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Engineering



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LABoratory



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Biomass
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i-REFO

Increase in the REduction and REcovery of EXpired FOod

Development of a tool to optimize economic and environmental feasibility of waste food chains

Dr. Pietro Bartocci

UNIVERSITA' DI PERUGIA
Dipartimento di Ingegneria



UNIVERSITÀ
DEGLI STUDI
DI PERUGIA

www.irexfo.eu

Partner of





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Presentation structure

- Introduction to the project
- Aim of the work
- Methodology
- Results



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WHY THE IREXFO PROJECT?

IN THE EU (Estimates, 2012)

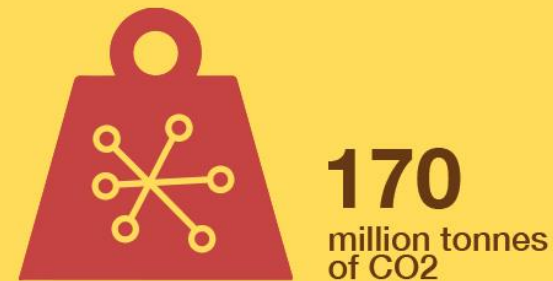
FOOD IS LOST OR WASTED THROUGHOUT THE ENTIRE SUPPLY CHAIN



from **agricultural production** to final household consumption



of food are wasted per year



emitted from production and disposal of EU food waste



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i-REXFO

Increase in the REduction and REcovery of Expired FOod

i-REXFO is an innovative **BUSINESS MODEL** to reduce waste food → It promotes actions to avoid waste food to be disposed in landfills and to produce bioenergy with the non edible fractions

iREXFO will provide an open source tool to transfer the Reduction of Expired Food (**REF**) chains and the Expired Food Energy (**EFE**) chains that will be tested in the Umbria region that is identified as a pilot case study

i-REXFO
increase in reduction and recovery of expired food

1 WHY
With one-quarter of the world population at risk of poverty and social exclusion, one-third of the food produced in the world gets lost or ends up in landfills. But there's more. The production of expiration food involves the use of **100 billion litres of water**, occupies **30% of the world's agricultural land area**, and releases **2.5 billion tonnes of climate-altering gases**. The direct economic consequences of all this waste amount to **750 billion dollars each year** (source: FAO).
According to FAO, food waste in industrialised countries are caused by a combination of factors:
consumers' behaviour: incorrect shopping planning, poor understanding of best before and use by dates, excess purchases, and left over the habit of storing and eating leftovers.
a production-purchase-distribution chain that does not give enough value to food that is near its expiration date, non-conforming products, and the donation of surplus.
a legal and distribution system that does not promote the reuse of food waste in the animal feed industry or more recently, its use in biomass-fed biogas production plants.

2 OUR GOAL
The i-REXFO project aims at demonstrating that food waste can be reduced through an **innovative business model** that is both economically and environmentally sustainable.
i-REXFO is based on an **integrated model** in which **expired food to energy (EFE) valorisation supports the Reduction of Expired Food (REF) chain**.

3 HOW
The project focuses on food waste produced by the food industry and farms, large-scale distribution, the catering industry (hotels, restaurants, bars, HORECA) and consumers. It does so through measures that reduce food waste and increase waste-to-energy valorisation.
Based on the **good practices in Europe (Denmark)**, i-REXFO has developed **innovative software** to plan and optimise the integrated model from a **technical, economic, and environmental point of view**.
The i-REXFO model **raises the awareness of consumers and operators** in the large-scale distribution and HORECA sectors, **promotes the sale and use of food** that is near its expiration date, is **environmentally pleasing** and increases **amounts of surplus food** to charities and food banks. These measures are **backed by the collection and use of expired food for the production of biogas** in anaerobic digestion plants, which use the resulting digestate as a fertiliser, thereby completing the cycle. The i-REXFO model will be **demonstrated in Umbria and then transferred to other countries (Hungary)**.

4 IMPACT
2,500 tonnes of CO₂ emissions avoided every year.
3,400 tonnes of food waste a year from the food industry, farms, shopping centres, and restaurants that don't end up in landfills.
280,000 m³ of water saved every year.
2,800 MWh of energy produced from renewable sources.
2,400 MWh in energy savings every year.
1,100 ha a year in reduced soil consumption.
100,000 aware consumers, thanks to the project's campaigns and activities.

