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FOODPRINT: A NOVEL TOOL FOR MEASURING AND MONITORING CARBON FOOTPRINT IN FOOD INDUSTRIES

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Introduction

Life FoodPrint, was a project with main goal to develop an ***integrated strategy for reducing the carbon footprint*** in the food industry sector.

The project was recently concluded with great success, and its main findings and deliverables, are available at:

Introduction

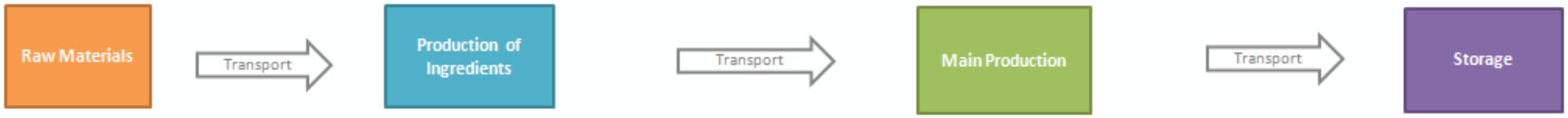
One of the main objectives of the Life project FOODPRINT was the development of a robust software tool that can:

- **Calculate** the CF of food products along the supply chain.
- **Quantify** the contribution of each activity to the overall CF of each product.
- **Identify** Carbon and Energy hotspots.
- **Propose** and **prioritize** GHG emissions reduction measures through multi-criteria analysis (MCA) to promote energy and resource efficiency, as well as reduced waste &

Scope

At this point, the tool focuses on **pastry and flour products.** However, database can be expended to cover all food products.

Includes **all stages of the supply chain of products** (*Farming, Ingredients Production, Main Product Manufacture, Storage and Transportation*).



Takes into account **direct** and **indirect** activities (*fuel combustion, energy consumption, waste and wastewater management, packaging production*

Methodology (1/3)

- ✓The software tool was modeled based on excessive **literature review, real data collection** from partners and actors associated with JOTIS' supply chain (suppliers etc), as well as **energy audits** performed at various food industries in Greece and Italy.

- ✓Development of **energy indicators** for various product lines/processes, from real data collected during energy audits.

- ✓Development of a **methodology** to calculate case-specific energy indicators with minimum

Methodology (2/3)

Development of case-specific procedures/methods for data collection

Methodology (3/3)

- ✓ **Establishment of a list of alternative energy and GHG emissions reduction measures**

  Measures were determined based on scientific studies conducted by the project team, and finalized through discussion with various stakeholders.

- ✓ **Evaluation of alternative measures**

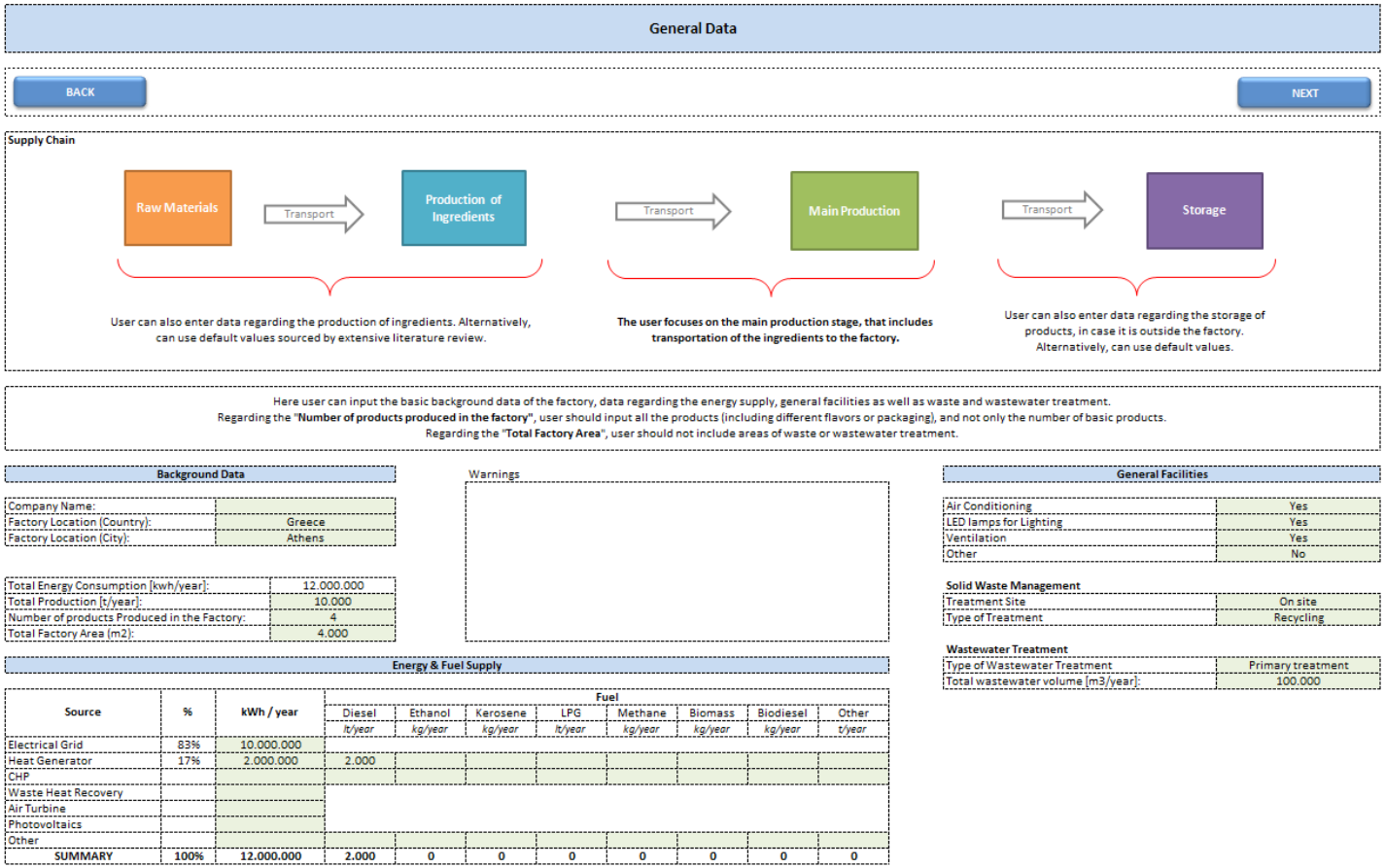
  Evaluation against various criteria, was based on real case examples, food processing equipment specifications and literature research.

