
>2500m²	30%-40%	0.19 kg/m²	27%

(1) Le froid alimentaire commercial, December 2014.

(2) ADEME Database, n.d.

3.2.4 Lighting system

Four types of light bulbs can be used within the lighting system: incandescent, fluorescence, halogen and LED (Les différentes énergies d'éclairage, n.d). Those four systems differ in many ways, amongst which their relative power, as shown in TABLE 8.

TABLE 8. Different types of lighting systems (Les différentes énergies d'éclairage, n.d.)

Lighting system	Relative power (W)
LED	1
Fluorescence	18-95
Incandescent	25-150
Halogen	25-50

The carbon footprint and the cost of the lighting system correspond to these of electricity.

3.3 Water consumption

Water consumption is separated into sanitary water, which comes from sinks and toilets, and water used in the technical processes, which mainly comes from the cold generation in the case of a water-based system. Although these fridges function with water as a closed loop, the possible breakdowns require the use of an alternative system to compensate, called “city water”. This system consists in using sanitary water as a coolant.

3.4 Chemical

Chemicals play a big part in the overall environmental impact, depending on whether they contain harmful components. Different hazard classifications exist, amongst which the R- and S-phrases system, used as an international indicator of possible hazards (R-) and safety measures to take (S-) in their Material Safety Data Sheets (MSDS – the documents gathering all of the necessary information about a chemical), as mentioned in the article ”R and S phrases”, published on the website MSDS Europe. To evaluate the environmental impact of the chemicals used, the following R-phrases are the most relevant:

- R50: Very toxic to aquatic organisms
- R51: Toxic to aquatic organisms
- R52: Harmful to aquatic organisms
- R53: May cause long-term adverse effects in the aquatic environment
- R54: Toxic to flora
- R55: Toxic to fauna
- R56: Toxic to soil organisms
- R57: Toxic to bees
- R58: May cause long-term adverse effects in the environment
- R59: Dangerous for the ozone layer

4 MATERIALS AND METHODS

The amount of waste per waste type was calculated thanks to information obtained from the workers (tallows, office and catalogue paper), measurements in-situ (polystyrene) and thanks to the analyses of shelf-withdrawal receipts (CtD). The amount of OM was calculated from the information gotten about all the other types of waste. The information related to the percentages of the consumption and of the cost represented by each sector was obtained by conducting Internet researches. In addition, an in-situ study of the fridges and the cold system was conducted to obtain the number and the type of fridges and the refrigerant used in the system. The information related to the water consumption calculations were obtained by asking the manager of the store about the details of the consumption. The information related to the R-phrases of the chemicals used were obtained by analysing the MSDSs of each chemical used in the store.

The possible ameliorations of the waste management were obtained by comparing the current situation with the theoretical data per waste type. The possible ameliorations for the energy consumption, the water consumption and the chemical usage were found by conducting Internet researches.

The tool was created with Microsoft Excel®. The current situation and the possible ameliorations were broadened by creating specific formulas for each of the sectors (waste management, energy and water consumption and chemical usage). In addition, the indicator to assess the sustainability performance of the store was also created thanks to specific formulas designed from the data of each sector.

5 RESULTS AND DISCUSSION

5.1 Current situation

5.1.1 Waste management

The amount of different waste, their treatment and their carbon footprint are summed up in TABLE 9 below. In addition, the treatment cost and the profit returned to the store per month are featured as well.

At the store, no glass is disposed in the waste at the moment. Currently, the waste types responsible for the most impact are the incinerated polystyrene and OM. They are also the waste types responsible for the most costs. In total, 75.46 tons of waste are incinerated per month and 9.60 tons of waste are recycled.

TABLE 9. Waste management information as done as the store.

	Plastic	**Card-board**	**CtD (1)**	**Tallows**	**Office paper**	**Catalogue paper**	**Polystyrene**	**OM**
Amount (tons)	0.428	8.72	0.4-0.5	0.2-0.3	0.51	0.06	33.8	40.84
Percent-age	0.48%	9.77%	0.45%	0.28%	0.60%	0.07%	39.58%	47.88%
Treatment	Rec*	Rec*	Rec*	Inc, nRE**	Inc, nRE**	Inc, nRE**	Inc, nRE**	Inc, nRE**
Carbon footprint (kgCO2eq)	**871.88**	**156.96**	**149.49 (2)**	**176.65**	**732.67**	**86.20**	**90872**	**32901**
Monthly treatment cost	0 €	0 €	171.7 €	6.27 €	12.78 €	1.50 €	842.32 €	1023.80 €
Returned to the store monthly	-	-	1705.6 €	-	-	-	-	-
Personnel cost	6684 €	6684 €	2864.58 €	18.45 €	37.65 €	4.43 €	2494.91 €	3014.56 €
Total cost	**6684 €**	**6684 €**	**1330.68 €**	**24.72 €**	**50.43 €**	**5.93 €**	**3337.23 €**	**4038.36 €**

(1) Calculations shown in Appendix 8

(2) The distance separating the charity organisms is of around 720 km per month.

* Rec = recycling

** Inc, nRE = Incineration without energy recovery

5.1.2 Energy

The theoretical heating needs of the room depend on the inside temperature as shown in Formula (1). The inside temperature without the influence of the heating system are shown in TABLE 10.1 and 10.2. Those temperatures were calculated according to the Formula (A) in Appendix 12, based on the meteorological data gathered in Appendix 9. The total heating needs of the building throughout the year is therefore around 65524.9 kWh.

TABLE 10.1. Inside temperature without heating system and the corresponding theoretical heating needs from January to July.

Month	Jan	Fev	Mar	Apr	May	Jun	Jul
Inside temperature without heating system	11.7081	11.5457	12.5955	13.4191	14.3442	15.3244	16.1567
Theoretical heating needs (kWh)	7771.6	7957.4	6756.2	5813.8	4755.3	3633.7	2681.3

TABLE 10.2. Inside temperature without heating system and the corresponding theoretical heating needs from August to December.

Month	Aug	Sep	Oct	Nov	Dec
Inside temperature without heating system	16.0378	15.0953	13.8947	12.6506	11.9633
Theoretical heating needs (kWh)	2817.4	3895.8	5269.6	6693.2	7479.6

As Super U Chatou's total area is 1700 m², the total consumption of the cold system can be estimated to be around 42.5% of the electricity consumption. The lighting system therefore accounts for 57.5% of the electricity consumption. Hence, it can be estimated that yearly, the cold system consumes around 354500 kWh and costs a total of 12100 € of electricity without taxes as well as 6050 € for maintenance, while the lighting system consumes the remaining 479620 kWh, for a total cost of 16370 € of electricity supply and 8185 € of maintenance.

In addition, the number and the nature of the fridges can be found in the TABLE 11 below. As shown in the table, only 18% of the fridges are closed, which contributes to a waste of energy and high heating costs. The fridges all have a LED lighting system, which is the less consuming system.

TABLE 11. Fridges information at the store

Type	Number(2)	Conservation temperature	Closed (Y/N)	Lighting system	Model(s) (1)
Positive	33	-3°C – 8°C	N	LED	Valea Multi Strateo Multi
Negative	6	-18°C	Y	LED	Skylight

(1) Sources: Valea Multi, 2014, Strateo Multi, 2014 and Skylight, 2014.

(2) See Appendix 10.

In addition, the refrigerant used in Super U Chatou is R-404A. 0.21 kg/m² of refrigerant is used in Super U Chatou (as it is 1700m²), that is to say 375 kg. The system has a 20% leaking rate per year, which means that 71.4 kg of refrigerant is susceptible to leak. This amount of R-404A triggers carbon emissions up to 280030 kgCO2eq yearly. The cost of the losses is up to 1291€.

5.1.3 Water consumption

As explained by the store manager, around 2 to 3 days per month is spent using the city water system, except for the months of June and July, and 80% of August, are spent using this system. The city water system is therefore used for around 85 days, which results in a consumption of 86.5 m3 per day using city water. The cost per day using city water is therefore of around 221.80 €.

5.1.4 Chemicals

All in all, 21 products are used, amongst which 13 of them contain R-phrases. They contain in total 20 R50-53-labelled chemicals. The list of chemicals and their R phrases can be found in Appendix 11.

5.2 Possible ameliorations

Possible ameliorations were found for waste management and energy consumption. Water consumption cannot be ameliorated, as the structure of the building do not allow for anything else than a water-based cold system. As for the chemicals, no alternatives were found because the suppliers of the chemicals and the chemicals themselves depend on the partners of the U-group.

5.2.1 Waste management

The most environmentally friendly waste management alternatives for each type of waste are shown in TABLE 12, along with their associated carbon footprint and theoretical treatment cost.

The recycling cost for tallows can be reduced to zero, as explained by the Phenix® consultant: whether it is for melting into edible fats, recycling into biofuels or given to wolf hunters, the disposal and collection logistics are organized by Phenix® and therefore would not cost anything to the store. Phenix ® only charges the percentage of the CtD donated.

Adopting the most environmentally friendly treatment methods would save the emission of around 85 to 89800 kgCO2eq depending on the type of waste. However, apart for tallows, switching to the most environmentally friendly treatment would trigger an increase of 10.12 € to 1255 € of treatment costs depending on the waste type.

The most economically friendly waste treatment options per type of waste are the ones used at the moment.

TABLE 12. Best treatment option and the corresponding theoretical cost and carbon footprint per waste type

	Plastic	**Card-board**	**CtD**	**Tallows**	**Office paper**	**Catalogue paper**	**Polysty-rene**	**OM**
Best treat-ment option	Lf	Current situation	Current situation	Rec	Rec	Rec	Lf	Lf
Carbon footprint associated, per month (kgCO2eq)	14.124			45	9.18	1.08	1115.4	27812.04
Theoretical cost associ-ated, per month	23.88 €			0 €	107.61 €	11.62 €	1886.04 €	2278.87 €

5.2.2 Energy

The different options for the heating system can be found in TABLE 13 below. The cheapest option is a natural gas heating system but it is also the most detrimental to en-vironment. The most environmentally friendly system is a solar panel heating system. The major problem of this system is the structural aspect of the building which, to this day, prevents any rooftop installations. A heat pump prevents good advantages for a building like Super U Chatou, however it represents a consequent investment.

TABLE 13. Different types of heating system

Heating system	**Installation cost (€)**	**Maintenance cost (€)**	**Energy cost (€/kWh, without taxes)**		**Efficiency**	**Carbon footprint (kgCO2eq /kWh)**
			Average France	**Most popular supplier**		
Natural gas	4500(1)	790(2)	0.054(3)	0.056(3)	0.8-0.9(1)	0.418
Electricity	895(1)	50% of kWh cost(6)	0.0887(4)	0.0967 (peak hours) 0.0787 (off-peak hours) (5)	1(1)	0.0330-0.0493
Solar energy	8000 + 1000 /m² solar cells (9)	0.000286 - 0.000571 per kWh(8)			0.35 (7)	0.0055
Heat pump	120-130/m² heated (10)	150-200/m² heated (11) + electricity maintenance cost			2-4 (12)	Electricity carbon footprint
Geothermal heat pump	150-170/m² heated (13)					

(1) Source: Electric heating vs Gas heating, n.d.
(2) Source: Information gotten from the gas maintenance bills of the store.
(3) Source: Prix du kWh des fournisseurs de gaz, n.d.
(4) Source: Prix d'un kWh d'électricité en France en 2017, n.d.
(5) Source: Combien coûte un kWh chez EDF en 2015, n.d.
(6) Source: Information gotten from the electricity bills of the store.
(7) Source: Solar Thermal vs. Photovoltaic, n.d.
(8) Source: Maintenance du système, 2017
(9) Source: How much does a solar thermal system cost, n.d.
(10) Source: Coût d'une pompe à chaleur, n.d.
(11) Source: Le coût de maintenance d'une pompe à chaleur, n.d.
(12) Source: Geothermal heat pumps, n.d.
(13) Source: Prix d'installation d'une pompe à chaleur, n.d.

The installation cost of a new lighting system consists, in a grocery store, in the replacement of the lightbulbs and the adjustment of the cables which cost, according to the article "Estimez le coût de votre installation d'éclairage" (n.d.), between 55€ and

80€. However, the store has already switched their lighting system to a LED-based system, which is the most environmentally and economically friendly on the market nowadays.

According to article entitled “Les supermarchés fermeront leurs meubles frigorifiques pour réduire leurs dépenses d'énergie” (2012), each linear meter of fridge will save to the store up to 4150 kWh for a cost of 2000€ per year. There are 0.2303 linear meters on average per fridge, as calculated from the data in Appendix 9. Changing all of the open fridges to closed ones would then save up to 31540 kWh, equivalent to 2827.20 € per year. The installation cost would be of 15200 € in total. The installation of doors would thus avoid the emission of 1300 kgCO2eq per year.
In addition, a change of refrigerant could considerably reduce the cost of such a system: using R-134a would decrease the carbon emissions to 102102 kgCO2eq per year. The cost of the losses would be also decreased to 639.70 €.

5.3 Creation of the tool

5.3.1 General information

The calculations made for those parts require essential information that can be filled in the first page, as demonstrated in FIGURE 1: the date (month/year) to which the tool is being filled (1), general information about the store can be filled according to the needs (2) – the total sales area, the total height of the sales area, the ideal inside temperature, the inside temperature that would be if no heating was applied, calculated from Formulas (A) and (B), Appendix 12 – the activity hours (3), the minimum hourly wage (4) and the ratio of importance of environmental vs economic to take into account in the score calculations (5) explained below.