SHARE THE PROJECT

TWITTER
@IREXFO

LINKEDIN
i-REXFO

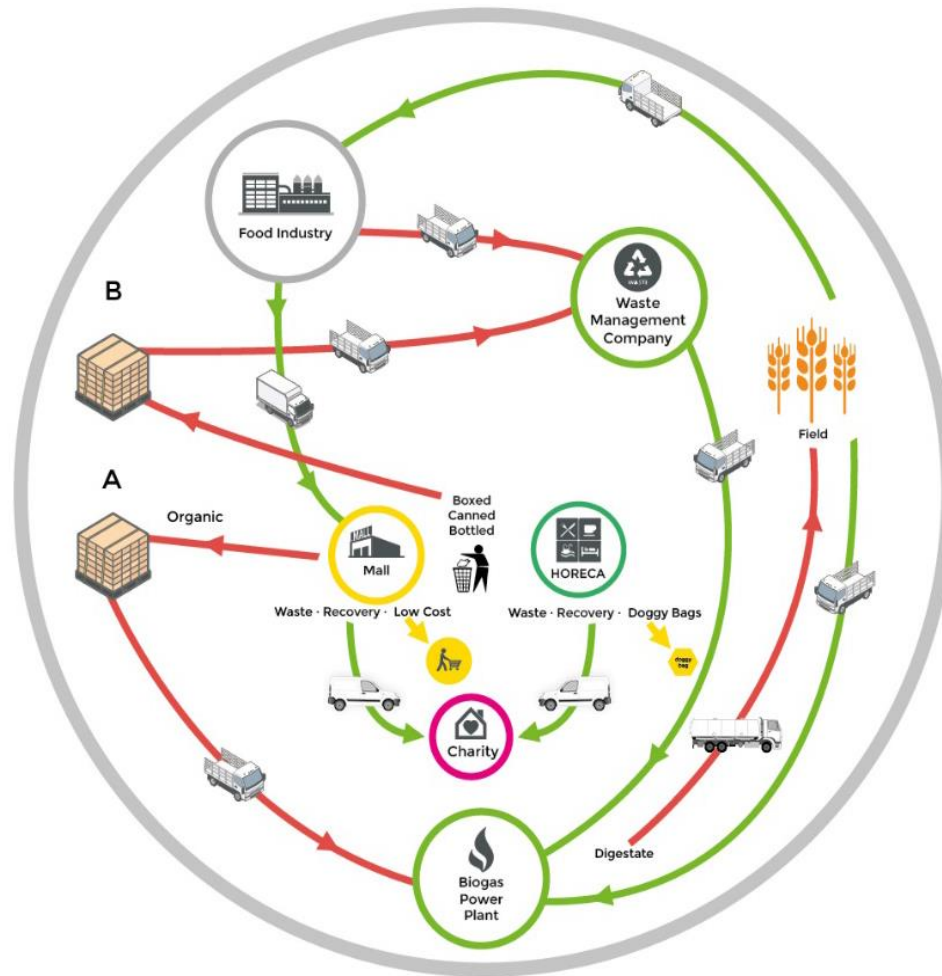
FACEBOOK
i-REXFO

i-REXFO model based on the EU package on Circular Economy

Circular diagram of the i-REXFO approach

Waste 
Matter 

i-REXFO
Increase in Reduction and recovery of expired foods



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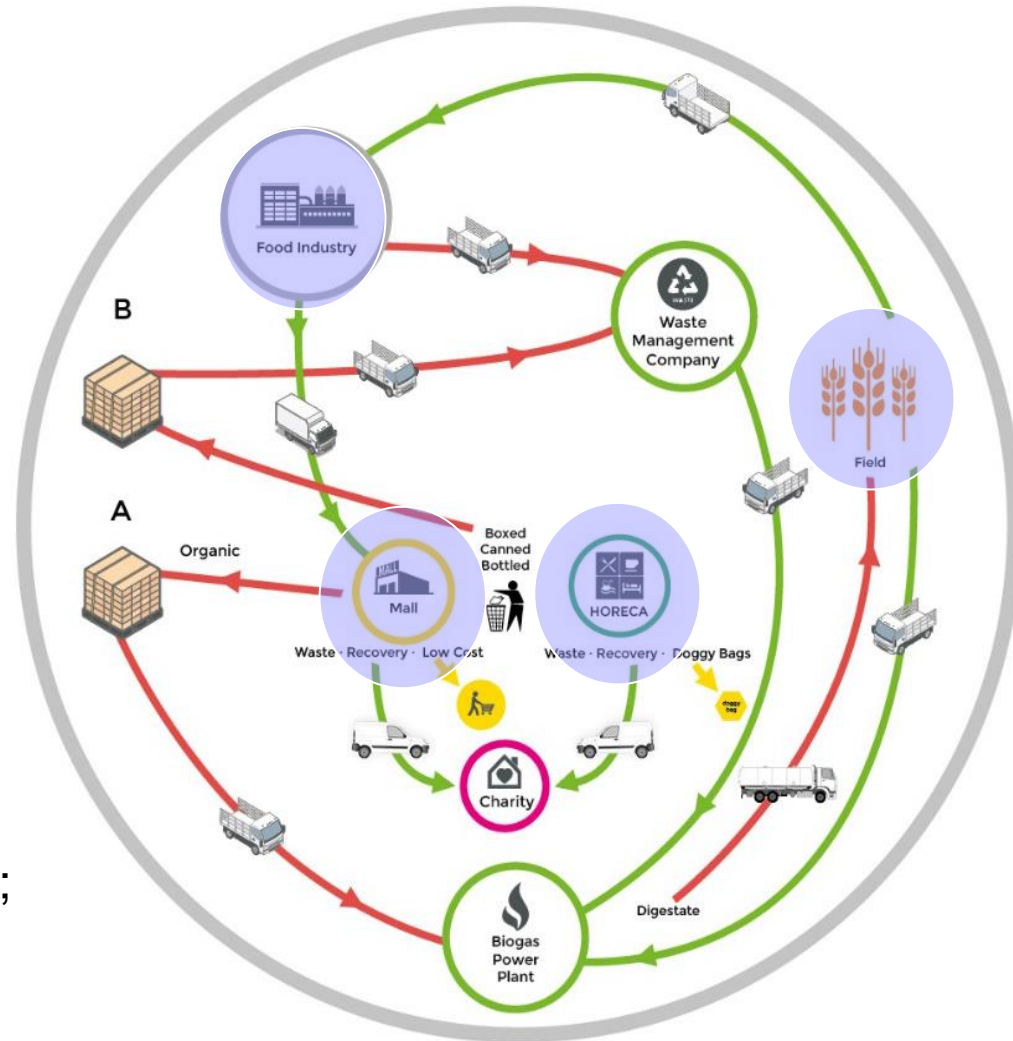
i-REXFO model based on the EU package on Circular Economy

Economy

Circular diagram of the i-REXFO approach

Waste 
Matter 

Food Waste Suppliers



Focus on:

- Food Industries;
- Farms;
- Retailers;
- HORECA;



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i-REXFO model based on the EU package on Circular