- ✓ **MCA Ranking method:** Weighted Sum Model *(one of best known & simplest methods)*

Tool Structure

1. Data input (general, production, transportation etc)
2. GHG Emissions Results & Hot Spots
3. GHG minimization Strategies formation
4. Multi-criteria Analysis
5. Recommendations

General data



General Data

BACK

NEXT

Supply Chain

Raw Materials → Transport → Production of Ingredients → Transport → Main Production → Transport → Storage

User can also enter data regarding the production of ingredients. Alternatively, can use default values sourced by extensive literature review.

The user focuses on the main production stage, that includes transportation of the ingredients to the factory.

User can also enter data regarding the storage of products, in case it is outside the factory. Alternatively, can use default values.

Here user can input the basic background data of the factory, data regarding the energy supply, general facilities as well as waste and wastewater treatment.
Regarding the "**Number of products produced in the factory**", user should input all the products (including different flavors or packaging), and not only the number of basic products.
Regarding the "**Total Factory Area**", user should not include areas of waste or wastewater treatment.

Background Data

Company Name:	
Factory Location (Country):	Greece
Factory Location (City):	Athens

Total Energy Consumption [kwh/year]:	12.000.000
Total Production [t/year]:	10.000
Number of products Produced in the Factory:	4
Total Factory Area (m2):	4.000

Warnings

General Facilities

Air Conditioning	Yes
LED lamps for Lighting	Yes
Ventilation	Yes
Other	No

Solid Waste Management

Treatment Site	On site
Type of Treatment	Recycling

Wastewater Treatment

Type of Wastewater Treatment	Primary treatment
Total wastewater volume [m3/year]:	100.000

Energy & Fuel Supply

Source	%	kWh / year	Fuel							
			Diesel	Ethanol	Kerosene	LPG	Methane	Biomass	Biodiesel	Other
			lt/year	kg/year	kg/year	lt/year	kg/year	kg/year	kg/year	t/year
Electrical Grid	83%	10.000.000								
Heat Generator	17%	2.000.000	2.000							
CHP										
Waste Heat Recovery										
Air Turbine										
Photovoltaics										
Other										
SUMMARY	100%	12.000.000	2.000	0	0	0	0	0	0	0

User inputs various general data, such as the total electric energy consumption of the factory, fuel consumption, waste and wastewater treatment methods etc.

Ingredients Data

Ingridients Background Data

BACK NEXT

Ingridient	Country of Origin	kg GHGe / t of ingridient				Water content (%)
		Farm	Transport	Processing	SUM	
SUGAR	EU average	279,8	31,7	573,0	**884,5**	10%
FLOUR	Greece	148,0	8,0	122,0	**278,0**	2%
MILK	EU average	998,0	30,0	124,0	**1152,0**	98%
COCOA	Ghana	54,5	6,5	259,0	**320,0**	2%
WATER	Greece	20,0	20,0	20,0	**60,0**	100%
SALT	Greece	100,0	5,0	50,0	**155,0**	15%
OTHER	Greece	100,0	100,0	100,0	**300,0**	20%
					0,0	
					0,0	
					0,0	
					0,0	
					0,0	
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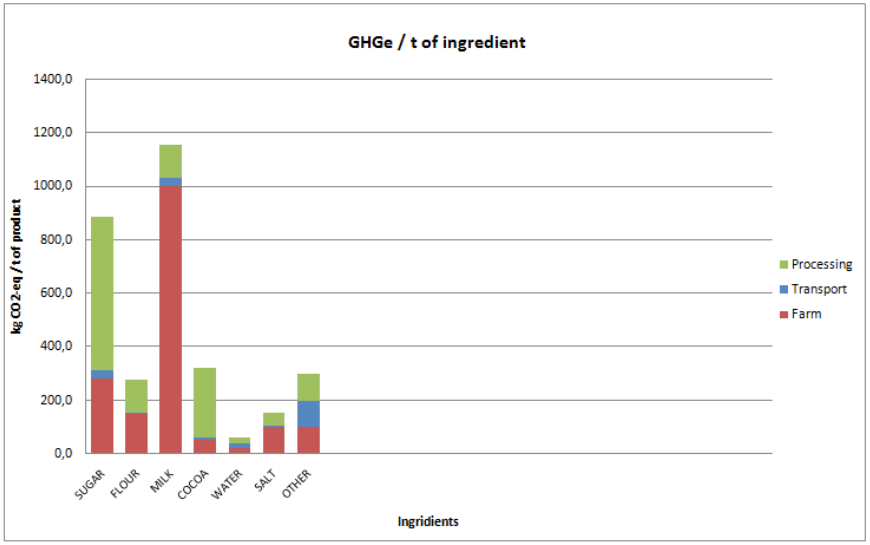
					0,0	