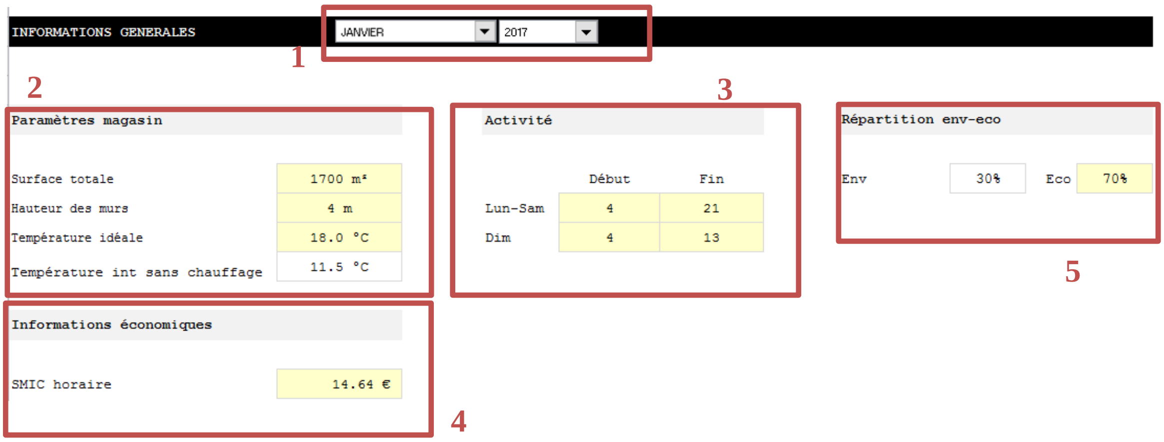


FIGURE 1. Overview of the general information

5.3.2 Current situation

The current situation is separated in three sections: waste management, energy and water, and chemicals. One page was dedicated per section.

The page dedicated to waste management is separated in four sections identified in FIGURE 2: the environmental information about waste (1), the economic information about waste (2), the score calculation (3a), the total score (3b).
The environmental section of the waste management section overall gathers, as shown in FIGURE 3: the treatment distribution of each type of waste and overall (2a) (Formula (C), Appendix 12), additional information about the recycling process of close-to-date products – the distance driven by the truck in a month to get the products from the store and the percentage of the value of the products returned as profit (2g), the amount of recycled (2b), non-recycled (2c), and total waste (2d) of each type, in tons per month, (Formula (D) and (E), Appendix 12), the proportion of each type of waste (2e) and the carbon footprint triggered by the waste treatment(s) per waste type (2f), calculated according to Formulas (F), Appendix 12.

The economic section gathers everything that relates to the cost and/or the profit. It is separated into the different waste treatment options (FIGURE 4, 3a). For each treatment option is indicated, as shown in FIGURE 4: the amount of waste corresponding to the option (3b), the provider of the service (3c), the average cost per ton per year (3d), the treatment cost per month (3e), the maintenance cost per month and per year (3f), the time spent to contribute to the treatment in hour per day and per employee for every day of the week and the number of employees responsible for the task (3g), the profit returned (3h) and the total cost per year (3i) calculated with formula (G), Appendix 12. The subtotal of those figures are also calculated for the total amount of recycled waste and for the total amount of non-recycled waste.

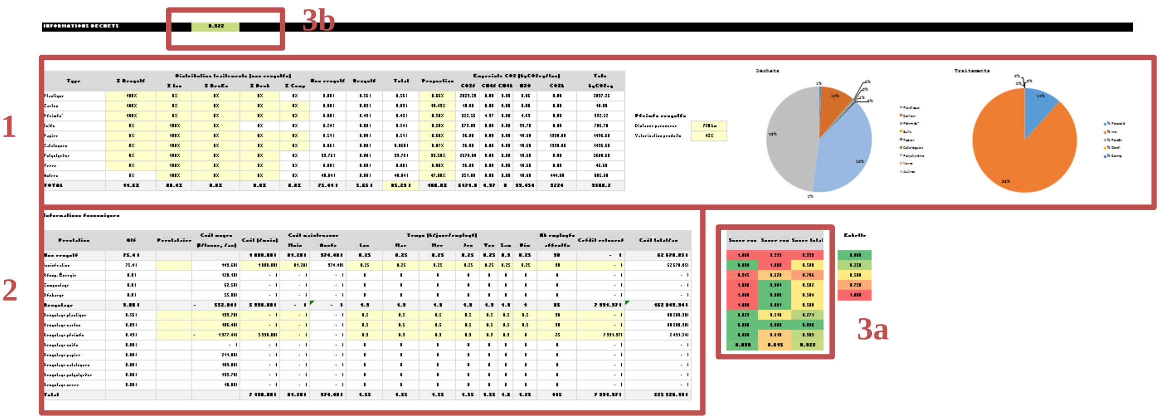
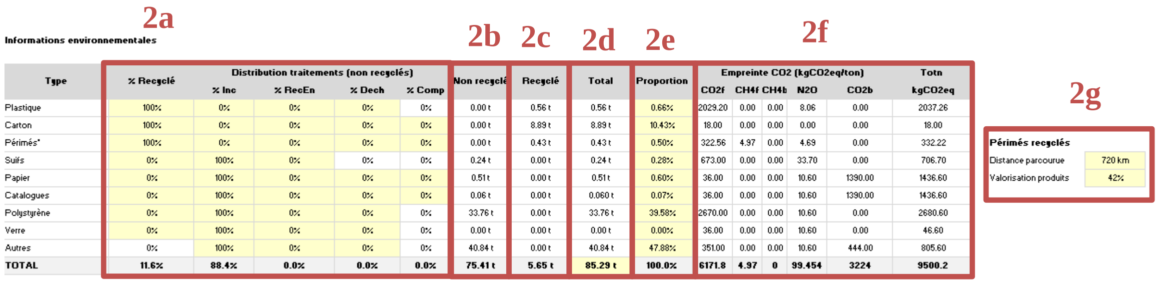
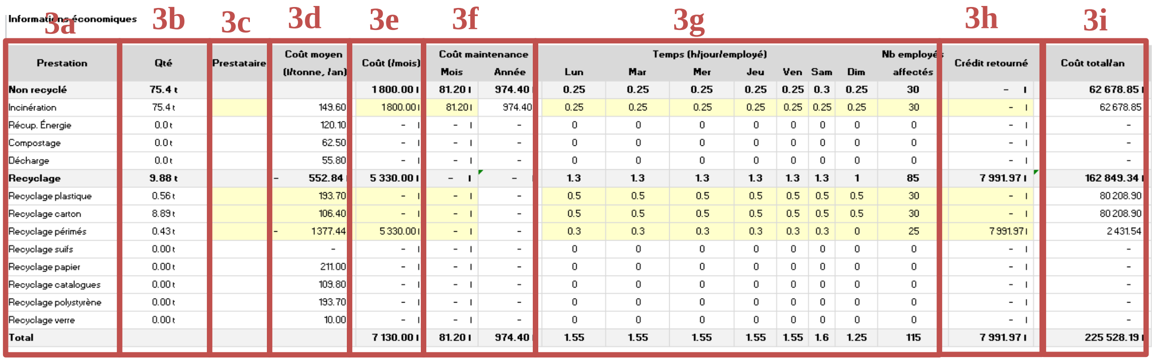


FIGURE 2. Overview of the waste management page



Type	% Recyclé	Distribution traitements (non recyclés)				Non recyclé	Recyclé	Total	Proportion	Empreinte CO2 (kgCO2eq/ton)					Totn
		% Inc	% RecEn	% Dech	% Comp					CO2f	CH4f	CH4b	N2O	CO2b	kgCO2eq
Plastique	100%	0%	0%	0%	0%	0.00 t	0.56 t	0.56 t	0.66%	2029.20	0.00	0.00	8.06	0.00	2037.26
Carton	100%	0%	0%	0%	0%	0.00 t	8.89 t	8.89 t	10.43%	18.00	0.00	0.00	0.00	0.00	18.00
Périmés*	100%	0%	0%	0%	0%	0.00 t	0.43 t	0.43 t	0.50%	322.56	4.97	0.00	4.69	0.00	332.22
Suifs	0%	100%	0%	0%	0%	0.24 t	0.00 t	0.24 t	0.28%	673.00	0.00	0.00	33.70	0.00	706.70
Papier	0%	100%	0%	0%	0%	0.51 t	0.00 t	0.51 t	0.60%	36.00	0.00	0.00	10.60	1390.00	1436.60
Catalogues	0%	100%	0%	0%	0%	0.06 t	0.00 t	0.060 t	0.07%	36.00	0.00	0.00	10.60	1390.00	1436.60
Polystyrène	0%	100%	0%	0%	0%	33.76 t	0.00 t	33.76 t	39.58%	2670.00	0.00	0.00	10.60	0.00	2680.60
Verre	0%	100%	0%	0%	0%	0.00 t	0.00 t	0.00 t	0.00%	36.00	0.00	0.00	10.60	0.00	46.60
Autres	0%	100%	0%	0%	0%	40.84 t	0.00 t	40.84 t	47.88%	351.00	0.00	0.00	10.60	444.00	805.60
TOTAL	**11.6%**	**88.4%**	**0.0%**	**0.0%**	**0.0%**	**75.41 t**	**5.65 t**	**85.29 t**	**100.0%**	**6171.8**	**4.97**	**0**	**99.454**	**3224**	**9500.2**

FIGURE 3: overall layout of the environmental information of waste management.



Prestation	Qté	Prestataire	Coût moyen (I/tonne, I/an)	Coût (I/mois)	Coût maintenance Mois	Coût maintenance Année	Temps (h/jour/employé) Lun	Mar	Mer	Jeu	Ven	Sam	Dim	Nb employés affectés	Crédit retourné	Coût total/an
Non recyclé	**75.4 t**			**1 800.00**	**81.20**	**974.40**	**0.25**	**0.25**	**0.25**	**0.25**	**0.25**	**0.3**	**0.25**	**30**	**–**	**62 678.85**
Incinération	75.4 t		149.60	1800.00	81.20	974.40	0.25	0.25	0.25	0.25	0.25	0.25	0.25	30	-	62 678.85
Récup. Énergie	0.0 t		120.10	-	-	-	0	0	0	0	0	0	0	0	-	-
Compostage	0.0 t		62.50	-	-	-	0	0	0	0	0	0	0	0	-	-
Décharge	0.0 t		55.80	-	-	-	0	0	0	0	0	0	0	0	-	-
Recyclage	**9.88 t**		**– 552.84**	**5 330.00**	**–**	**–**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1**	**85**	**7 991.97**	**162 849.34**
Recyclage plastique	0.56 t		193.70	-	-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	30	-	80 208.90
Recyclage carton	8.89 t		106.40	-	-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	30	-	80 208.90
Recyclage périmés	0.43 t		- 1377.44	5 330.00	-	-	0.3	0.3	0.3	0.3	0.3	0.3	0	25	7 991.97	2 431.54
Recyclage suifs	0.00 t		-	-	-	-	0	0	0	0	0	0	0	0	-	-
Recyclage papier	0.00 t		211.00	-	-	-	0	0	0	0	0	0	0	0	-	-
Recyclage catalogues	0.00 t		109.80	-	-	-	0	0	0	0	0	0	0	0	-	-
Recyclage polystyrène	0.00 t		193.70	-	-	-	0	0	0	0	0	0	0	0	-	-
Recyclage verre	0.00 t		10.00	-	-	-	0	0	0	0	0	0	0	0	-	-
Total				**7 130.00**	**81.20**	**974.40**	**1.55**	**1.55**	**1.55**	**1.55**	**1.55**	**1.6**	**1.25**	**115**	**7 991.97**	**225 528.19**

FIGURE 4: Overview of the economics section of the waste management page.

The page dedicated to energy consists in different sections (FIGURE 5): the general information, composed of: the electricity cost information (1a) and the distribution graph (1b), the environmental information (2a), the economic information (2b), a graph summary of the current situation (2c), the total score (2d).

The general information consists in different sections shown in FIGURE 9: the electricity and gas distributions (1a.aa), the distribution percentages and kWh price to fill in case of a personnalized electricity distribution choice (1a.ab), the distribution graph (1a.ac), the peak and off-peak hours in percentage (1a.b), the average kWh price without taxes for electricity supply and maintenance (1a.c), the average kWh price of gas heating (1a.d).

The choice of the electricity distribution option (FIGURE 6, 1a.aa) can be made by the user between EDF standards, the French average and personalized. In the case of a personalized choice, the user must fill themselves the distribution of the different sources (nuclear, petroleum, etc.) and the kWh cost (FIGURE 6, 1a.ab).

The gas distribution option (FIGURE 6, 1a.aa) can be made by the user between GDF standards, the French average and personalised. In the case of a personalized choice, the user must fill themselves kWh cost (FIGURE 6, 1a.ab).

The environmental information regarding the energy usage is distributed into four different sections pointed out in FIGURE 7: the information regarding the heating system (2a.a), the information regarding the lighting system (2a.b), the information regarding the fridges (2a.ca and 2a.cb). In addition, an overview of the environmental impact distribution according to the different sectors can be seen at the bottom of the page.

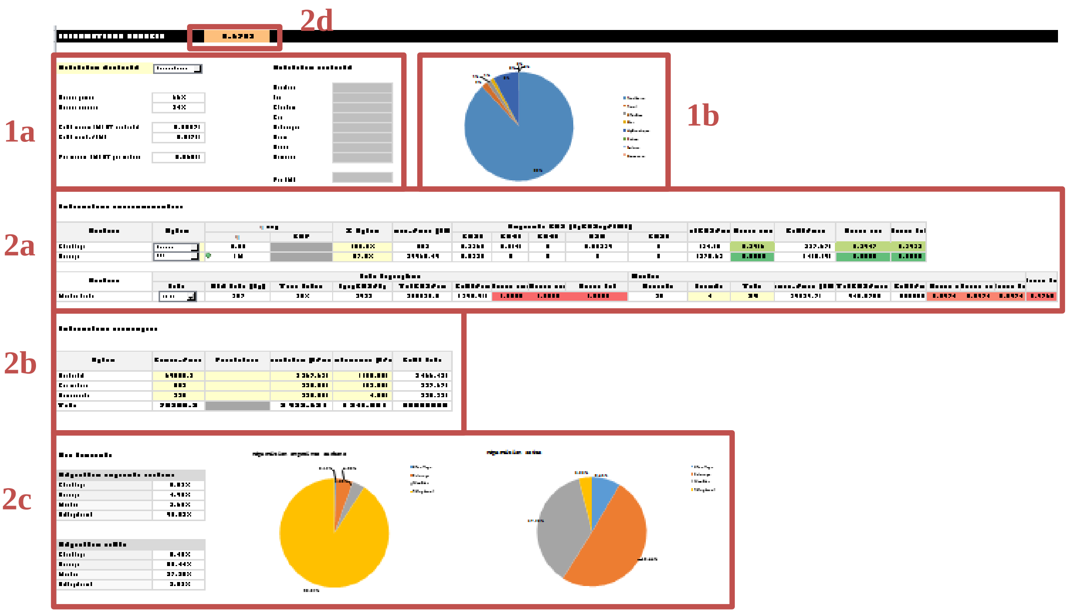


FIGURE 5: Overall layout of the energy section.