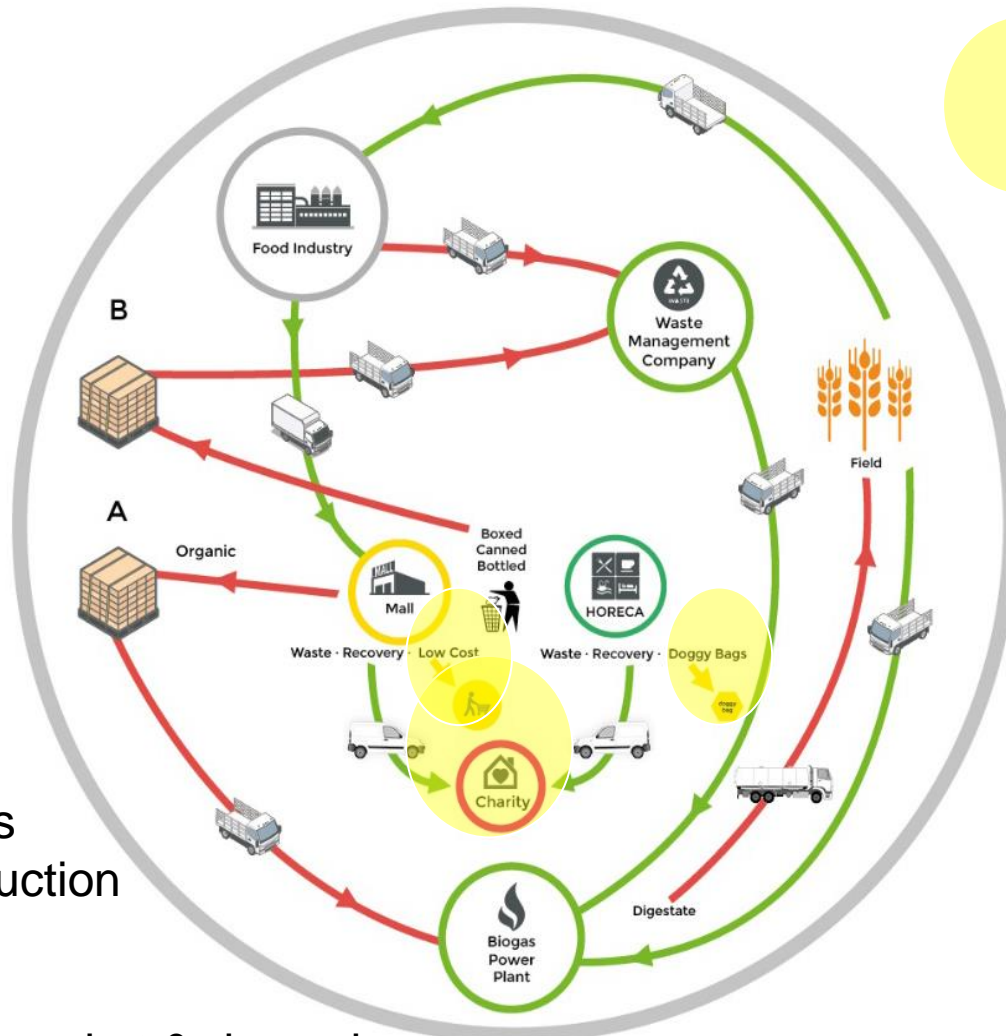
Economy

Circular diagram of the i-REXFO approach



Waste 
Matter 

Food Waste users



Actions towards food waste reduction

- ➔ training
- ➔ donations
- ➔ last minute market & doggy bags



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i-REXFO model based on the EU package on Circular