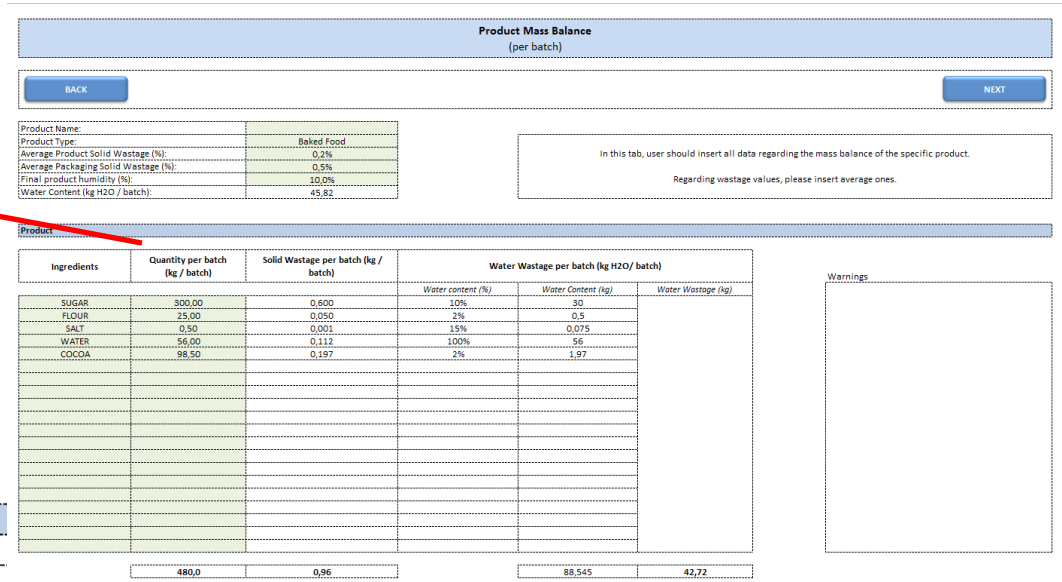
Copy Values from Database



User should check that all the ingredients of the product under examination, exist in the database of the tool. It contains a fairly broad database; however, if there is no data for a specific ingredient, the user can import very easily new data.

Product Mass Balance Data

Ingredients	Quantity per batch (kg / batch)
SUGAR	300,00
FLOUR	25,00
SALT	0,50
WATER	56,00
COCOA	98,50



Packaging

Material	Quantity per batch (kg / batch)	Solid Wastage per batch (kg / batch)
Film	2,00	0,01
Wrap	10,00	0,05
Box	10,00	0,05
	22,00	0,110

User enters basic data regarding the product (*name, type etc*) and information about the quantities of each ingredient (recipe) and packaging materials.

Transportation Data

Transportation of Ingredients
(to the factory)

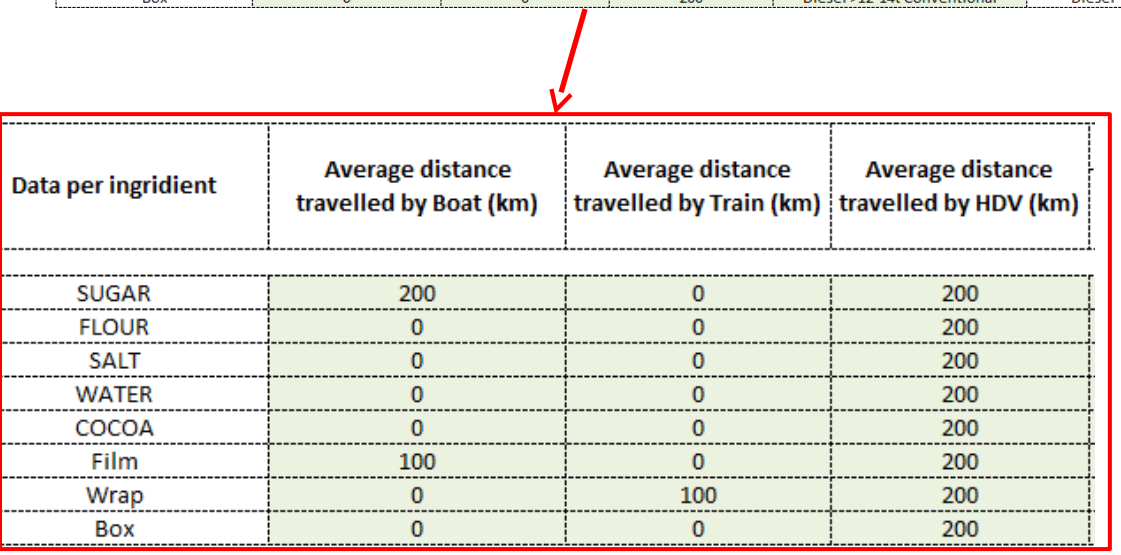
BACK NEXT

Here, user should insert the average distance per mean or tranportation, that each ingredient or packaging material was tranported, from the supplier to the factory.

In case of multiply suppliers, please insert average values, while in case of only one mean of transportation, please insert 0 in other choises.

Warnings

Data per ingridient	Average distance travelled by Boat (km)	Average distance travelled by Train (km)	Average distance travelled by HDV (km)	HDV Transportation Data					
				Average Type of HDV	Fuel	Refrigerator truck	Average HDV Capacity (t/HDV)	Average fuel consumption (l/100 km)	Average fuel consumption (l/t of ingredient)
SUGAR	200	0	200	Diesel >20-26t Conventional	Diesel	No	23	80	6,96
FLOUR	0	0	200	Diesel >16-20t Euro II	Diesel	No	18	70	7,78
SALT	0	0	200	Diesel >16-20t Euro II	Diesel	No	18	70	7,78
WATER	0	0	200	Diesel >16-20t Euro II	Diesel	No	18	70	7,78
COCOA	0	0	200	Diesel >16-20t Euro II	Diesel	No	18	70	7,78
Film	100	0	200	Diesel <7,5t Conventional	Diesel	No	5	40	16,00
Wrap	0	100	200	Diesel <7,5t Euro IV	Diesel	No	5	40	16,00
Box	0	0	200	Diesel >12-14t Conventional	Diesel	No	13	50	7,69



Data per ingridient	Average distance travelled by Boat (km)	Average distance travelled by Train (km)	Average distance travelled by HDV (km)
SUGAR	200	0	200
FLOUR	0	0	200
SALT	0	0	200
WATER	0	0	200
COCOA	0	0	200
Film	100	0	200
Wrap	0	100	200
Box	0	0	200

User enters data regarding the transport of all ingredients used for the manufacturing and packaging of the final product (*average distance per mean of*

Main Production Data

(1/2)

Production Processes

BACK NEXT

General Process Data

Product Name:	Farine Lactee
Product Type:	Baked Food
Kg per Batch:	458
1 piece weight (gr):	240
Pieces per Batch:	1.909
Batches per month:	22
Batch time (hr):	6

Data have been calculated from energy audits in various factories, as well as from literature review.

In case the user is familiar with more technical parameters, Enegy (fuel) Consumption (kWh/kg of product) data can be modified.