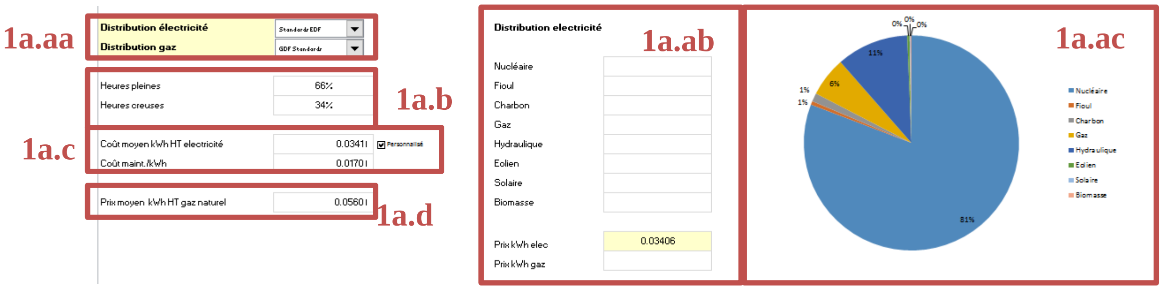


FIGURE 6: Overview of the general energy information section

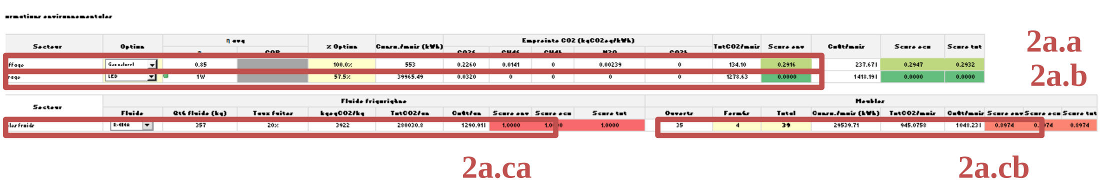


FIGURE 7. Overview of the environmental information section of the energy consumption page.

The heating system section is separated in seven parts, as pointed out in FIGURE 8: the energy source (2a.aa), the efficiency/COP of the system (2a.ab), the proportion of the type of energy source, depending on the energy source of other systems (2a.ac), the monthly consumption of the system in kWh (2a.ad), the carbon footprint of the system in kgCO2eq/kWh (2a.ae), the total carbon footprint for the heating system (2a.af) and the environmental score for the heating system (2a.ag).

The lighting system section is built according to the same model as described as the heating system section.

	2a.aa	2a.ab		2a.ac	2a.ad	2a.ae					2a.af	2a.ag
Secteur	Option	η avg		% Option	Conso./mois (kWh)	Empreinte CO2 (kgCO2eq/kWh)					TotCO2/mois	Score env
		η	COP			CO2f	CH4f	CH4b	N2O	CO2b		
hauffage	Gaz naturel	0.85		100.0%	553	0.2260	0.0141	0	0.00239	0	134.10	0.2916

FIGURE 8. Overview of the heating system information

The cold system section is separated into two different parts: the information about the refrigerant (FIGURE 9) – containing the choice of the refrigerant, the amount of refrigerant used in the system, the leaking rate per year, the carbon footprint per kg of refrigerant, the total carbon footprint for the refrigerant per year and the environmental score – and the information about the fridges themselves (FIGURE 10) – containing the number of open fridges, the number of closed fridges, the total number of fridges, the monthly consumption of the system, the total carbon footprint for the fridges per month and the environmental score.

Secteur	Fluide frigorigène						
	Fluide	Qté fluide (kg)	Taux fuites	kgeqCO2/kg	TotCO2/an	Coût/an	Score env
Meubles froids	R-404A	357	20%	3922	280030.8	1290.91	1.0000

FIGURE 9: Overview of the refrigerant information

Meubles						
Ouverts	Fermés	Total	Conso./mois (kWh)	TotCO2/mois	Coût/mois	Score env
35	4	39	29539.71	945.0758	1 048.23 €	0.8974

FIGURE 10: Overview of the fridges information

The economic information is separated into three parts (FIGURE 11): electricity, natural gas and renewable energy. Each of those parts consists in the monthly consumption and the energy distribution, the provider of the energy service, the monthly cost for energy consumption, the maintenance cost per year and the total cost per month. An overview of the distribution of the costs depending on the sector (heating system, lighting system and fridge and refrigerant) is displayed at the bottom of the page.

Option	Conso./mois	Prestataire	Prestation (€/mois)	Maintenance (€/an)	Coût total
Electricité	69505.2		2 367.63 €	1 185.50 €	2 466.43 €
Gaz naturel	553		225.00 €	152.00 €	237.67 €
Renouvelable	230		330.00 €	4.00 €	330.33 €
Total	70288.2		2 922.63 €	1 341.50 €	3 034.43 €

FIGURE 11: Overview of the economic information about energy and water consumptions. The figures are not specific to the store.

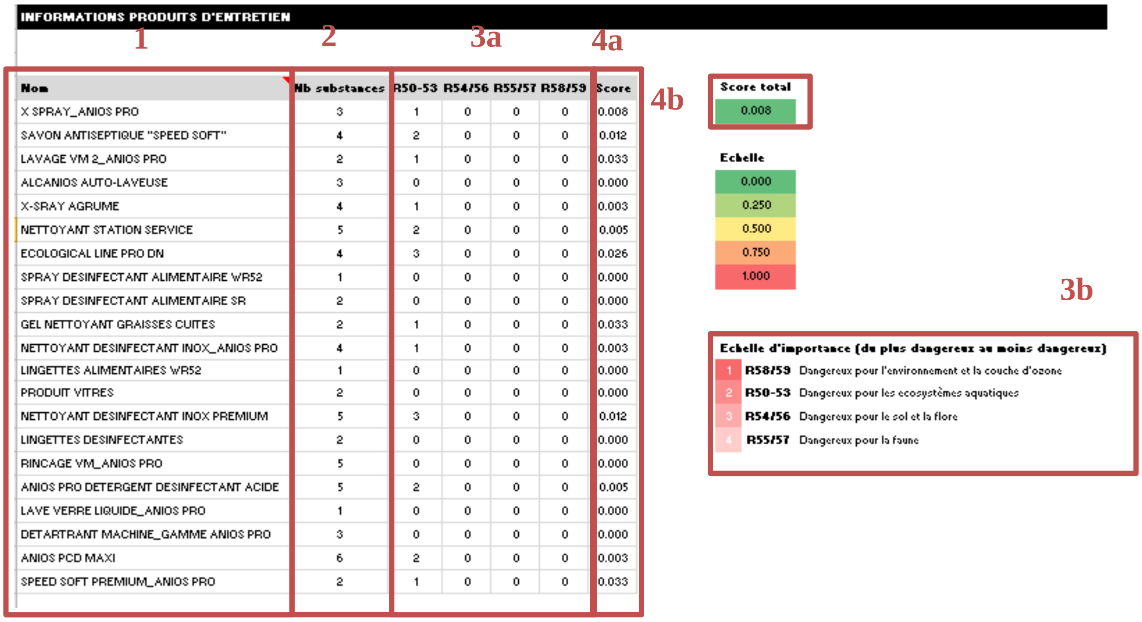
The information required about the water consumption are, as shown in FIGURE 12, the monthly consumption in m3 (1), the supplier of the service (2), the cost of the supply and treatment of the water per month (3), the pollution tax per month (4), the total cost, calculated by adding together the pollution tax and the monthly supply and treatment cost (5) and the score, explained in details further (6).

INFORMATIONS EAU 0.0852 (6)

Prestation	Conso./mois (m3) (1)	Prestataire (2)	Prestation (l/mois) (3)	Redevance poll (l/mois) (4)	Coût total (5)
Eau	1253	Suez pro environnement	445	1230	1675.00 l

FIGURE 12. Water consumption information

The section of the tool focusing on chemicals gathers environmental risk information about the different chemical products used at the store. It consists in four characteristics pointed out in FIGURE 13: the name of the products as indicated on its MSDS (1), the amount of chemicals contained in the product (2), the amount of R-phrases all in all contained in the product (3a) and their hazard index (3b) and the score per product (4a) as well as the total score (4b).



INFORMATIONS PRODUITS D'ENTRETIEN

Nom	Nb substances	R50-53	R54/56	R55/57	R58/59	Score
X SPRAY_ANIOS PRO	3	1	0	0	0	0.008
SAVON ANTISEPTIQUE "SPEED SOFT"	4	2	0	0	0	0.012
LAVAGE VM 2_ANIOS PRO	2	1	0	0	0	0.033
ALCANIOS AUTO-LAVEUSE	3	0	0	0	0	0.000
X-SRAY AGRUME	4	1	0	0	0	0.003
NETTOYANT STATION SERVICE	5	2	0	0	0	0.005
ECOLOGICAL LINE PRO DN	4	3	0	0	0	0.026
SPRAY DESINFECTANT ALIMENTAIRE WR52	1	0	0	0	0	0.000
SPRAY DESINFECTANT ALIMENTAIRE SR	2	0	0	0	0	0.000
GEL NETTOYANT GRAISSES CUITES	2	1	0	0	0	0.033
NETTOYANT DESINFECTANT INOX_ANIOS PRO	4	1	0	0	0	0.003
LINGETTES ALIMENTAIRES WR52	1	0	0	0	0	0.000
PRODUIT VITRES	2	0	0	0	0	0.000
NETTOYANT DESINFECTANT INOX PREMIUM	5	3	0	0	0	0.012
LINGETTES DESINFECTANTES	2	0	0	0	0	0.000
RINCAGE VM_ANIOS PRO	5	0	0	0	0	0.000
ANIOS PRO DETERGENT DESINFECTANT ACIDE	5	2	0	0	0	0.005
LAVE VERRE LIQUIDE_ANIOS PRO	1	0	0	0	0	0.000
DETARTRANT MACHINE_GAMME ANIOS PRO	3	0	0	0	0	0.000
ANIOS PCD MAXI	6	2	0	0	0	0.003
SPEED SOFT PREMIUM_ANIOS PRO	2	1	0	0	0	0.033

FIGURE 13: Overview of the chemical section

5.3.3 Possible ameliorations

The amelioration section focuses the two sectors of waste management and energy, as water consumption is inevitable and the change of products used often depend on the different partnerships that the U-group and suppliers agree on.

The waste management amelioration section offers the possibility to fill up to three options of change at the same time. The number was decided as such, because it is unlikely for the store to implement more than three different changes at once, but it is also possible that more than one option is considered. The change possibilities offered for the user of the tool rely on the type of waste in order to give a clear picture of the amelioration thought about.

The waste management amelioration section is organized in three different sections pointed out in FIGURE 14:

- General information (1), offering the possibility to select a new treatment, the amount of waste treated by the new treatment and the new distribution of waste,
- Environmental information (2), displaying the new carbon footprint calculated with Formulas (AJ) and (AK), Appendix 12 and the new environmental score,
- Economic information (3), displaying the new economical score and the new costs : the monthly cost, calculated from Formulas (AL) and (AM), Appendix

11, the maintenance cost, calculated from Formula (AN), the personnel cost, calculated from Formula (AO), Appendix 12, the total cost, calculated from Formula (G), Appendix 12.

- Additional information to fill in case of close-to-date products (x)

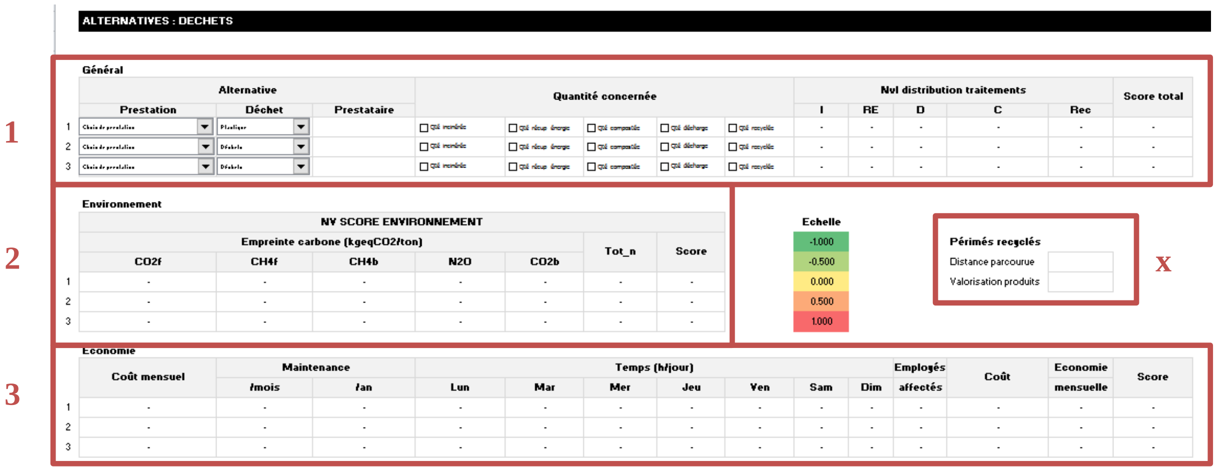


FIGURE 14. Overview of the waste management amelioration section

The energy section is separated in the three sectors of heating, lighting and fridges. Only one option possibility is available to fill at once, as relevantly only one change is likely to be considered at once for each sector, as identified in FIGURE 15 (the heating system (1), the fridges (2) and the lighting system (3)). For each of the sectors, the environmental impact section displays the new consumption, the efficiency of the new system, the new carbon footprint and the new environmental score. The economic section displays the new costs, the profitable year or the new system, the savings made per year and the new economic score.