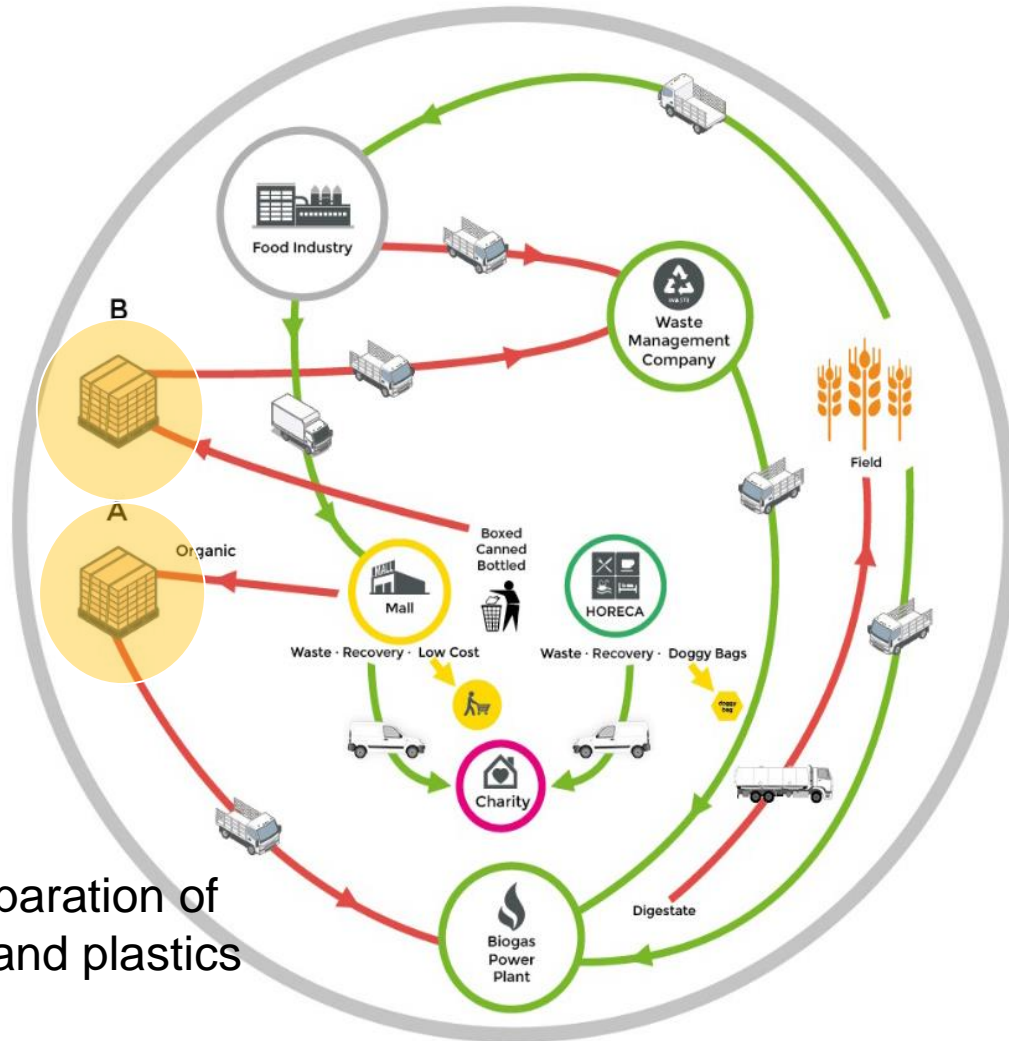
Economy

Circular diagram of the i-REXFO approach



Waste 
Matter 

Food Waste Collection



With packaging
➔ Requires separation of Cardboard, tin and plastics

Without packaging