Calculate Thermal Data | Calculate Cooling Data

Warnings

Electrical & Thermal Processes

Step	Process	Type of Power	Electrical Source					Thermal Source			
			Electrical power (kw)	Batch Operation Time (h)	Real Equipment Operation per Batch (%)	Real Equipment Operation per Batch (h)	Electrical Consumption (kWh/kg of product)	Fuel	Thermal Medium	Enegy (fuel) Consumption (kWh/kg of product)	Enegy (fuel) Consumption (kWh/kg of product)
										Database	*User*
1	Preheating / Heating	Electrical & Thermal	10	6	100%	6	0,131	LPG	Steam	0,132	
2	Drying	Electrical & Thermal	8	6	50%	3	0,052	LPG	Flue Gas	3,523	
3	Boiling	Electrical & Thermal	8	6	100%	6	0,105	Biomass	Hot water	1,136	
4	Baking	Electrical & Thermal	8	6	100%	6	0,105	Biomass	Superheated Steam	0,828	
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

User enters data regarding all the processes involved in the manufacturing stage. Processes are divided into three main categories, namely

i) electrical,

ii) thermal & cooling, and finally

iii) cleaning & maintenance.

Main Production Data

(2/2)

Step	Process	Type of Power	Electrical power (kw)
1	Preheating / Heating	Electrical & Thermal	10
2	Drying	Electrical & Thermal	8
3	Boiling	Electrical & Thermal	8
4	Baking	Electrical & Thermal	8
5			
6			
7			
8			
9			
10			
11			
12			

(Air) Conveying system
Baking
Boiling
Conches
Drying
Frying
Metal detector
Mixing

Thermal Source				
Electrical Consumption (kWh/kg of product)	Fuel	Thermal Medium	Energy (fuel) Consumption (kWh/kg of product)	Energy (fuel) Consumption (kWh/kg of product)
			Database	*User*
0,131	LPG	Steam	0,132	
0,052	LPG	Flue Gas	3,523	
0,105	Biomass	Hot water	1,136	
0,105	Biomass	uperheated Steam	0,828	

Biodiesel
Biomass
Diesel
Ethanol
Kerosene
LPG
Methane

Thermal Source			
Fuel	Thermal Medium	Energy (fuel) Consumption (kWh/kg of product)	Energy (fuel) Consumption (kWh/kg of product)
		Database	*User*
LPG	Steam	0,132	
LPG	Flue Gas	3,523	
Biomass	Hot water	1,136	
Biomass	Superheated Steam	0,828	

Air
Flue Gas
Hot water
Other
Steam
Superheated Steam
Superheated water
Thermic oil

GHG Emissions & Hot Spots

(1/5)

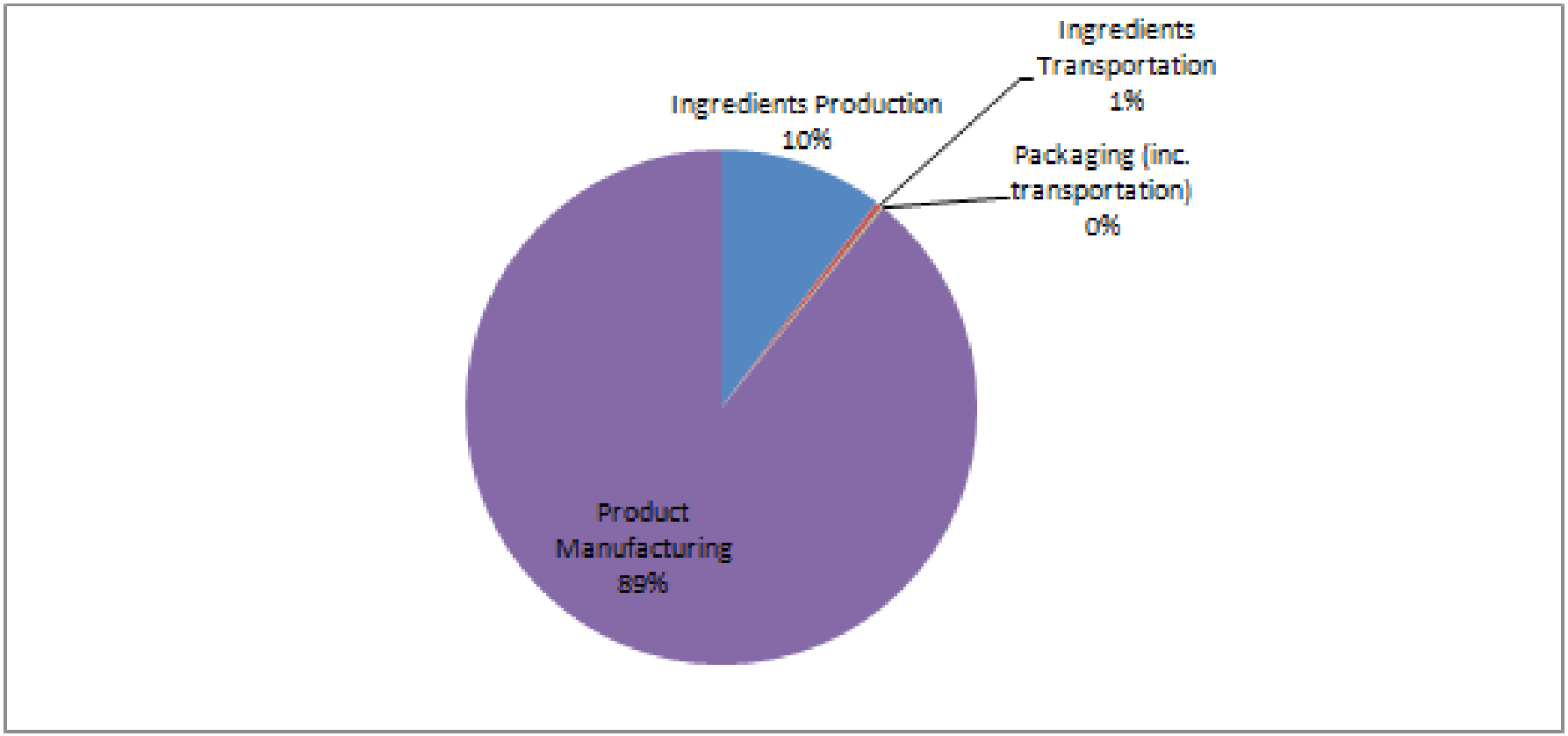
Summary Results

Stage	GHG emissions (kg GHGe / kg of product)	GHG emissions (kg GHGe / piece)	Allocation (%)	Energy Consumption (kwh / kg of product)
Ingredients Production	0,671	0,161	6,8%	
Ingredients Transportation	0,027	0,006	0,3%	
Packaging (inc. transportation)	0,006	0,002	0,1%	
Product Manufacturing	5,798	1,392	58,7%	
General Facilities	3,369	0,809	34,1%	
SUM	**9,87**	**2,37**	**100%**	**1,20**