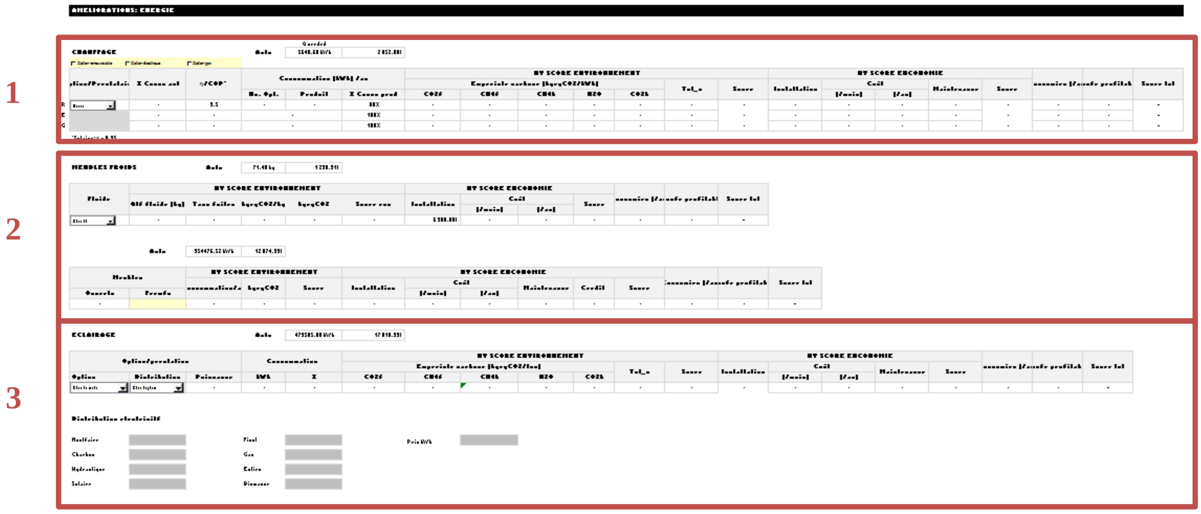


FIGURE 15: Overview of the energy amelioration section.

5.3.4 Score calculation

The calculation process for the environmental or economical score is shown in Formula (2). The total score, balanced between the environmental and economical scores, can be found in Formula (3). The score is situated between 0 and 1, 0 being the best case and 1 the worst.

$$Sc_{current} = \frac{X_{current} - X_{\min}}{X_{\max} - X_{\min}} \tag{2}$$

With:

$Sc_{current}$ the current score

$X_{current}$ the current impact

$X_{\min}$ the minimum impact

$X_{\max}$ the maximum impact

$$X_{tot_{en}} = x_{env} \cdot X_{env} + x_{eco} \cdot X_{eco} \tag{3}$$

With:

$X_{tot_{en}}$ the total score for the sector calculated

x_{env} the proportion of the environmental impact in the sustainability calculations

x_{eco} the proportion of the enconomical impact in the sustainability calculations

X_{env} the environmental score for the energy sector calculated

X_{eco} the economic score for the energy sector calculated

The current, maximum and minimum environmental impacts calculations are obtained by using the formulas listed in TABLE 14. All of those formulas can be found in Appendix 12.

TABLE 14. Formula index for the current, minimum and maximum situation.

Sector	Environment			Economy		
	Current	**Min.**	**Max.**	**Current**	**Min.**	**Max.**
Waste management	(F)	(H)	(I)	(J)	(K)	(L)
Heating system	-	(M)	(N)	-	(Y)	(Z)
Lighting system	-	(O)	(P)	-	(AA)	(AB)
Refrigerant	-	(Q)	(R)	-	(AC)	(AD)
Fridges	-	(S)	(T)	-	(AE)	(AF)

The total waste management score was obtained by adding together all of the total scores of the different waste types, pondered with the proportion of the corresponding waste type amongst the total waste. The total score was 0.696 for the waste management.

The total energy score is calculated by pondering the heating system, cold system and lighting system scores: in total, the score was of 0.600 for the energy consumption, from which: 1.000 for the heating system, 0.000 for the lighting system, 1.000 for the refrigerant and 0.897 for the fridges.

The total score for the water consumption was 0.005.

The total score for the chemical usage is calculated according to Formula (4).
In order to make the calculations for the chemical usage more relevant, the R-phrases were classified from the one that indicates the most hazard to the one indicating the least hazard: R58/R59 is the most hazardous (n°1), R50-53 is n°2, R54/56 is n°3 and R55/57 is the least hazardous (n°4). The score for each product is calculated according to Formula (AI), Appendix 12.

$$Sc_{chem_{tot}} = \frac{\sum Sc_{pr}}{\sum chem} \tag{4}$$

With:

$Sc_{chem_{tot}}$ the total score for the chemical section

$\sum Sc_{pr}$ the sum of the score of each product

$\sum chem$ the total number of products

The total score for the chemicals used was 0.0084.

The total sustainability score can be calculated by pondering the different scores for each sector (waste management, energy, water and chemical products) with their respective importance indexes and dividing the sum of all of the pondered scores by the sum of all of the importance indexes. The formula illustrating this calculation process is shown in Formula (5) below.

The importance indexes were decided as follows : chemical products usage is the least significant (n°1) as it is the sector that brings the smallest impacts, water consumption the n°2 as it is an inevitable feature of the structure of some buildings and therefore demand special measures to be modified, energy consumption the n°3 as it is a large part of the impact of the store and can be monitored and changed according to the results and waste management the n°4, or the most significant as it is the sector that can be influenced the most on a day-to-day basis.

$$Sc_{tot} = \frac{Sc_{wm} * 4 + Sc_{en} * 3 + Sc_{w} * 2 + Sc_{chem} * 1}{1 + 2 + 3 + 4} \tag{5}$$

With:

Sc_{wm} the waste management score

Sc_{en} the energy score

Sc_{w} the water score

Sc_{chem} the chemical score

$1, 2, 3, 4$ the importance indexes of the different scores

The total score was of 0.4605, which places Super U Chatou relatively close to the middle line between perfectly sustainable and not sustainable at all.

The environmental and economic scores for the selected waste type are calculated by normalizing the new impact (environmental or economic) (as shown in formula (2)) with the same minimum and maximum impacts calculated for the current score. The current score of the selected waste type will then be subtracted from this operation. The formula illustrating this calculation is shown in Formula (6). The final indicator will be a number between -1 and 1. The closest the indicator gets close to -1, the best the solution is, and the closest it gets to 1, the worst the solution is. If the indicator shows 0, it means that there is no difference between the current and the new solutions.

$$Sc_{new} = \frac{X_{new} - X_{\min}}{X_{\max} - X_{\min}} - Sc_{current} \tag{6}$$

With:

Sc_{new} the new score

X_{new} the current impact

$X_{\min}$ the maximum impact

$X_{\max}$ the maximum impact

$Sc_{current}$ the current score

6 CONCLUSION

All in all, 75.46 tons of waste are incinerated at the store and 9.60 tons of waste are recycled, costing in total around 22160 € per year and triggering around 126 tCO2eq. The yearly heating needs of the store is of 65524.9 kWh. The electricity consumption is split between the lighting system which costs 24555 € and the cold system which costs 18150 €. The cold system function with 375 kg of R-404A with a leaking responsible for up to 280 tCO2eq emitted and 1291 € of losses. The citywater system triggers a consumption of 86.5 m3 per day of citywater use, which costs 221.80 €. In the store, 21 chemical products are used, gathering 20 R50-53-phrases.

If the most environmentally friendly waste handling solution was used for each of the waste types, 14.8 tCO2eq would be saved per year but an additional cost of around 2400 € per year would be generated. The cheapest alternatives are the currently used ones. The cheapest heating system method is the current – gas heating –, but the most environmentally friendly is a solar system. The current lighting system is already the cheapest and most environmentally friendly possible. The cold system could be 100 % equipped with doors, which would save up to 2827.20 € and 13 tCO2eq. Switching the refrigerant to R-134A would on the long term avoid the emission of 102 tCO2eq.

The tool contains one page for the current waste management situation, one page for the current energy situation, one page for the water consumption currently and one page for the current chemical consumption. The indicator for the current situation is given by a number between 0 and 1, 0 being the best situation and 1 being the worst situation, taking into account the environment and the economy with specifically designed formulas. In addition, it contains one page for the possible waste management ameliorations and one page for the possible energy consumption ameliorations. The amelioration indicator is designed by comparing the current score and the amelioration score. It is between -1 and 1, where -1 is the best situation, 0 the same exact situation as currently and 1 the worst situation. The total current score is 0.4605, from which waste management has a score of 0.696, energy a score of 0.600, water a score of 0.005 and chemicals a score of 0.0084.

REFERENCES

Air sourced heat pumps. N.d. US Department of Energy. Read on 20/06/2017. https://energy.gov/energysaver/air-source-heat-pumps

Annex E – Estimated Solid Waste Management Costs. N.d. Urban development series – knowledge papers. Worldbank. Read on 02/07/2017. http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/AnnexE.pdf

Choisir les meubles frigorifiques. N.d. Energie Plus. Read on 14/07/2017. https://www.energieplus-lesite.be/index.php?id=11654#c3087

Combien coûte un kWh chez EDF en 2015. N.d. Selectra. Read on 22/10/2017. https://www.fournisseurs-electricite.com/actualites/30447-combien-coute-un-kwh-edf-2015

COP (Coefficient of Performance). N.d. Grundfos. Read on 23/06/2017. http://uk.grundfos.com/service-support/encyclopedia-search/cop-coefficient-ofperformance.html

Coût d'une pompe à chaleur. N.d. Consoneo. Read on 26/06/2017. http://energies-renouvelables.consoneo.com/guide/maison-ecologique/cout-une-pompe-chaleur/642/

Densities of common solids. N.d. The Engineering ToolBox. Read on 13/06/2017. http://www.engineeringtoolbox.com/density-solids-d_1265.html

Données climatiques de la station de Paris. N.d. Météo France. Read on 23/06/2017. http://www.meteofrance.com/climat/france/paris/75114001/releves

Eco2Mix database. N.d. RTE France. Read on 22/06/2017. http://www.rte-france.com/fr/eco2mix/.

Electric Heating vs. Gas Heating. N.d. Diffen. Read on 22/06/2016. http://www.diffen.com/difference/Electric_Heating_vs_Gas_Heating

Energy recovery from the combustion of municipal solid waste (MSW). N.d. United States Environmental Protection Agency. Read on 13/06/2017. https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw

Estimez le coût de votre installation d'éclairage. N.d. LIGHT my boutique. Read on 25/07/2017. https://www.light-my-boutique.com/content/53-estimez-le-cout-de-votre-installation

Food Handling and Equipment. N.d. Plastics International. Read on 12/06/2017. http://www.plasticsintl.com/food_compliant_materials.html

Geothermal heat pumps. N.d. US Department of Energy. Read on 20/06/2017. https://energy.gov/energysaver/geothermal-heat-pumps

Glass prices 2017. June 2017. N.d. Let's Recycle. Available at: http://www.letsrecycle.com/prices/glass/glass-prices-2017/. Read on 02/07/2017.

Heat pumps systems. N.d. US Department of Energy. Read on 20/06/2017. https://energy.gov/energysaver/heat-pump-systems

How much does a solar thermal system work. N.d. Renewable Energy hub. Read on 20/06/2017.https://www.renewableenergyhub.co.uk/solar-thermal-information/how-much-does-solar-thermal-cost.html

Industrial gases – R134a. N.d. Linde. Read on 15/07/2017. http://www.linde-gas.com/en/products_and_supply/refrigerants/hfc_refrigerants/r134a/index.html
Industrial gases – R404A. N.d. Linde. Read on 15/07/2017. http://www.linde-gas.com/en/products_and_supply/refrigerants/hfc_refrigerants/r404a/index.html

Industrial gases – R407C. N.d. Linde. Read on 15/07/2017. http://www.linde-gas.com/en/products_and_supply/refrigerants/hfc_refrigerants/r407c/index.html

Industrial gases – R410A. N.d. Linde. Read on 15/07/2017. http://www.linde-gas.com/en/products_and_supply/refrigerants/hfc_refrigerants/r410a/index.html

Information sur l'origine de l'électricité fournie par EDF. N.d. EDF. Read on 22/06/2017. https://www.edf.fr/groupe-edf/information-sur-l-origine-de-l-electricite-fournie-par-edf

Le coût de maintenance d'une pompe à chaleur. N.d. Consoneo. Read on 14/07/2017. http://energies-renouvelables.consoneo.com/guide/maison-ecologique/le-cout-maintenance-une-pompe-chaleur/644/

Le froid alimentaire commercial. December 17, 2014. ADEME. Read on 19/06/2017. http://www.ademe.fr/expertises/batiment/passer-a-laction/elements-dequipement/dossier/usages-professionnels/froid-alimentaire-commercial

Les condenseurs. N.d. Energie Plus. Read on 27/06/2017. https://www.energieplus-lesite.be/index.php?id=11670#c5384+c5385+c11644+c5386+c5387

Les différentes energies d'éclairage. N.d. Collège Jean Racine. Read on 26/06/2017. http://www.clg-racine-st-cyr.ac-versailles.fr/IMG/pdf/R_-_CI1-1_-_differents_types_d_eclairage2.pdf.