➔ Directly used for biogas



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i-REXFO model based on the EU package on Circular Economy

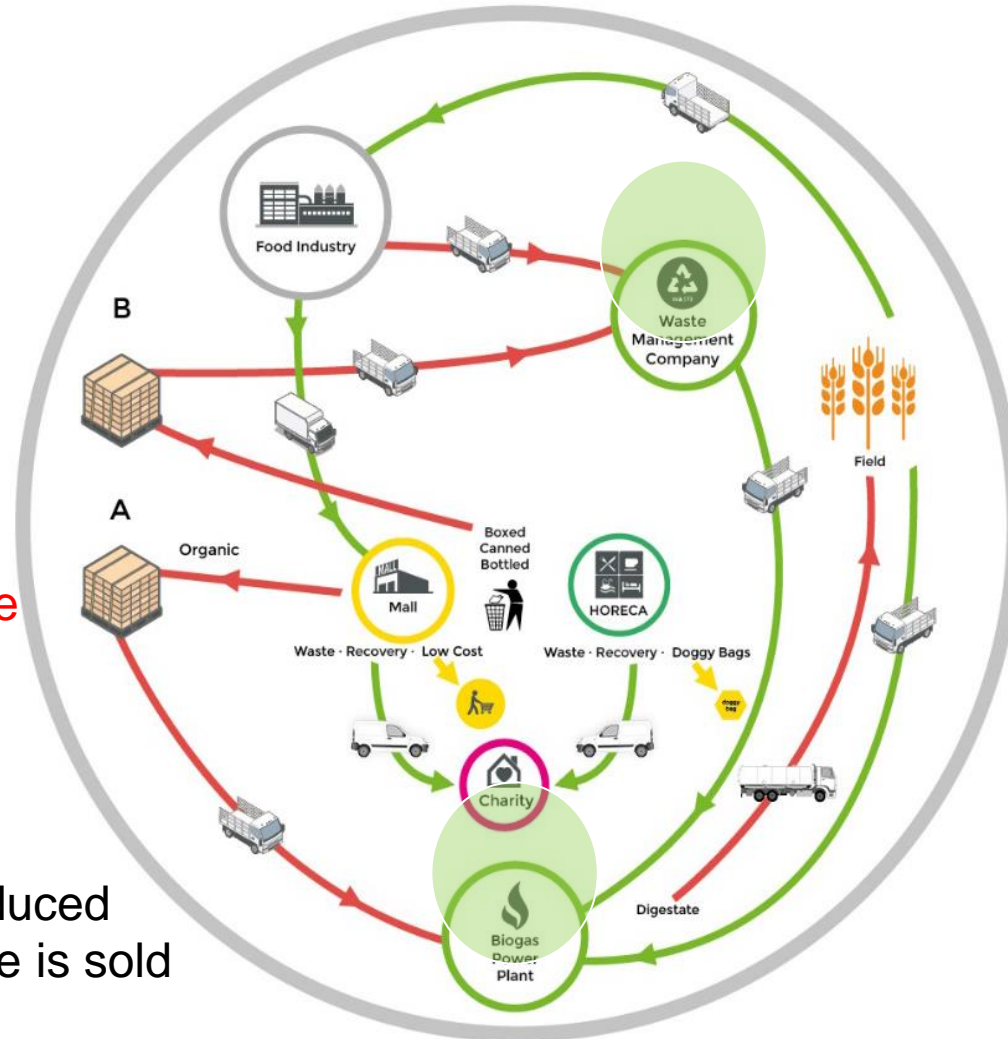
Circular diagram of the i-REXFO approach