GHG emissions per Year	GHG emissions (kg GHGe / year)	Product GHGe contribution to total factory GHGe (%)
From production of	1.194.058	11%
From the whole factory	10.605.200	

GHG emissions Allocation	GHG emissions (kg GHGe / year)
Electricity	10.600.000
Fuels	5.200

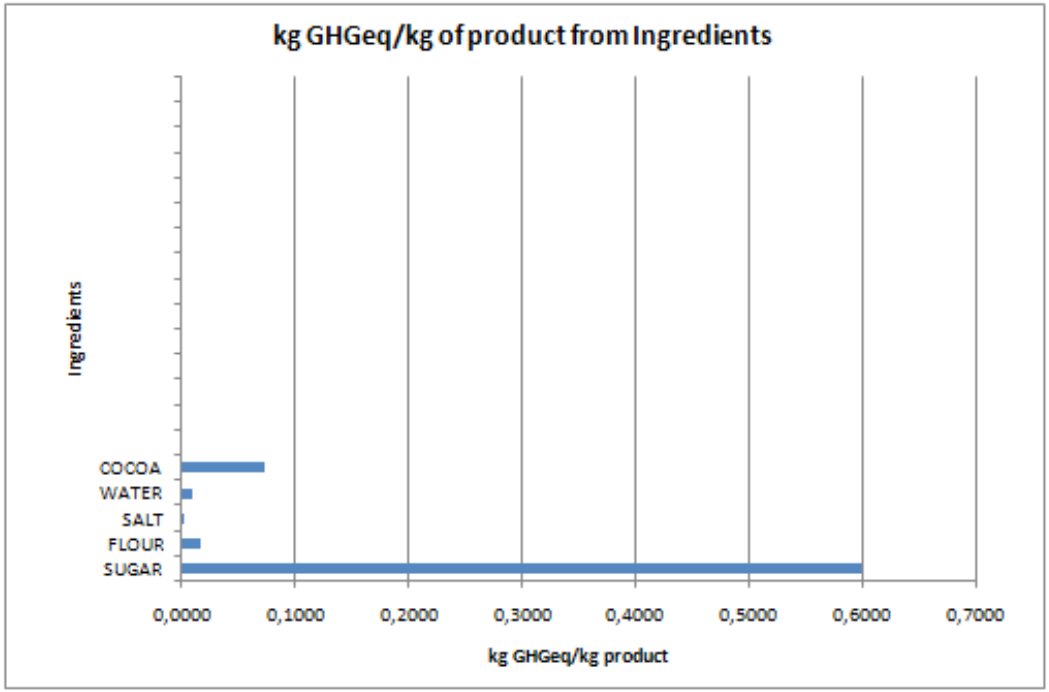
GHG Emissions & Hot Spots
(2/5)



GHG Emissions & Hot Spots
(3/5)

Ingredients Production & Transportation

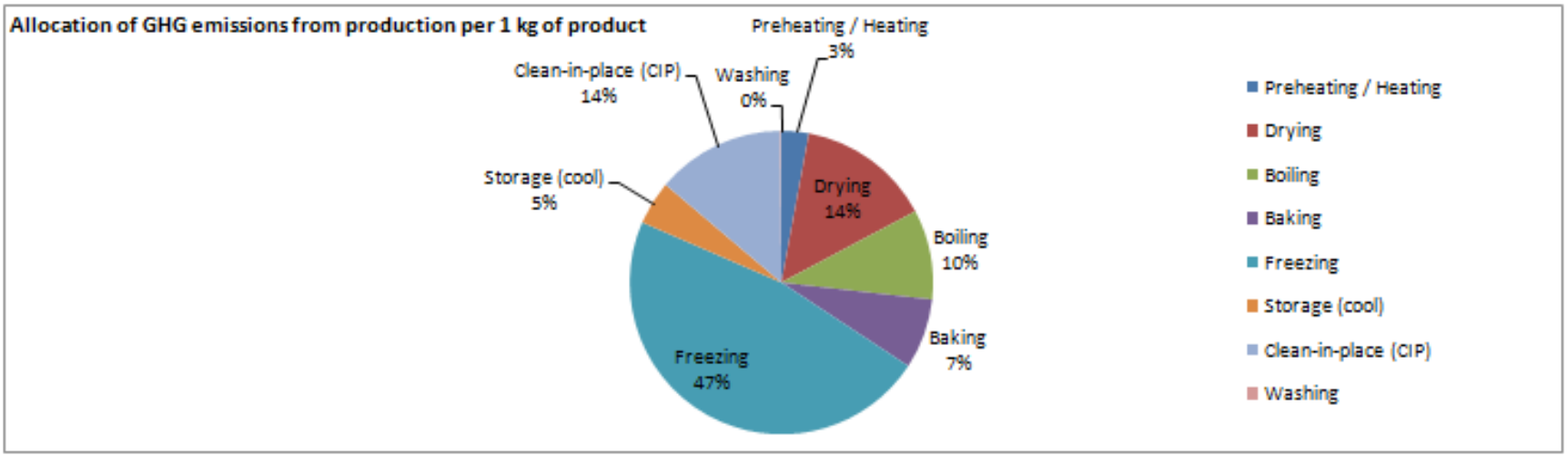
Ingredients Production & Transportation	Production	Transportation	Total	Allocation (%)
	kg GHGe / kg of product	kg GHGe / kg of product	kg GHGe / kg of product	
SUGAR	0,579	0,019	0,5978	85,7%
FLOUR	0,015	0,001	0,0163	2,3%
SALT	0,000	0,000	0,0002	0,0%
WATER	0,007	0,003	0,0099	1,4%
COCOA	0,069	0,004	0,0732	10,5%
Summary	0,6706	0,(		



GHG Emissions & Hot Spots
(4/5)

Process	Production kg GHGeq/kg of product	Allocation (%)
Preheating / Heating	0,17	2,9%
Drying	0,83	14,3%
Boiling	0,55	9,6%
Baking	0,43	7,5%
Freezing	2,74	47,2%
Storage (cool)	0,27	4,7%
Clean-in-place (CIP)	0,79	13,7%
Washing	0,01	0,1%
Summary	**5,7981**	**100%**

Regarding product manufacturing, Freezing is the biggest contributors of GHGe, and a possible Hot Spot.