Les supermarchés fermeront leurs meubles frigorifiques pour réduire leurs dépenses d'énergie. February 6, 2012. Portail du gouvernement. Read on 25/07/2017. http://archives.gouvernement.fr/fillon_version2/gouvernement/les-supermarches-fermeront-leurs-meubles-frigorifiques-pour-reduire-leurs-depenses-d-en.html#fnref:1

Maintenance du système. January 4, 2017. Photovoltaic Info. Read on 14/07/2017. http://www.photovoltaique.info/Maintenance-du-systeme.html

Plastic film 2017. June 2017. Let's Recycle. Read on 02/07/2017. http://www.letsrecycle.com/prices/plastics/plastic-film/plastic-film-2017/

Prix d'installation d'une pompe à chaleur. N.d. Travaux.com. Read on 22/06/2017. http://www.travaux.com/guide-des-prix/pompe-a-chaleur/prix-installation-pompe-a-chaleur

Prix du kWh des fournisseurs de gaz. N.d. Fournisseurs-gaz.com. Read on 24/07/2017.: https://www.fournisseurs-gaz.com/prix/kwh

Prix d'un kWh d'électricité en France en 2017. N.d. Selectra. Read on 22/06/2017. https://www.fournisseurs-electricite.com/comparatif-electricite/actu-electricite/1082-prix-dun-kwh-delectricite-en-france

Production d'énergie solaire thermique (GWh). N.d. Observatoire de l'énergie et des gaz à effet de serre de Rhône-Alpes. Read on 20/06/2017.http://www.cpeauvergnerhonealpes.org/tooladmin/user_upload/mediatheque/oreges/Publications/Indicateurs/IS7PROD.pdf

R and S phrases. N.d. MSDS Europe. Read on 27/06/2017. http://www.msds-europe.com/id-485-r_s_phrases.html

Risk Management Monitor. N.d. Read on 25/07/2017. www.riskmanagementmonitor.com/wp-content/uploads/2010/06/sustainability.jpg

Solar thermal power plants. November 28, 2016. EIA. Read on 20/06/2017. https://www.eia.gov/energyexplained/?page=solar_thermal_power_plants

Solar thermal vs Photovoltaic. N.d. Solar-thermal.com. Read on 13/07/2017. http://www.solar-thermal.com/solar_vs_pv.html

Strateo Multi. 2014. Bonnet Névé. Read on 20/06/2017. http://catalogue.bonnetneve.com/ExportWeb/052589_280342_1441734161_2916_2845_1_not_logged.pdf

SkyLight. October 2016. Bonnet Névé. Read on 20/06/2017. http://catalogue.bonnetneve.com/ExportWeb/392261_392341_CH1_BONNET_SAA_SkyLight_Rev.pdf

Valea Multi. 2014. Bonnet Névé. Read on 20/06/2017. http://catalogue.bonnetneve.com/ExportWeb/052609_280304_1441731322_2909_2838_1_not_logged.pdf

Waste paper. June 2017. Let's Recycle. Read on 02/07/2017.http://www.letsrecycle.com/prices/waste-paper/

What is sustainability?. N.d. EPA. Read on 25/07/2017. https://www.epa.gov/sustainability/learn-about-sustainability#what

APPENDICES

Appendix 1. Accounting year 2015-2016 waste management cost

Time period	Waste volume (m3)	Treatment cost (duty free) (€)	Renting	
			Number of containers	Cost (€)
oct-15	112	1 729.28 €	5	58.00 €
nov-15	137	2 115.28 €	7	81.20 €
dec-15	138	2 130.78 €	7	81.20 €
jan-16	110	1 698.40 €	7	81.20 €
feb-16	123	1 899.12 €	7	81.20 €
mar-16	116	1 791.04 €	7	81.20 €
apr-16	104	1 605.76 €	7	81.20 €
may-16	108	1 667.32 €	7	81.20 €
jun-16	121	1 868.24 €	7	81.20 €
jul-16	122	1 883.68 €	7	81.20 €
aug-16	102	1 574.88 €	7	81.20 €
Total	1293	19 963.78 €	75	870.00 €
Total/year	**1410.55**	**21 778.67 €**	**81.82**	**949.09 €**

Appendix 2. Amount of plastic recycled at the store yearly

Year	**Date**	**Quantity**	**Net Weight (kg)**
2017	15.04.2017	1	281
2017	27.03.2017	1	315
2017	06.03.2017	1	254
2017	09.02.2017	1	285
2017	25.01.2017	1	275
2017	02.01.2017	1	300

The average bale weight is 285 kg, which rounds up to 428 kg of plastic recycled per month.

Appendix 3. Amount of recycled cardboard at the store yearly

Year	Date	Quantity	Bale weight (kg)
2017	02.05.2017	2	816
2017	28.04.2017	3	1236
2017	24.04.2017	2	899
2017	20.04.2017	4	1656
2017	15.04.2017	2	742
2017	13.04.2017	2	796
2017	10.04.2017	2	967
2017	06.04.2017	2	958
2017	03.04.2017	2	764
2017	30.03.2017	3	1263
2017	27.03.2017	2	890
2017	23.03.2017	3	1238
2017	20.03.2017	3	1248
2017	16.03.2017	2	899
2017	13.03.2017	3	1309
2017	09.03.2017	3	1292
2017	06.03.2017	3	1336
2017	02.03.2017	2	851
2017	27.02.2017	2	504
2017	23.02.2017	3	1245
2017	20.02.2017	2	927
2017	16.02.2017	3	1288
2017	13.02.2017	2	932
2017	09.02.2017	2	818
2017	06.02.2017	3	1337
2017	02.02.2017	2	913
2017	30.01.2017	1	352
2017	26.01.2017	4	1562
2017	25.01.2017	2	740
2017	19.01.2017	2	848
2017	16.01.2017	2	888
2017	13.01.2017	3	1173
2017	11.01.2017	3	1258
2017	02.01.2017	2	919

The average weight of one bale during that time period was 420 kg, therefore the total average amount of cardboard recycled is of 8716 kg.

Appendix 4. Details of the natural gas cost and consumption for the heating system of Super U Chatou over the year 2016.

Time period	**Routing cost**	**Consumption (kWh)**	**Cost (HT)**	**Tax fee**	**Counter reading cost**
January	154.70 €	13356	301.44 €	57.97 €	
February	67.10 €	3390	76.51 €	14.71 €	27.46 €
March	135.82 €	11208	252.96 €	48.64 €	
April	76.77 €	4917	110.98 €	21.34 €	
May	52.21 €	2123	47.92 €	9.21 €	
June	43.87 €	1174	26.50 €	5.10 €	
July	40.66 €	763	17.22 €	3.31 €	
August	191.05 €	17289	390.21 €	75.03 €	
Total yearly average	**1 143.27 €**	**81330**	**1 835.61 €**	**352.97 €**	**27.46 €**

Appendix 5. Electricity consumption

TABLE C1. Electricity consumption and cost for the period of April to August 2016.

Time period	Consumption						Maintenance	Cost tax free (€)
	Peak hour (kWh)	€/kWh	€	Off-peak hours (kWh)	€/kWh	€		
April	42185	0.03934	1659.6	23511	0.02465	579.5	1130.76	2239.1
May	41514	0.03934	1633.2	23914	0.02465	589.5	1137.9	2222.6
June	45467	0.03934	1788.8	23829	0.02465	587.4	1176.52	2376.1
July	45191	0.03934	1777.8	27169	0.02465	669.7	1220.07	2447.5
August	48356	0.03934	1902.3	26390	0.02465	650.5	1262.43	2552.8
Total/year	**534511.2**	**0.03934**	**21027.7**	**299551.2**	**0.02465**	**7383.9**	**14226.43**	**28411.6**

TABLE C2. Distribution of peak and off-peak hours and price per kWh in 2016 for the period April to August 2016.

Time period	Peak hour (kWh)	Off-peak hours (kWh)	€/kWh tax free	€/kWh with taxes
April	64.2%	35.8%	0.03408	0.04703
May	63.4%	36.6%	0.03397	0.04688
June	65.6%	34.4%	0.03429	0.04732
July	62.5%	37.5%	0.03382	0.04668
August	64.7%	35.3%	0.03415	0.04713
Total/year	**64.1%**	**35.9%**	**0.03406**	**0.04701**

Appendix 6. Calculation of the carbon footprint associated with the combustion with energy recovery for the different types of waste (1)

According to the United States Environmental Protection Agency in their information page about Energy recovery from the combustion of municipal solid waste, a typical waste-to-energy plant generates on average 550 kWh of energy per ton of waste.[1]

In order to calculate what this value would be for each type of waste, the calorific value of the different type were used: as mentioned in TABLE A1, to produce those 550 kWh of energy, the calorific value of mixed waste is of 4500 kcal/kg. The calorific value of plastic is 10990 kcal/kg, this of cardboard is 3800 kcal/kg and this of paper is 4400 kcal/kg.[1]

The calorific value of glass is 60 btu/lb of dry weight[2], which amounts to 24.25 kcal/kg after converting the btu to kWh with the formula (2)[3] then to kcal with the formula (1) and the lbs to kgs with the formula (3)[4].

---

1 Energy information and data. N.d. Pyromex Waste to Energy. Read on 13/06/2017.http://www.sludgefacts.org/Ref87_2.pdf

2 Reinhart. July 2004. Estimation of Energy Content of Municipal Solid Waste. University of Central Florida. Read on 13/06/2017.http://www.msw.cecs.ucf.edu/EnergyProblem.pdf

3 BTU to KWh conversion. N.d. RapidTables. Read on 13/06/2017. http://rapidtables.com/convert/energy/BTU_to_kWh.htm

4 Convert lbs to kg – Conversion of Measurement Units. N.d. ConvertUnits. Read on 13/06/2017. http://www.convertunits.com/from/lbs/to/kg

Appendix 6. Calculation of the carbon footprint associated with the combustion with energy recovery for the different types of waste (2)

$$kcal = \frac{kWh.kg^{-1} \cdot 1000}{1.6} \tag{1}$$

$$E_{kWh} = 0.00029307107017 \cdot E_{BTU} \tag{2}$$

$$m_{kg} = 0.45359237 \cdot m_{lb} \tag{3}$$

With:

$kcal$ the energy in kcal

$kWh.kg^{-1}$ the energy in kWh/kg

$\frac{1000}{1.6}$ the conversion factor from kWh/kg to kcal

$E_{kWh}$the energy in kWh

E_{BTU} the energy in BTU

0.00029307107017 the conversion factor from BTU to kWh

m_{kg} the mass in kg

m_{lb} the mass in lb

0.45359237 the conversion factor from kg to lb

The calorific value of tallow is 9020 kcal[5].

The power generated for each type of waste was then calculated with formula (4) as compared with the reference mixed waste value. From those energy values were calculated the equivalent carbon footprints for the different types of waste. As the energy produced in a waste to energy plant is converted into electricity or district heating, the equivalent carbon footprint values were calculated for an equivalent electricity amount.

[5] Basic Report: 04001, Fat, beef tallow. National Nutrient Database for Standard Reference Release 28. N.d. Agricultural Research Service. United States Department of Agriculture. Read on 13/06/2017. https://ndb.nal.usda.gov/ndb/foods/show/634?manu=&fgcd=&ds=

Appendix 6. Calculation of the carbon footprint associated with the combustion with energy recovery for the different types of waste (3)

TABLE A1. Calorific value and kWh produced per ton of waste for each waste type, compared to the reference value for mixed waste.

Waste type	Calorific value (kcal/kg)	kWh produced/ton	kgCO2eq saved
Mixed waste (reference)	4500	550	27.12
Plastic	10990	1343.2	66.22
Glass	24.25	2.964	0.15
Tallow	9020	1102.4	54.35
Cardboard	3800	464.4	22.89
Paper	4400	537.8	26.51

$$kWh\ produced/ton_{waste\ type} = \frac{n_{waste\ type} \cdot 550}{4500} \quad (4)$$

With:

$kWh\ produced/ton_{waste\ type}$ the energy produced per ton of waste (kWh/ton)

$n_{waste\ type}$ the amount of waste (ton)

550 the amount of kWh produced per ton of waste (kWh/ton)

4500 the calorific value per ton of waste (kcal/kg)

The final carbon footprint was obtained by subtracting the emissions avoided by the energy production from the incineration without energy recovery values. The values per waste type can be found in TABLE A2.

TABLE A2. Carbon footprint per waste type treated by incineration with energy recovery.

Waste type	Carbon foot-print (kqCO2eq/ton)
Plastic, polystyrene	2614.38
Cardboard	1413.71
CtD	778.49
Tallows(4)	652.35
Paper	1410.09
Glass	46.45
OM	778.49

Appendix 7. Calculation of the carbon footprint of the recycling process of different types of waste. (1)

1. Plastic (incl. polystyrene)

Using 100% recycled material for a product reduces its carbon footprint of 24%[6]. As the ADEME Database shows an environmental impact of 2680.6 kgCO2eq for plastic incineration, it can be estimated that the final carbon footprint of recycling plastic is 2037.1 kgCO2eq.

2. Cardboard and paper (incl. office and catalogue paper)

As recycling paper or cardboard involves re-separating the fibers into pulp to create new sheets – steps which belong to the manufacturing process of recycled paper –, the only environmental impact to take into account for the disposal process of recycling paper is this of collection. Therefore, recycling cardboard or paper is responsible for 18 kgCO2eq (TABLE B1).

TABLE B1. Paper and cardboard incineration environmental impact, detailed (ADEME database, n.d.)

	CO2f	CH4f	CH4b	N2O	CO2b
Collection	18	0	0	0	0
Treatment	18	0	0	0	0
Incineration fumes	0	0	0	10.6	1390
Total	36	0	0	10.6	1390

3. Tallows

Tallows can be recycled in several ways, amongst which the two most common are melting into edible fats and recycling into biofuels. In order to approximate the recycling environmental impact, the average of those two methods' environmental impacts will be used.