Waste 
Matter 

Food Waste Recovery

Bioenergy produced from food waste is sold on the market





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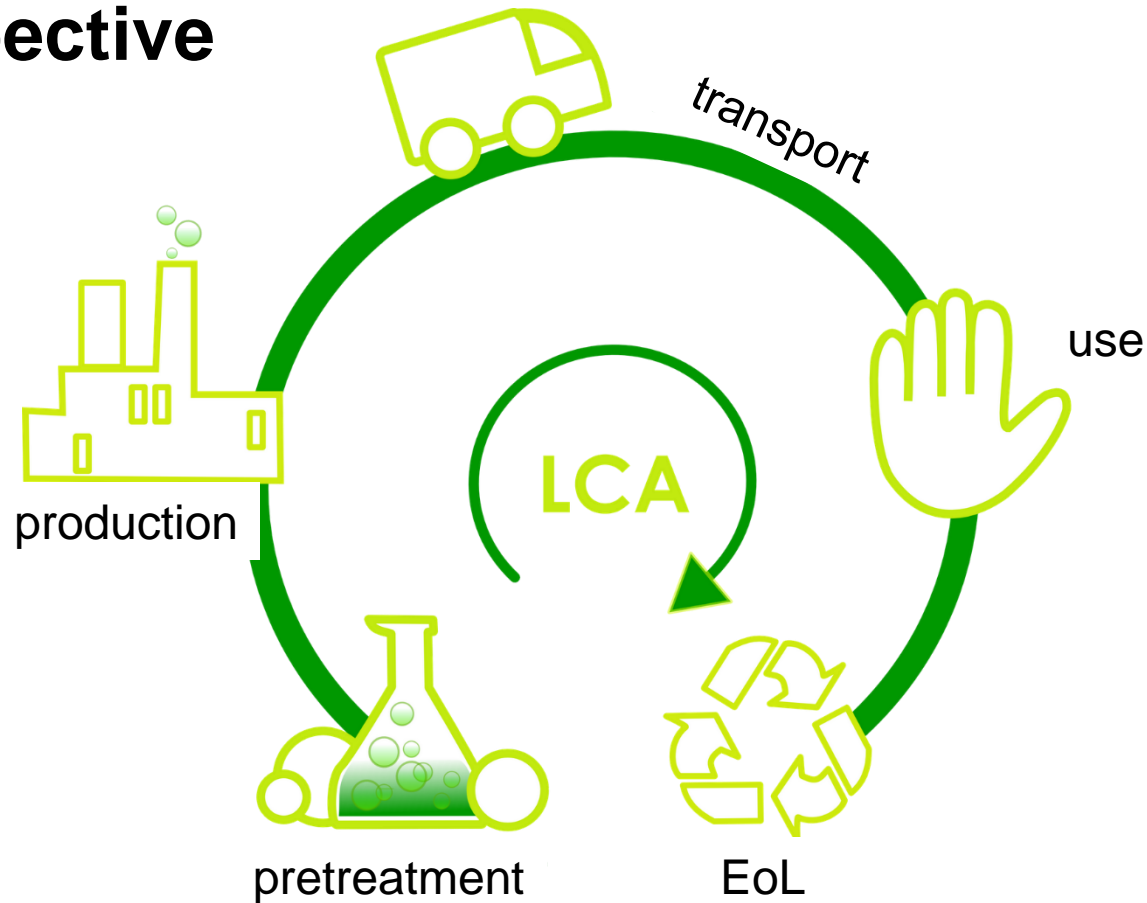


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iREXFO is optimised on a Life Cycle perspective



An OPEN SOURCE tool will optimize the:

- Technical performances;
- Economic performances;
- Environmental performances.