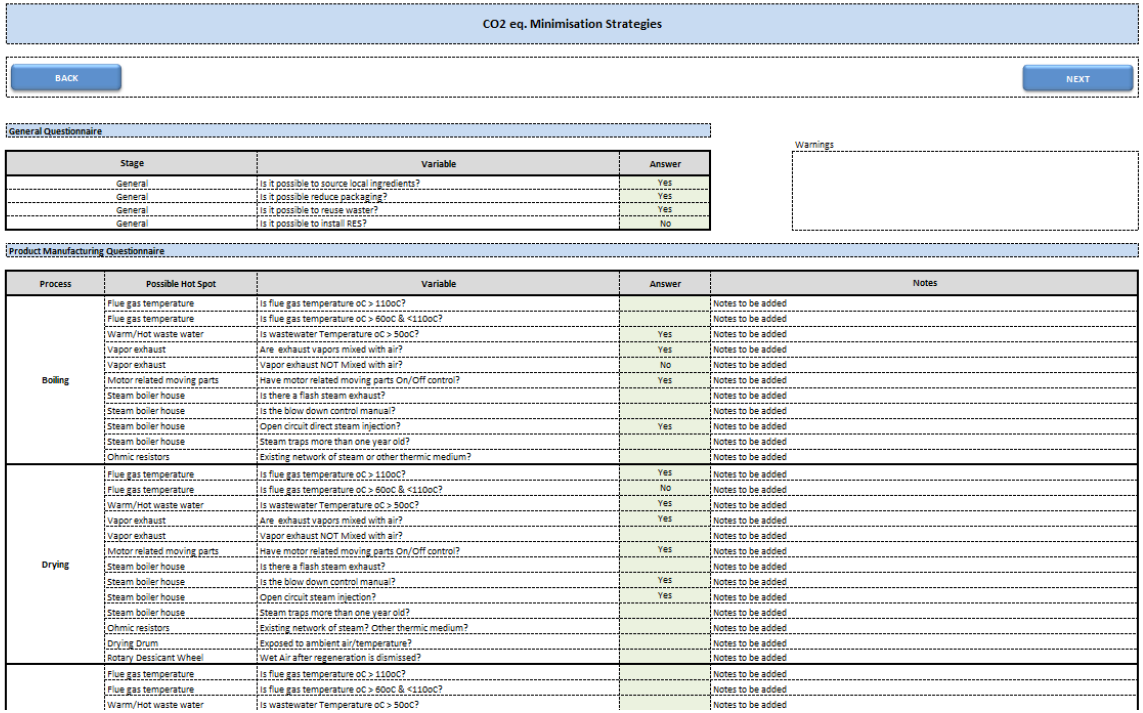


GHG Emissions & Hot Spots
(5/5)

Possible Hot Spot			
Stage	**GHG emissions (kg GHGe / kg of product)**	**Simiral Products Average (kg GHGe / kg of product)**	**General Possible Hot Spot**
Ingredients Production	0,671	0,671	
Ingredients Transportation	0,027	0,027	
Packaging (inc. transportation)	0,006	0,050	
Product Manufacturing	5,798	2,200	*Yes*
General Facilities	3,369	1,000	*Yes*
SUM	**9,87**	**4,00**	**Yes**

User can easily see the energy/GHG emissions distribution among all production processes, and spot the most energy & carbon-intensive stage(s).

GHG minimization Strategies



CO2 eq. Minimisation Strategies

BACK NEXT

General Questionnaire

Stage	Variable	Answer
General	Is it possible to source local ingredients?	Yes
General	Is it possible reduce packaging?	Yes
General	Is it possible to reuse waster?	Yes
General	Is it possible to install RES?	No

Warnings

Product Manufacturing Questionnaire

Process	Possible Hot Spot	Variable	Answer	Notes
Boiling	Flue gas temperature	Is flue gas temperature oC > 110oC?		Notes to be added
	Flue gas temperature	Is flue gas temperature oC > 60oC & <110oC?		Notes to be added
	Warm/Hot waste water	Is wastewater Temperature oC > 50oC?	Yes	Notes to be added
	Vapor exhaust	Are exhaust vapors mixed with air?	Yes	Notes to be added
	Vapor exhaust	Vapor exhaust NOT Mixed with air?	No	Notes to be added
	Motor related moving parts	Have motor related moving parts On/Off control?	Yes	Notes to be added
	Steam boiler house	Is there a flash steam exhaust?		Notes to be added
	Steam boiler house	Is the blow down control manual?		Notes to be added
	Steam boiler house	Open circuit direct steam injection?	Yes	Notes to be added
	Steam boiler house	Steam traps more than one year old?		Notes to be added
	Ohmic resistors	Existing network of steam or other thermic medium?		Notes to be added
Drying	Flue gas temperature	Is flue gas temperature oC > 110oC?	Yes	Notes to be added
	Flue gas temperature	Is flue gas temperature oC > 60oC & <110oC?	No	Notes to be added
	Warm/Hot waste water	Is wastewater Temperature oC > 50oC?	Yes	Notes to be added
	Vapor exhaust	Are exhaust vapors mixed with air?	Yes	Notes to be added
	Vapor exhaust	Vapor exhaust NOT Mixed with air?		Notes to be added
	Motor related moving parts	Have motor related moving parts On/Off control?	Yes	Notes to be added
	Steam boiler house	Is there a flash steam exhaust?		Notes to be added
	Steam boiler house	Is the blow down control manual?	Yes	Notes to be added
	Steam boiler house	Open circuit steam injection?	Yes	Notes to be added
	Steam boiler house	Steam traps more than one year old?		Notes to be added
	Ohmic resistors	Existing network of steam? Other thermic medium?		Notes to be added
	Drying Drum	Exposed to ambient air/temperature?		Notes to be added
	Rotary Dessicant Wheel	Wet Air after regeneration is dismissed?		Notes to be added
	Flue gas temperature	Is flue gas temperature oC > 110oC?		Notes to be added
	Flue gas temperature	Is flue gas temperature oC > 60oC & <110oC?		Notes to be added
	Warm/Hot waste water	Is wastewater Temperature oC > 50oC?		