---

[6] Science for Environmental Policy. June 6, 2013. European Commission. Read on 19/06/2017. http://ec.europa.eu/environment/integration/research/newsalert/pdf/331na5_en.pdf

Appendix 7. Calculation of the carbon footprint of the recycling process of different types of waste. (2)

Recycling by melting into edible fats

The energy consumption is 8.14 MW from the melting container and 265 kW comes from the melting process. The melting rate is limited at 60 tons per day, which amounts to one ton for 0.4 hours.[7] The total energy consumed by the process is then 8,405 MW which, for 1 ton, corresponds to 3.362 MWh. This consumption amounts to a total carbon footprint of 198.67 kgCO2eq (including the collection, 18 kgCO2eq).

Recycling by transforming into biofuels

In the process of transformation of tallow into biofuels, the impact only to take into account is the transportation impact, as the rest belongs to the impact of biofuel manufacturing. On average, the plant where the recycling process happens is situated at 350 km of the collection point, which amounts to a total of 161.5 kgCO2eq. The values used to calculate this carbon footprint are obtained by multiplying the distance between the collection point and the recycling plant with the environmental impact triggered by a 12 tons transportation truck (0.461 kgCO2eq per ton of waste per kilometer traveled through)[8].

Final carbon footprint

The final carbon footprint of the recycling process of tallow is calculated from the average of the two different processes. Therefore, the final carbon footprint taken into account for the recycling of tallow is 180.04 kgCO2eq.

---

[7] Thirard, G. March 24, 2014. Arrêté préfectoral imposant à la S.A.R.L. FONDOIR DE SUIFS BUCHEZ des prescriptions complémentaires modifiant l'arrêté préfectoral d'autorisation du 22 juillet 2009 pour la poursuite d'exploitation de son établissement situé à ESTAIRES. Secrétariat general de la prefecture du Nord, direction des politiques publiques, bureau des installations classes pour la protection de l'environnement. Read on 19/06/2017. http://www.nord.gouv.fr/content/download/17384/106737/tool/SARL%20FONDOIR%20DE%20SUIFS%20BUCHEZ%20-%20ESTAIRES.pdf

[8] ADEME Database, n.d.

Appendix 7. Calculation of the carbon footprint of the recycling process of different types of waste. (3)

4. Glass

In the case of glass, recycling 10% decreases the carbon footprint from 5%.[9] TABLE B2 shows the value for different ratios of recycled versus non recycled plastic and the corresponding carbon footprint. As incinerating one ton of glass is triggering 36 kgCO2eq, in recycling one ton of glass 21.6 kgCO2eq is emitted.

TABLE B2. Emissions for different ratios of recycled versus non recycled plastic for one ton of final waste

Recycled (ton)	**Not recycled (ton)**	**Emissions (kgCO2eq)**
0	1	36
0,1	0,9	34,2
0,2	0,8	32,5
0,3	0,7	30,9
0,4	0,6	29,3
0,5	0,5	27,9
0,6	0,4	26,5
0,7	0,3	25,1
0,8	0,2	23,9
0,9	0,1	22,7
1	0	21,6

[9] Carbon footprint. N.d. O-I New Zealand. Read on 19/06/2017. http://recycleglass.co.nz/glass-lifecycle/carbon-footprint/

Appendix 8. Amount of close-to-date products donated at the store yearly

Date	Value (€)	Weight (kg)
13-déc	406.83 €	108.9
08-déc	261.82 €	80.0
06-déc	286.05 €	91.5
01-déc	462.11 €	162.7
22-nov	472.43 €	91.0
18-nov	208.82 €	81.0
15-nov	126.75 €	53.8
08-nov	215.19 €	52.1
03-nov	300.94 €	117.7
27-oct	312.74 €	88.2
25-oct	354.37 €	127.9
20-oct	505.67 €	139.6
18-oct	166.05 €	52.5
13-oct	196.30 €	56.9
Total	**4 276.07 €**	**1303.8**
Total/month	**1 425.36 €**	**434.6**

The average amount of donations per month is of 0.43 tons of products, which is equivalent to around 1425€ worth of products. It can be estimated that Easter increases the donations of 30%, and Christmas and New Year of 50%. Therefore, the yearly average can be estimated to be around 5.8 tons, which is equivalent to 19000€-worth yearly donations.

The value per ton, based on those values, can be averaged by dividing the total product value per month by the total waste weight per month in tons. It amounts to around 3280 € per ton per year.

Appendix 9. Meteorological data of the Paris weather station (1)

Mois	**2012**		**2013**	
	Min (°C)	**Max (°C)**	**Min (°C)**	**Max (°C)**
January	4.9	9.4	2.4	5.9
February	0.1	5.8	1.3	6
March	7.3	15.7	3	8.7
April	6.4	14.2	6.9	15.4
May	11.7	20.8	9.1	16.7
June	13.6	21.8	13.1	21.9
July	15.1	24	17.5	28.3
August	16.2	27.2	15.8	25.7
September	12.3	21.2	13.6	21.5
October	10.1	16	11.7	17.8
November	6	10.3	5.7	10
December	4.6	9.1	4.1	9.4

Month	**2014**		**2015**		**2016**	
	Min (°C)	**Max (°C)**	**Min (°C)**	**Max (°C)**	**Min (°C)**	**Max (°C)**
January	5.3	9.7	2.9	7.8	4	8.5
February	5.1	10.8	2.3	7.6	4.2	9.6
March	6.2	15.4	5.4	12.9	4.5	10.8
April	9.1	17.9	8.5	18.3	6.9	15
May	10.5	19.2	10.7	19.6	11.3	19.6
June	14.1	23.4	14.1	25.2	14.7	21.9
July	16.5	25.4	17.1	27.4	16.6	25.8
August	14.4	22.7	16.6	26.9	16.5	27.1
September	14.3	23.7	11.7	19.6	15.2	23.9
October	11.9	18.6	9.1	15.5	8.8	15.8
November	8.2	13	9	14	6.2	10.7
December	4.4	7.9	7.7	12.3	2.8	8

Appendix 9. Meteorological data of the Paris weather station (2)

Month	**Normalized values**		**Average values**		
	Min (°C)	**Max (°C)**	**Min (°C)**	**Max (°C)**	**Average (°C)**
January	2.7	7.2	3.70	8.08	5.89
February	2.8	8.3	2.63	8.02	5.33
March	5.3	12.2	5.28	12.62	8.95
April	7.3	15.6	7.52	16.07	11.79
May	10.9	19.6	10.70	19.25	14.98
June	13.8	22.7	13.90	22.82	18.36
July	15.8	25.2	16.43	26.02	21.23
August	15.7	25	15.87	25.77	20.82
September	12.7	21.1	13.30	21.83	17.57
October	9.6	16.3	10.20	16.67	13.43
November	5.8	10.8	6.82	11.47	9.14
December	3.4	7.5	4.50	9.03	6.77

Appendix 10. Detailed list of the fridges of the store in 2017 (1)

1. Positive temperatures

Intern number	**Amount**	**Dimensions (cm) (height*length)**	**Use**
05	2	200*250	Cheese
	1	200*375	Cheese
06	1	200*156	Creamery
07	2	200*250	Ultra fresh
	1	200*375	Ultra fresh
08	2	200*250	Ultra fresh
	1	200*375	Ultra fresh
09	1	200*188	Delicatessen
10	1	200*375	Delicatessen
11	2	150*250	Cheese
12	1	200*375	Fats
13	2	200*250	Delicatessen
14	1	200*375	Delicatessen
15	1	200*250	Fresh pasta
16	2	200*375	Prepared meals
17	1	200*250	Fresh juices
18	1	200*125	Meat
	1	200*188	Meat
	1	200*250	Meat
19	2	200*250	Meat
	1	200*188	Meat
20	2	150*313	Prepared meals
	1	150*167	Prepared meals
21	2	150*375	Meat
22	1	225*250	Packaged vegeta-bles
23	1	200*250	Fresh pastries

Appendix 10. Detailed list of the fridges of the store in 2017 (2)

Intern number	Amount	Dimensions (cm) (height*length)	Use
24	1	200*250	Fish products
24A	1	200*250	Fish products
25	1	150*250	Packaged fish products
26	2	200*250	Ready-made

2. Negative temperatures

Intern number	Number	Dimensions (number of doors – height*length (cm))
01	3	4 – 200*313
02	1	3 – 200*234
03	1	3 – 200*234
	1	4 – 200*313

Appendix 11. Chemicals and their R-phrases (1)

Nom	Nb substances	R50-53	R54/56	R55/57	R58/59	Score
X SPRAY_ANIOS PRO[10]	3	1	0	0	0	0.008
SAVON ANTISEPTIQUE "SPEED SOFT"[11]	4	2	0	0	0	0.012
LAVAGE VM 2_ANIOS PRO[12]	2	1	0	0	0	0.033
ALCANIOS AUTO-LAVEUSE[13]	3	0	0	0	0	0.000
X-SRAY AGRUME[14]	4	1	0	0	0	0.003
NETTOYANT STATION SERVICE[15]	5	2	0	0	0	0.005
ECOLOGICAL LINE PRO DN[16]	4	3	0	0	0	0.026
SPRAY DESINFECTANT ALIMENTAIRE WR52[17]	1	0	0	0	0	0.000

[10] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – X Spray_Anios pro – 1365000. December 8, 2015. Laboratoires Anios. Read on 27/06/2017.

[11] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Savon antiseptique \”Speed Soft”\ – 1359000. January 29, 2015. Laboratoires Anios. Read on 27/06/2017.

[12] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Lavage VM 2_Anios Pro – 1252000. March 12, 2015. Laboratoires Anios. Read on 27/06/2017.

[13] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Alcanios auto-laveuse – 766000. December 8, 2015. Laboratoires Anios. Read on 27/06/2017.

[14] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – X-spray agrumes – 2327000. January 20, 2015. Laboratoires Anios. Read on 27/06/2017.

[15] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Nettoyant station service – 885000. May 11, 2015. Laboratoires Anios. Read on 27/06/2017.

[16] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Ecological line pro DN – 2225000. February 10, 2015. Laboratoires Anios. Read on 27/06/2017.

[17] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Spray desinfectant alimentaire WR52 – 2723000. February 8, 2015. Laboratoires Anios. Read on 27/06/2017.

Appendix 11. Chemicals and their R-phrases (2)

Nom	Nb substances	R50-53	R54/56	R55/57	R58/59	Score
SPRAY DESINFECTANT ALIMENTAIRE SR[18]	2	0	0	0	0	0.000
GEL NETTOYANT GRAISSES CUITES[19]	2	1	0	0	0	0.033
NETTOYANT DESINFECTANT INOX_ANIOS PRO[20]	4	1	0	0	0	0.003
LINGETTES ALIMENTAIRES WR52[21]	1	0	0	0	0	0.000
PRODUIT VITRES[22]	2	0	0	0	0	0.000
NETTOYANT DESINFECTANT INOX PREMIUM[23]	5	3	0	0	0	0.012
LINGETTES DESINFECTANTES[24]	2	0	0	0	0	0.000
RINCAGE VM_ANIOS PRO[25]	5	0	0	0	0	0.000

[18] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Spray désinfectant alimentaire SR – 1611000. January 29, 2015. Laboratoires Anios. Read on 27/06/2017.

[19] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Ecological line dégraissant graisses cuites – 1801000. February 6, 2015. Laboratoires Anios. Read on 27/06/2017.

[20] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Nettoyant désinfectant inox premium – 2764000. September 2, 2015. Laboratoires Anios. Read on 27/06/2017.

[21] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Lingettes alimentaires WR52 – 2772000. June 22, 2016. Laboratoires Anios. Read on 27/06/2017.

[22] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Produit vitres – 833000. December 2, 2014. Laboratoires Anios. Read on 27/06/2017.

[23] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Nettoyant pour Inox_Anios Pro – 835000. January 29, 2015. Laboratoires Anios. Read on 27/06/2017.

[24] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Lingettes désinfectantes – 1141000. January 29, 2015. Laboratoires Anios. Read on 27/06/2017.

[25] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Rinçage VM_Anios pro – 1959000. April 29, 2015. Laboratoires Anios. Read on 27/06/2017.

Appendix 11. Chemicals and their R-phrases (3)

Nom	Nb substances	R50-53	R54/56	R55/57	R58/59	Score
ANIOS PRO DETERGENT DESINFECTANT ACIDE[26]	5	2	0	0	0	0.005
LAVE VERRE LIQUIDE_ANIOS PRO[27]	1	0	0	0	0	0.000
DETARTRANT MACHINE_GAMME ANIOS PRO[28]	3	0	0	0	0	0.000
ANIOS PCD MAXI[29]	6	2	0	0	0	0.003
SPEED SOFT PREMIUM_ANIOS PRO[30]	2	1	0	0	0	0.033

[26] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Anios Pro detergent désinfectant acide (DDA) – 8000. December 19, 2014. Laboratoires Anios. Read on 27/06/2017.

[27] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Lavage VM 2_Anios Pro – 1252000. March 12, 2015. Laboratoires Anios. Read on 27/06/2017.

[28] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Detartrant machine_Gamme Anios Pro – 1924000. January 20, 2015. Laboratoires Anios. Read on 27/06/2017.

[29] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Anios PCD Maxi –1799000. April 23, 2015. Laboratoires Anios. Read on 27/06/2017.

[30] Fiche de données de sécurité (Règlement (CE) n° 1907/2006 – REACH) – Speed soft premium_Anios Pro – 2199000. May 7, 2015. Laboratoires Anios. Read on 27/06/2017.