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i-REFO

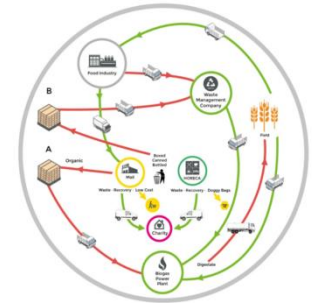
Increase in the REduction and REcovery of EXpired FOod

1. Trasferability tool



2. Design

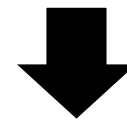
Circular diagram of the i-REXFO approach



Waste
Matter



Good practices: Denmark



4. Transfer - Hungary



3. Demo - Umbria





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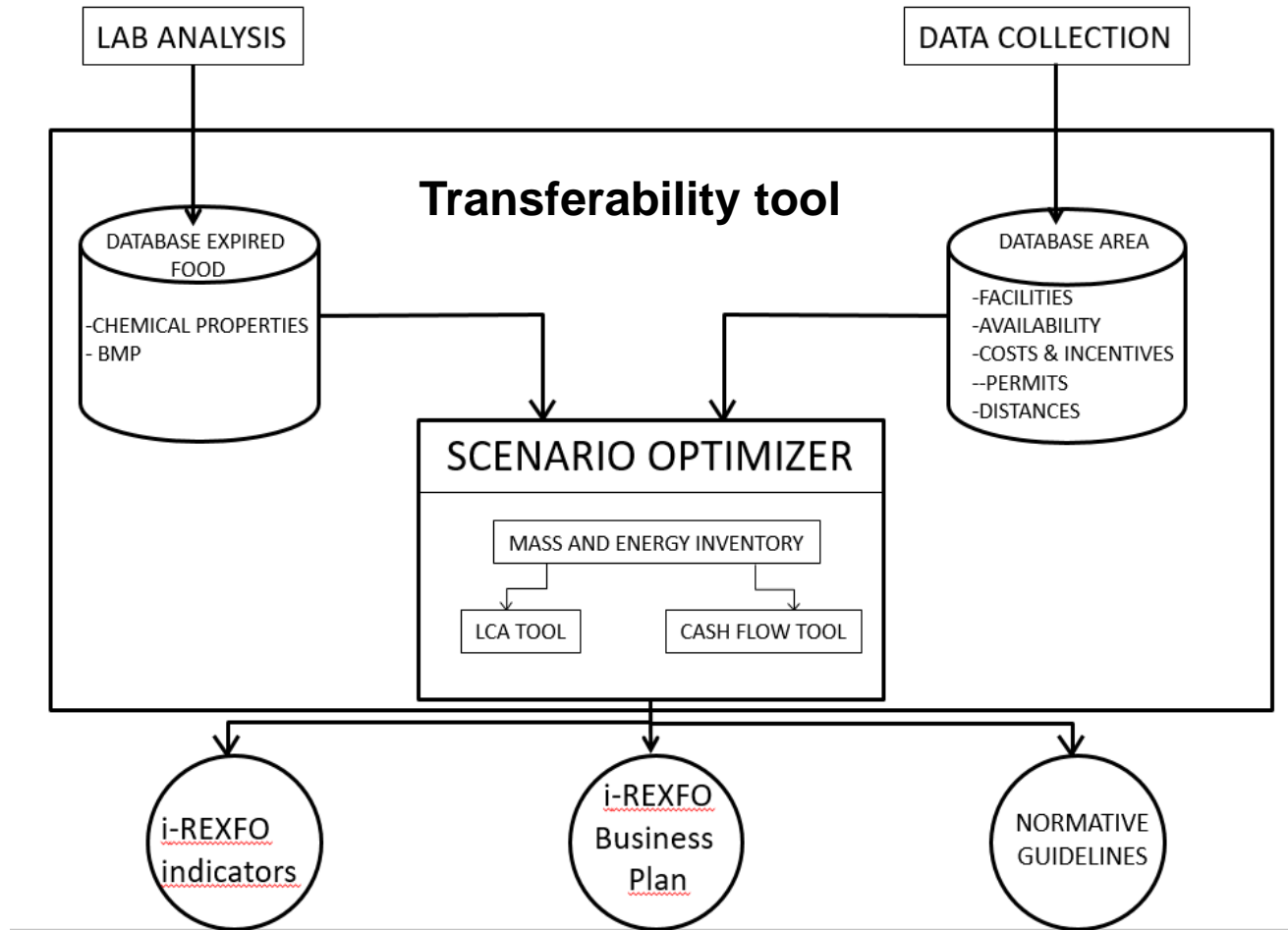