User fills in a specific questionnaire, that is compiled based on the data have been input in the previous steps.

These answers, will enable the tool to develop a list of possible measurements, that will be later rank based

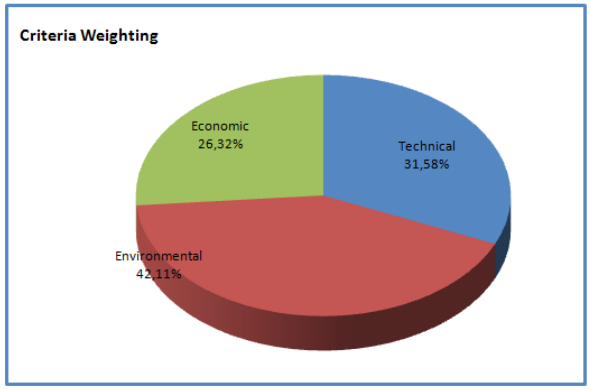
Criteria Weighting

Criteria Weighting

BACK | NEXT

Please rate each criterion with values ranging between 0 and 100, with a value of 0 represents the least important criterion and the value of 100 the most important criterion.

Warnings



Add Criterion

Type	Criterion	Rating
Economic	Capital Expenditure (CAPEX)	50
Technical	Implementation Difficulty	60
Environmental	GHGe Reduction	80
	[Add Criterion]	
	[Add Criterion]	
	[Add Criterion]	

The 3 basic criteria set by the tool are:

✓ the estimated investment cost of the reduction measure,

✓ the degree of implementation difficulty, and

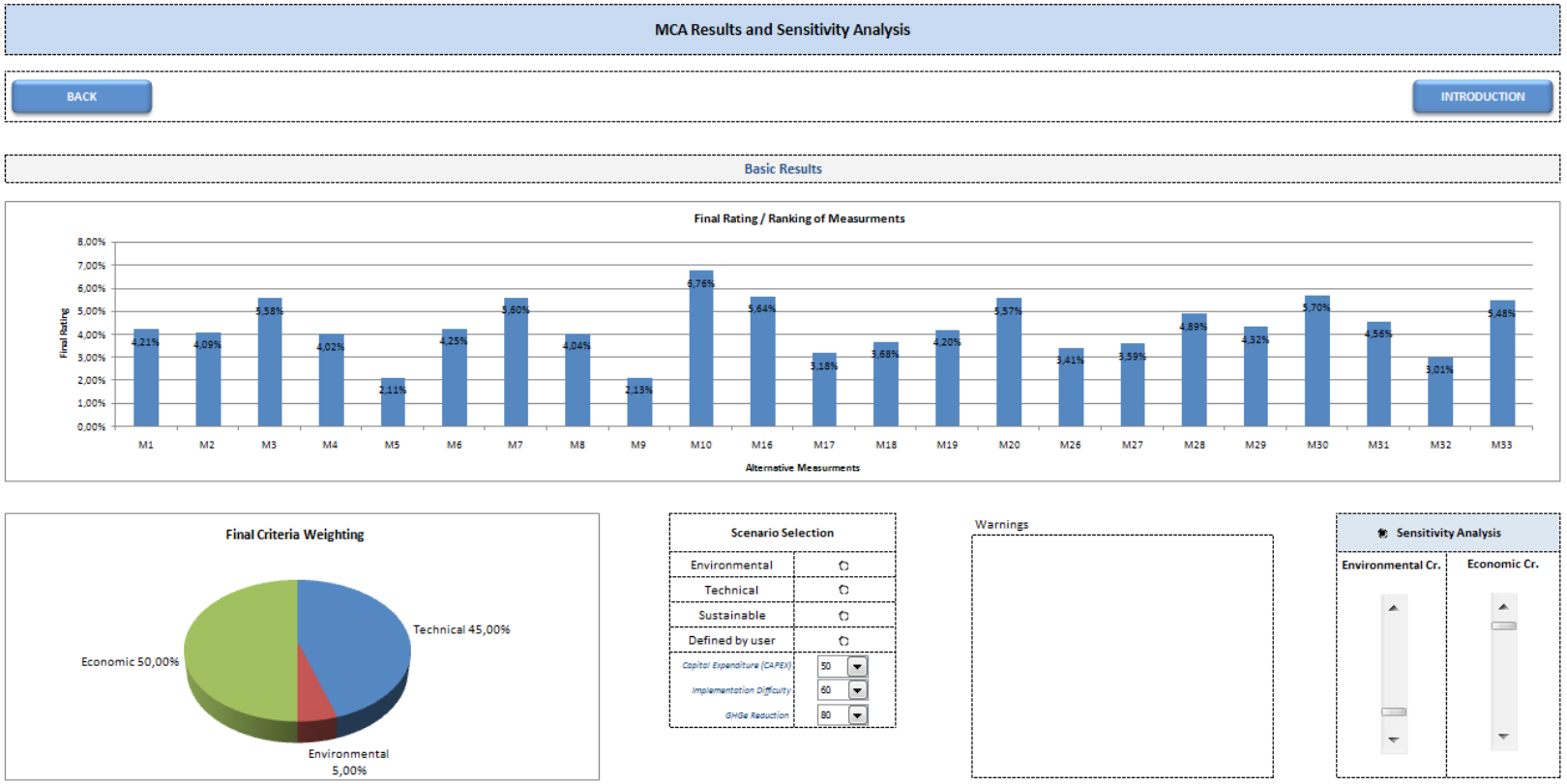
✓ the expected reduction of greenhouse gas