Appendix 12. Formula sheet (1)

Inside temperature if no heating was applied

$$T_{int_{\bar{Q}}} = T_{int_{\overline{MFV}}} + p_{o_i} * T_{avg_m} \quad \text{(A)}$$

$$p_{o_i} = \frac{\left(\frac{t_o}{AH}\right)_{mon-sat} * 6 + \left(\frac{t_o}{AH}\right)_{sun}}{7}, \qquad with: t_o = \frac{OH}{\mu_o} * t_{avg_o} \quad \text{(B)}$$

With:

$T_{int_{\bar{Q}}}$ the inside temperature if no heating was applied (°C)

$T_{int_{\overline{MFV}}}$ the average temperature of the store without outdoors influence (°C)

p_{o_i} the proportion of the activity hours for which the outside temperature influences the inside temperature

T_{avg_m} the average outside temperature per month m (°C)

t_o the time period during which the outside temperature influences the inside temperature (h)

AH the activity hours of the store (h)

OH the opening hours (h)

μ_o the frequency of opening of the entrance door (h)

t_{avg_o} the average time period of one opening of the entrance door (h)

Total percentage of one treatment

$$p_{tr_{tot}} = \frac{\sum_{waste\ type\ 1}^{waste\ type\ j} p_{j_{tr}} * n_{j_{tot}}}{n_{tot}} \quad \text{(C)}$$

With:

$p_{tr_{tot}}$ the total percentage of one treatment

$p_{j_{tr}}$ the treatment percentage of the waste type j

$n_{j_{tot}}$ the total amount of the waste type j (ton)

n_{tot} the total amount of waste (ton)

$1 < j \leq 9$

Appendix 12. Formula sheet (2)

The amount of recycled waste (ton)

$$n_{nr_{tot}} = \left(p_i + p_{re} + p_c + p_{lf}\right) * n_{tot} \qquad \text{(D)}$$

$$n_{r_{tot}} = p_{rec} * n_{tot} \qquad \text{(E)}$$

With:

$n_{r_{tot}}$ the amount of recycled waste (ton)

n_{tot} the total amount of waste (ton)

$n_{nr_{tot}}$ the amount of non-recycled waste (ton)

p_i the proportion of incinerated waste

p_{re} the proportion of combusted waste with energy recovery

p_c the proportion of composted waste

p_{lf} the proportion of landfilled waste

p_{rec} the proportion of recycled waste

The total carbon footprint of the waste type j per GHG

$$EI_{j_{GHG_{tot}}} = \sum_{treatment\ 1}^{treatment\ t} EI_t * p_t \qquad \text{(F)}$$

With:

$EI_{j_{GHG_{tot}}}$ the total carbon footprint of the waste type j per GHG (kgCO2eq)

EI_t the carbon footprint of the treatment t (kgCO2eq)

p_t the proportion of waste treated by the treatment t

$1 < t \leq 5$

The total cost per year

$$€_{tot} = €_{t,\ month} \cdot 12 + €_{m,\ year} + \frac{\sum_{Mon}^{Sun} t_{day} \cdot\ 365.25}{7} \cdot n_{ea} - €_p \qquad \text{(G)}$$

With:

$€_{tot}$ the total cost per year (€)

$€_{t,\ month}$ the monthly treatment cost (€)

$€_{m,\ year}$ the yearly maintenance cost (€)

$\sum_{Mon}^{Sun} t_{day}$ the sum of the total time taken per employee per week while contributing to the treatment (h)

n_{ea} the number of employees involved in the treatment calculated

$€_p$ the possible profit returned (€)

Appendix 12. Formula sheet (3)

The minimum and maximum environmental situations regarding waste management

$$X_{\text{min\_env}} = \min\left((EI)_{inc}; (EI)_{recen}; (EI)_{comp}; (EI)_{lf}; (EI)_{rec}\right) \cdot n_{tot} \quad \text{(H)}$$

$$X_{\text{max\_env}} = \max\left((EI)_{inc}; (EI)_{recen}; (EI)_{comp}; (EI)_{lf}; (EI)_{rec}\right) \cdot n_{tot} \quad \text{(I)}$$

With:

$(EI)_{inc}$ the environmental impact of the incineration treatment (kgCO2eq)

$(EI)_{recen}$ the environmental impact of the combustion with energy recovery treatment (kgCO2eq)

$(EI)_{comp}$ the environmental impact of the composting treatment (kgCO2eq)

$(EI)_{lf}$ the environmental impact of the landfilling treatment (kgCO2eq)

$(EI)_{rec}$ the environmental impact of the recycling treatment (kgCO2eq)

n_{tot} the total amount of waste for one waste type (ton)

The current economic situation of waste management

$$X_{current_{eco}} = \%waste \cdot \left(\%Inc \cdot €_{tot_{inc}} + \%RecEn \cdot €_{tot_{recen}} + \%Comp \cdot €_{rec_{comp}} + \%lf \cdot €_{tot_{lf}} + \%rec \cdot €_{tot_{rec}}\right) \quad \text{(J)}$$

With:

$\%waste$ the proportion of waste

$\%Inc$ the percentage of waste incinerated

$\%RecEn$ the percentage of waste combusted with energy recovery

$\%Comp$ the percentage of waste composted

$\%lf$ the percentage of waste landfilled

$\%rec$ the percentage of waste recycled

$€_{tot_{inc}}$ the total current cost of the incineration treatment (€), see formula (G)

$€_{tot_{recen}}$ the total current cost of the combustion with energy recovery treatment (€), see formula (G)

$€_{tot_{comp}}$ the total current cost of the composting treatment (€), see formula (G)

$€_{tot_{lf}}$ the total current cost of the landfilling treatment (€), see formula (G)

$€_{tot_{rec}}$ the total current cost of the recycling treatment (€), see formula (G)

Appendix 12. Formula sheet (5)

The minimum and maximum economic situation of waste management

$$X_{\min\_eco} = \min\Bigg(€_{avg_{inc}} + €_{m_{inc},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{inc}} \cdot 365.25}{7} \cdot n_{ea_{inc}} - €_{p_{inc}};\ €_{avg_{recen}} + €_{m_{recen},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{recen}} \cdot 365.25}{7} \cdot n_{ea_{recen}} - €_{p_{recen}};\ €_{avg_{comp}} + €_{m_{comp},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{comp}} \cdot 365.25}{7} \cdot n_{ea_{comp}} - €_{p_{comp}};\ €_{avg_{lf}} + €_{m_{lf},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{lf}} \cdot 365.25}{7} \cdot n_{ea_{lf}} - €_{p_{lf}};\ €_{avg_{rec}} + €_{m_{rec},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{rec}} \cdot 365.25}{7} \cdot n_{ea_{rec}} - €_{p_{rec}} \Bigg) \quad (K)$$

$$X_{\max\_eco} = \max\Bigg(€_{avg_{inc}} + €_{m_{inc},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{inc}} \cdot 365.25}{7} \cdot n_{ea_{inc}} - €_{p_{inc}};\ €_{avg_{recen}} + €_{m_{recen},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{recen}} \cdot 365.25}{7} \cdot n_{ea_{recen}} - €_{p_{recen}};\ €_{avg_{comp}} + €_{m_{comp},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{comp}} \cdot 365.25}{7} \cdot n_{ea_{comp}} - €_{p_{comp}};\ €_{avg_{lf}} + €_{m_{lf},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{lf}} \cdot 365.25}{7} \cdot n_{ea_{lf}} - €_{p_{lf}};\ €_{avg_{rec}} + €_{m_{rec},\ year} + \frac{\sum_{Mon}^{Sun} t_{day_{rec}} \cdot 365.25}{7} \cdot n_{ea_{rec}} - €_{p_{rec}} \Bigg) \quad (L)$$

With:

$€_{avg_{inc}}$ the average yearly cost of an incineration treatment (€)

$€_{avg_{recen}}$ the average yearly cost of a combustion with energy recovery treatment (€)

$€_{avg_{comp}}$ the average yearly cost of a composting treatment (€)

$€_{avg_{lf}}$ the average yearly cost of a landfilling treatment (€)

$€_{avg_{rec}}$ the average yearly cost of a recycling treatment (€)

$€_{m_{inc},\ year}$ the yearly maintenance cost of an incineration treatment (€)

$€_{m_{recen},\ year}$ the yearly maintenance cost of a combustion with energy recovery treatment (€)

$€_{m_{comp},\ year}$ the yearly maintenance cost of a composting treatment (€)

$€_{m_{lf},\ year}$ the yearly maintenance cost of a landfilling treatment (€)

$€_{m_{rec},\ year}$ the yearly maintenance cost of a recycling treatment (€)

$n_{ea_{inc}}$ the number of employees affiliated with an incineration treatment (ton)

$n_{ea_{recen}}$ the number of employees affiliated with a combustion with energy recovery treatment (ton)

$n_{ea_{comp}}$ the number of employees affiliated with a composting treatment (ton)

$n_{ea_{lf}}$ the number of employees affiliated with a landfilling treatment (ton)

Appendix 12. Formula sheet (6)

$n_{ea_{rec}}$ the number of employees affiliated with a recycling treatment (ton)

$\sum_{Mon}^{Sun} t_{day_{inc}}$ the total number of hours spent per employee per week for an incineration treatment (h)

$\sum_{Mon}^{Sun} t_{day_{recen}}$ the total number of hours spent per employee per week for a combustion with energy recovery treatment (h)

$\sum_{Mon}^{Sun} t_{day_{comp}}$ the total number of hours spent per employee per week for a composting treatment (h)

$\sum_{Mon}^{Sun} t_{day_{lf}}$ the total number of hours spent per employee per week for a landfilling treatment (h)

$\sum_{Mon}^{Sun} t_{day_{rec}}$ the total number of hours spent per employee per week for a recycling treatment (h)

$€_{p_{inc}}$ the possible profit returned in the case of an incineration treatment (€)

$€_{p_{recen}}$ the possible profit returned in the case of a combustion with energy recovery treatment (€)

$€_{p_{comp}}$ the possible profit returned in the case of a composting treatment (€)

$€_{p_{lf}}$ the possible profit returned in the case of a landfilling treatment (€)

$€_{p_{rec}}$ the possible profit returned in the case of a recycling treatment (€)

The minimum and maximum environmental impacts possible regarding the heating system

$$X_{min_Q} = C_{p_Q} * \min(EI_G; EI_{\theta P}; EI_{GP}; EI_{\varphi};\ EI_e) \tag{M}$$

$$X_{max_Q} = C_{p_Q} * \max(EI_G; EI_{\theta P}; EI_{GP}; EI_{\varphi};\ EI_e) \tag{N}$$

With:

X_{min_Q} the minimum environmental impact possible regarding the heating system (kgCO2eq)

X_{max_Q} the maximum environmental impact possible regarding the heating system (kgCO2eq)

C_{p_Q} the yearly energy consumption for heating (kWh)

EI_G the environmental impact per kWh of gas heating (kgCO2eq/kWh)

$EI_{\theta P}$ the environmental impact per kWh of a heat pump (kgCO2eq/kWh)

EI_{GP} the environmental impact per kWh of a geothermal heat pump (kgCO2eq/kWh)

EI_{φ} the environmental impact per kWh of a solar heating system (kgCO2eq/kWh)

EI_e the environmental impact per kWh of electric heating (kgCO2eq/kWh)

Appendix 12. Formula sheet (7)

The minimum and maximum environmental impacts possible regarding the lighting system

$$X_{min_\gamma} = EIn_{current_\gamma} \cdot \frac{\min(\eta_\gamma)}{\eta_{\gamma current}} \quad \text{(O)}$$

$$X_{max_\gamma} = EIn_{current_\gamma} \cdot \frac{\max(\eta_\gamma)}{\eta_{\gamma current}} \quad \text{(P)}$$

With:

X_{min_γ} the minimum environmental impact possible regarding the lighting system (kgCO2eq)

X_{max_γ} the maximum environmental impact possible regarding the lighting system (kgCO2eq)

$\min(\eta_\gamma)$ the minimum lighting system efficiency (W)

$\max(\eta_\gamma)$ the minimum lighting system efficiency (W)

$\eta_{\gamma current}$ the current lighting system efficiency (W)

$EIn_{current_\gamma}$ the current carbon footprint (kgCO2eq).