Alternative Measurements Rating

No	Alternative Measurment	Capital Expenditure (CAPEX) [1:Low, 2:Medium, 3:High]	Implementation Difficulty [0 min - 100 max]	GHGe Reduction %
1	Boiling: Vapor exhaust: Keep air to minimum & Heat exchanger to recover latent & sensible energy	1	70	1%
2	Boiling: Warm/Hot waste water: Special design non-corossive/clogging Heat Exchanger	2	30	2%
3	Boiling: Vapor exhaust: Heat exchanger to recover latent & sensible energy	1	30	1%
4	Boiling: Motor related moving parts: Variable speed driver control	2	30	1%
5	Boiling: Steam boiler house: Implement closed circuit heat exchangers and return condensate	3	70	1%
6	Drying: Vapor exhaust: Keep air to minimum & Heat exchanger to recover latent & sensible energy	1	70	2%
7	Drying: Vapor exhaust: Heat exchanger to recover latent & sensible energy	1	30	1%
8	Drying: Motor related moving parts: Variable speed driver control	2	30	1%

User should manually rate each alternative reduction measure in relation to the criteria selected. Alternatively, the user can click the Default Values button and enter the predefined values from the tool's database.

Results (1/3)



- ✓Final ranking based on various criteria weights scenarios
- ✓Sensitivity analysis with real time changes (*each time the weights are changed, user can directly see the effect on the final ranking of the measures*)
- ✓Expected reductions based on a final selection

Results (2/3)

Final Measurements Raking							
Ranking	Measurement No	Proccess	Hot Spot	Description	Rating	GHGe savings (kgGHG/kg of product)	GHGe savings (kgGHG/year)
1	M10	Drying	Steam boiler house	Implement Automatic control with conductivity sensor and electrovalve	6,76%	0,02	3.014
2	M30	Cooling and similar	General note	Substitute with Electronic control (EV)	5,70%	0,30	36.413
3	M16	Baking	Vapor exhaust	Heat exchanger to recover latent & sensible energy	5,64%	0,20	23.628
4	M7	Drying	Vapor exhaust	Heat exchanger to recover latent & sensible energy	5,60%	0,12	15.070
5	M3	Boiling	Vapor exhaust	Heat exchanger to recover latent & sensible energy	5,58%	0,08	10.053
6	M20	Baking	Vapor exhaust	Heat exchanger to recover latent & sensible energy	5,57%	0,07	7.876
7	M33	General	Wastewater Treatment	Reuse at least 15% of the cleaned wastewater for various purposes	5,48%	0,50	60.000
8	M28	Cooling and similar	General note	Implement a water cooled heat exchanger in series with condenser to produce free hot water	4,89%	0,60	72.826
9	M31	General	Ingredients	Source local ingredients in order to avoid GHGe from transportation	4,56%	0,01	973
10	M29	Cooling and similar	General note	Substitute fuel burning heat generator with electrical compresson driven Heat Pump	4,32%	0,60	72.826

User can choose the desired measures based on the results

Results (3/3)

Number of selected measurments	2
GHGe savings (kgGHG/kg of product)	2,904
GHGe savings (kgGHG/year)	351.303

GHGe savings (kgGHG/kg of product)	
Ingredients Production	0,000
Ingredients Transportation	0,000
Packaging (inc. transportation)	0,000
Product Manufacturing	2,408
General Facilities	0,496

Expected reduction (%) in case of the application of the selected measurements.

	Before the measurements application			After the measurements application			Expected reduction
Stage	(kg GHGe / kg of product)	(kg GHGe / piece)	(kg GHGe / year)	(kg GHGe / kg of product)	(kg GHGe / piece)	(kg GHGe / year)	(%)
Ingredients Production	0,671	*0,161*		0,671	*0,161*		0%
Ingredients Transportation	0,027	*0,006*		0,027	*0,006*		0%
Packaging (inc. transportation)	0,006	*0,002*		0,006	*0,002*		0%
Product Manufacturing	5,798	*1,392*		3,390	*0,814*		-42%
General Facilities	3,369	*0,809*		2,873	*0,690*		-15%
SUM	**9,871**	***2,369***		**6,967**	***1,672***		**-29%**
			1.194.058			**842.755**	**-29%**

Then the tool calculates the total expected savings for each production stage, not only per kg of product, but also per year.

Website

Foodprint

Development of an integrated strategy for reducing the carbon footprint in the food industry sector

Project Budget

Project Budget

Total project budget: 1,874,864€

EC Funding: 50% (891,182€)

Duration

Start date: 01/09/2014

End date: 31/10/2017

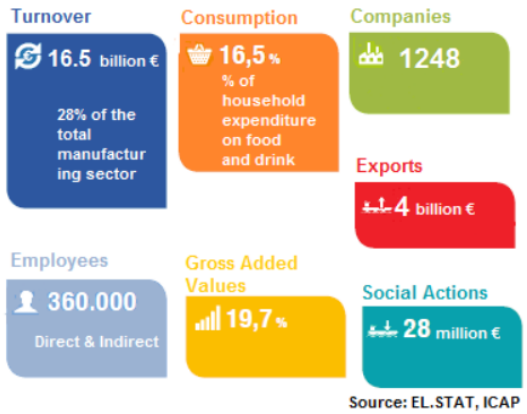
Duration: 38 months

FOODPRINT MCA TOOL is available HERE, and the manual is available HERE.
For any inquiries or questions please send us please send us an email at: lifeprojectfoodprint@gmail.com

The Greek Food & Drink Industry in figures

The Food & Drink Industry is a key sector of the Greek economy, with an annual turnover of 16,5 billion €, employing 360.000 people - direct and indirect employees - covering the 28% of the manufacturing sector and exporting products of 4 billion €.

It is a dynamic, competitive, export-oriented industry, with extensive investments and trade in Greece, Balkans, Europe and all over the world.



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Thank you for your attention.

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