The minimum and maximum environmental impacts for the refrigerant

$$X_{min_{env\,MFV_{FF}}} = 1430 * n_{FF} * \phi_l \quad \text{(Q)}$$

$$X_{max_{env\,MFV_{FF}}} = 3922 * n_{FF} * \phi_l \quad \text{(R)}$$

With:

$X_{min_{env\,MFV_{FF}}}$ the minimum environmental impacts for the refrigerant (kgCO2eq)

$X_{max_{env\,MFV_{FF}}}$ the maximum environmental impacts for the refrigerant (kgCO2eq)

n_{FF} the amount of refrigerant in the system (kg)

ϕ_l the annual leaking rate

Appendix 12. Formula sheet (8)

The minimum and maximum environmental impacts for the fridges

$$X_{min_{env\,MFV_f}} = EI_{MFV_f} - 0.2303 * n_{open} * EI_e * 4150 \quad \text{(S)}$$

$$X_{max_{env\,MFV_f}} = EI_{MFV_f} + 0.2303 * n_{closed} * EI_e * 4150 \quad \text{(T)}$$

With:

$X_{min_{env\,MFV_f}}$ the minimum environmental impact for the fridges (kgCO2eq)

$X_{max_{env\,MFV_f}}$ the maximum environmental impact for the fridges (kgCO2eq)

EI_{MFV_f} the current carbon footprint of the fridges (kgCO2eq)

n_{open} the number of open fridges

n_{closed} the number of closed fridges

EI_e the carbon footprint of electricity (kgCO2eq)

The theorectical cost of a gas heating system

$$€_{tot_{th_g}} = \frac{C_{th}}{\eta_g} * €_{kWh_g} + €_{m_{th_g}} \quad \text{(U)}$$

With:

$€_{tot_{th_g}}$ the theorectical cost of a gas heating system (€)

C_{th} the theoretical consumption needed to heat the building (kWh)

η_g the efficiency of a gas heating system

$€_{kWh_g}$ the cost per kWh of gas (€/kWh)

$€_{m_{th_g}}$ the maintenance cost of a gas heating system (€)

The theorectical cost of an electric heating system

$$€_{tot_{th_e}} = \frac{C_{th}}{\eta_e} * (€_{kWh_e} + €_{kWhm_{th_e}}) \quad \text{(V)}$$

With:

$€_{tot_{th_e}}$ the theorectical cost of an electric heating system (€)

C_{th} the theoretical consumption needed to heat the building (kWh)

η_e the efficiency of an electricity heating system

$€_{kWh_e}$ the cost per kWh of electricity (€/kWh)

$€_{kWhm_{th_e}}$ the maintenance cost per kWh of electricity (€/kWh)

Appendix 12. Formula sheet (9)

The theoretical cost of a solar heating system

$$€_{tot_{th_\varphi}} = €_{m_{th_\varphi}} \tag{W}$$

With:

$€_{tot_{th_\varphi}}$ the theoretical cost of a solar heating system (€)

$€_{m_{th_\varphi}}$ the maintenance cost of a solar heating system (€)

The theorectical cost of a heat pump

$$€_{tot_{th_\theta}} = \frac{C_{th}}{COP_\theta} * (€_{kWh_e} + €_{m_{th_e}}) + €_{m_{th_\theta}} \tag{X}$$

With:

$€_{tot_{th_\theta}}$ the theorectical cost of a heat pump (€)

C_{th} the theoretical consumption needed to heat the building (kWh)

COP_θ the COP of a heat pump (on average, 3 for a general heat pump and 4 for a geothermal heat pump

$€_{kWh_e}$ the cost per kWh of electricity (€/kWh)

$€_{m_{th_e}}$ the maintenance cost per kWh of electricity (€/kWh)

$€_{m_{th_\theta}}$ the maintenance cost of heat pump system, around (€)

The minimum and maximum economic situations for the heating system

$$X_{min_Q} = \min(€_{tot_{th_G}};\ €_{tot_{th_e}};\ €_{tot_{th_{\theta 1}}};\ €_{tot_{th_{\theta 2}}};\ €_{tot_{th_\varphi}}) \tag{Y}$$

$$X_{max_Q} = \max(€_{tot_{th_G}};\ €_{tot_{th_e}};\ €_{tot_{th_{\theta 1}}};\ €_{tot_{th_{\theta 2}}};\ €_{tot_{th_\varphi}}) \tag{Z}$$

With:

$€_{tot_{th_G}}$ the theoretical cost of a gas heating system (€), see formula (U)

$€_{tot_{th_e}}$ the theoretical cost of an electric heating system (€), see formula (V)

$€_{tot_{th_\varphi}}$ the theoretical cost of a solar heating system (€), see formula (W)

$€_{tot_{th_{\theta 1}}}$ the theoretical cost of a heat pump (€), see formula (X)

$€_{tot_{th_{\theta 1}}}$ the theoretical cost of a geothermal heat pump (€), see formula (X)

Appendix 12. Formula sheet (10)

The minimum and maximum economic situations for the lighting system

$$X_{min_{\gamma}} = \frac{\min(\eta_{\gamma})}{\eta_{\gamma current}} \cdot Cp_{\gamma} \cdot €_{kWh_e} \quad \text{(AA)}$$

$$X_{max_{\gamma}} = \frac{\max(\eta_{\gamma})}{\eta_{\gamma current}} \cdot Cp_{\gamma} \cdot €_{kWh_e} \quad \text{(AB)}$$

With:

$€_{kWh_e} = €_{kWh_s} + €_{kWh_m}$ the cost of per kWh of electricity, obtained by adding the supply cost per kWh ($€_{kWh_s}$) and the maintenance cost per kWh ($€_{kWh_m}$) (€/kWh)

Cp_{γ} the current yearly lighting consumption (kWh)

$\min(\eta_{\gamma})$ the minimum lighting system efficiency (W)

$\max(\eta_{\gamma})$ the minimum lighting system efficiency (W)

$\eta_{\gamma current}$ the current lighting system efficiency (W)

The minimum and maximum economic impacts for the refrigerant

$$X_{min_{eco\,MFV_{FF}}} = 8.90 * n_{FF} * \phi_l \quad \text{(AC)}$$

$$X_{max_{eco\,MFV_{FF}}} = 18.08 * n_{FF} * \phi_l \quad \text{(AD)}$$

With:

$X_{min_{eco\,MFV_{FF}}}$ the minimum economic impacts for the refrigerant (€)

$X_{max_{eco\,MFV_{FF}}}$ the maximum economic impacts for the refrigerant (€)

n_{FF} the amount of refrigerant in the system (kg)

ϕ_l the annual leaking rate

Appendix 12. Formula sheet (10)

The minimum and maximum economic impacts for the fridges

$$X_{min_{eco\,MFV_f}} = €_{MFV_f} - 0.2303 * n_{open} * €_e * 4150 \quad \text{(AE)}$$

$$X_{max_{eco\,MFV_f}} = €_{MFV_f} + 0.2303 * n_{closed} * €_e * 4150 \quad \text{(AF)}$$

With:

$X_{min_{eco\,MFV_f}}$ the minimum economic impact for the fridges

$X_{max_{eco\,MFV_f}}$ the maximum economic impact for the fridges

$€_{MFV_f}$ the current cost of the fridges

n_{open} the number of open fridges

n_{closed} the number of closed fridges

$€_e$ the cost of electricity

The personnel cost of the waste type j

$$€_{j_{tot}} = €_{j_{tottr}} + €_{m_{j_{new}}} + €_{j_{totp}} \quad \text{(AG)}$$

With:

$€_{j_{totp}}$ the personnel cost of the waste type j (€)

$€_{m_{j_{new}}}$ the new maintenance cost of the waste type j (€)

$€_{j_{tottr}}$ the total treatment cost of the waste type j (€)

Appendix 12. Formula sheet (11)

The total energy score

$$Sc_{en_{tot}} = \left(Sc_{env_Q} * p_{env_Q} + Sc_{env_\gamma} * p_{env_\gamma} + Sc_{env_{MFV_f}} * p_{env_{MFV_f}} + Sc_{env_{MFV_{FF}}} * p_{env_{MFV_{FF}}}\right) * p_{env} + \left(Sc_{eco_Q} * p_{eco_Q} + Sc_{eco_\gamma} * p_{eco_\gamma} + Sc_{eco_{MFV_f}} * p_{eco_{MFV_f}} + Sc_{eco_{MFV_{FF}}} * p_{eco_{MFV_{FF}}}\right) * p_{eco} \quad \text{(AH)}$$

With:

$Sc_{en_{tot}}$ the total energy score

Sc_{env_Q} the heating system environmental score

Sc_{env_γ} the lighting system environmental score

$Sc_{env_{MFV_f}}$ the fridges environmental score

$Sc_{env_{MFV_{FF}}}$ the refrigerant environmental score

p_{env_Q} the heating system environmental impact proportion

p_{env_γ} the lighting system environmental impact proportion

$p_{env_{MFV_f}}$ the fridges environmental impact proportion

$p_{env_{MFV_{FF}}}$ the refrigerant environmental impact proportion

Sc_{eco_Q} the heating system economic score

Sc_{eco_γ} the lighting system economic score

$Sc_{eco_{MFV_f}}$ the fridges economic score

$Sc_{eco_{MFV_{FF}}}$ the refrigerant environmental score

p_{eco_Q} the heating system environmental impact proportion

p_{eco_γ} the lighting system environmental impact proportion

$p_{eco_{MFV_f}}$ the lighting system environmental impact proportion

$p_{eco_{MFV_{FF}}}$ the refrigerant environmental impact proportion

p_{env} the proportion of the environmental impact to take into account in sustainability calculations

p_{eco} the proportion of the economic impact to take into account in sustainability calculations

Appendix 12. Formula sheet (12)

The score per chemical

$$Sc_{pr} = \frac{\sum_{\left\{ j \in \{R58/59;\, R50-53; R54/56;\, R55/57\} \atop i=1 \right.}^{\left\{ i=4 \atop j \in \{R58/59;\, R50-53; R54/56;\, R55/57\} \right.} n_j^i}{\sum_{i=1}^{i=4} n_s^i} = \frac{n_{R58/59}^1 + n_{R50-53}^2 + n_{R54/56}^3 + n_{R55/57}^4}{n_s^1 + n_s^2 + n_s^3 + n_s^4} \tag{AI}$$

With:

Sc_{pr} the score per chemical

n_j^i the number of the R-phrases group j, to the power of the hazard index i

$j \in \{R58/59;\ R50-53; R54/56;\ R55/57\}$

n_s^i the number of chemicals in the product, to the power of the hazard index i

$1 \leq i \leq 4$

The total new carbon footprint per ton of waste type j

$$EI_{j_{tot/ton}} = \%_{i_j} * EI_{j_i} + \%_{RE_j} * EI_{j_{RE}} + \%_{c_j} * EI_{j_c} + \%_{lf_j} * EI_{j_{lf}} + \%_{rec_j} * EI_{j_{rec}} \tag{AJ}$$

$$EI_{CtdP_{rec}} = EI_{truck} * d \tag{AK}$$

With:

$EI_{j_{tot/ton}}$ the total new carbon footprint per ton of waste type j (kgCO2eq)

EI_{j_i} the incineration carbon footprint for the waste type j (kgCO2eq)

$EI_{j_{RE}}$ the combustion with energy recovery carbon footprint for the waste type j (kgCO2eq)

EI_{j_c} the composting carbon footprint for the waste type j (kgCO2eq)

$EI_{j_{lf}}$ the landfilling carbon footprint for the waste type j (kgCO2eq)

$EI_{j_{rec}}$ the recycling carbon footprint for the waste type j (kgCO2eq)

$\%_{i_j}$ the new incineration percentage of the waste type j (kgCO2eq)

$\%_{RE_j}$ the new combustion with energy recovery percentage of the waste type j

$\%_{c_j}$ the new composting percentage of the waste type j

$\%_{lf_j}$ the new landfilling percentage of the waste type j

$\%_{rec_j}$ the new recycling percentage of the waste type j

$EI_{CtdP_{rec}}$ the new recycling carbon footprint for close-to-date products (kgCO2eq)

EI_{truck} the carbon footprint of the collection truck per km per ton (kgCO2eq)

d the distance travelled by the collection truck (km)

Appendix 12. Formula sheet (13)

The total treatment cost of the waste type j

$$€_{j_{tottr}} = \left(\%_{i_j} * \overline{€_i} + \%_{RE_j} * \overline{€_{RE}} + \%_{c_j} * \overline{€_c} + \%_{lf_j} * \overline{€_{lf}} + \%_{rec_j} * \overline{€_{j_{rec}}}\right) * C_j \quad \text{(AL)}$$

$$\overline{€_{CtdP_{rec}}} = \overline{€_{credit}} * \%_V \quad \text{(AM)}$$

With:

$€_{j_{tottr}}$ the total treatment cost of the waste type j

$\overline{€_i}$ the average cost of waste incineration (€)

$\overline{€_{RE}}$ the average cost of waste combustion with energy recovery (€)

$\overline{€_c}$ the average cost of waste composting (€)

$\overline{€_{lf}}$ the average cost of waste landfilling (€)

$\overline{€_{j_{rec}}}$ the average cost of recycling of the waste type j (€)

C_j the consumption of the waste type j (kWh)

$\%_{i_j}$ the new incineration percentage of the waste type j

$\%_{RE_j}$ the new combustion with energy recovery percentage of the waste type j

$\%_{c_j}$ the new composting percentage of the waste type j

$\%_{lf_j}$ the new landfilling percentage of the waste type j

$\%_{rec_j}$ the new recycling percentage of the waste type j

$\overline{€_{CtdP_{rec}}}$ the average cost of close-to-date products recycling (€)

$\overline{€_{credit}}$ the average credit value per ton of waste (€)

$\%_V$ the valorization percentage of the products

The new maintenance cost of the waste type j

$$€_{m_{j_{new}}} = €_{m_{i_{curr}}} * \frac{C_j}{C_i} \quad \text{(AN)}$$

With:

$€_{m_{j_{new}}}$ the new maintenance cost of the waste type j (€)

$€_{m_{i_{curr}}}$ the current maintenance for waste incineration (€)

C_j the consumption of waste type j (kWh)

C_i the current consumption of incinerated waste (kWh)

Appendix 12. Formula sheet (14)

The personnel cost of the waste type j

$$€_{j_{totp}} = \frac{\left(\%_{i_j} * \overline{t_i} + \%_{RE_j} * \overline{t_{RE}} + \%_{c_j} * \overline{t_c} + \%_{lf_j} * \overline{t_{lf}} + \%_{rec_j} * \overline{t_{J rec}}\right) * 365.25}{7} * n_{emp_j} * €_{SMIC} \quad \text{(AO)}$$

With:

$€_{j_{totp}}$ the personnel cost of the waste type j (€)

$\overline{t_i}$ the average time spent per employee for the disposal of incinerated waste (h)

$\overline{t_{RE}}$ the average time spent per employee for the disposal of waste combusted with energy recovery (h)

$\overline{t_c}$ the average time spent per employee for the disposal of composted waste (h)

$\overline{t_{lf}}$ the average time spent per employee for the disposal of landfilled waste (h)

$\overline{t_{j_{rec}}}$ the average time spent per employee for the disposal of recycled waste of the waste type j (h)

n_{emp_j} the number of employees responsible of the disposal of the waste type j

$€_{SMIC}$ the minimum hourly wage as paid by the employer (€)

$\%_{i_j}$ the new incineration percentage of the waste type j

$\%_{RE_j}$ the new combustion with energy recovery percentage of the waste type j

$\%_{c_j}$ the new composting percentage of the waste type j

$\%_{lf_j}$ the new landfilling percentage of the waste type j

$\%_{rec_j}$ the new recycling percentage of the waste type j