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Increase in the REduction and REcovery of EXpired FOod

1. The transferability tool





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OPTIMIZATION SOFTWARE

DATABASE - CHEMICAL AND PHYSICAL CHARACTERIZATION

Substrate: CHOCOLATE-PUDDING Chemical and physical characterization



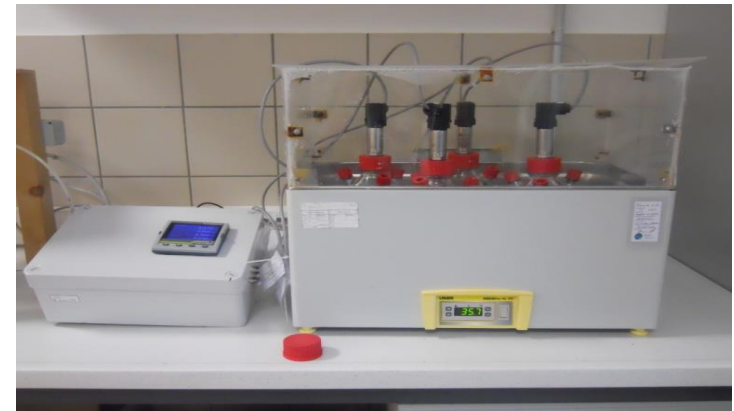
Ultimate analysis

C (%wb)	43.50
H (%wb)	8.89
N (%wb)	1.14
C/N	38.16

Proximate analysis

Moisture (%)	15.68
Total solids (%wb)	84.32
Volatile solid (%wb)	69.63
Asb (%)	1.19
Fixed Carbon (%)	13.51

TOC (%)	-
TKN (%)	-
Fat (%db)	-
Protein (%db)	-
Carbohydrate (%db)	-
TP (%db)	-
TK (%db)	-
pH	5.13

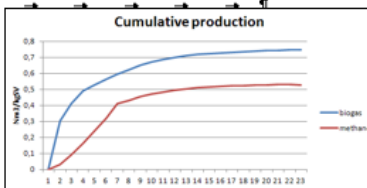


BIOMETHANE-POTENTIAL-TEST

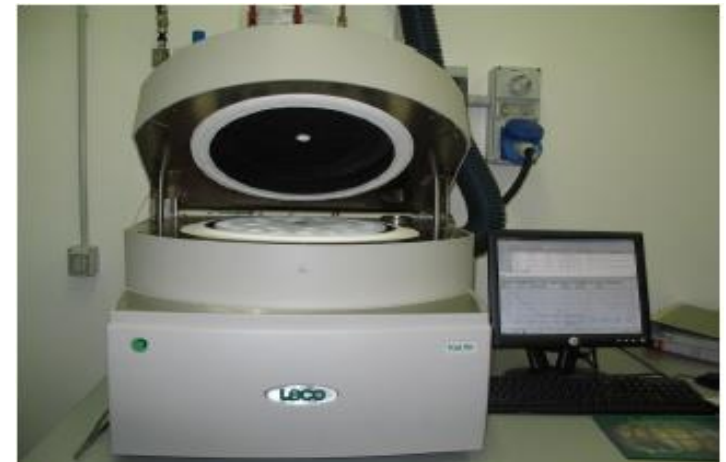
Experimental design

Substrate/inoculum ratio (VS-basis)	0.303
Temperature (°C)	40
Starting pH	7.75
Total Solids (wb) (%)	12.15
Volatile Solids (wb) (%)	9.06
C/N mixture	18.13

Results



Biogas yield	0.747-Nm ³ /kg SV
Methane yield (BMP)	0.527-Nm ³ /kg SV





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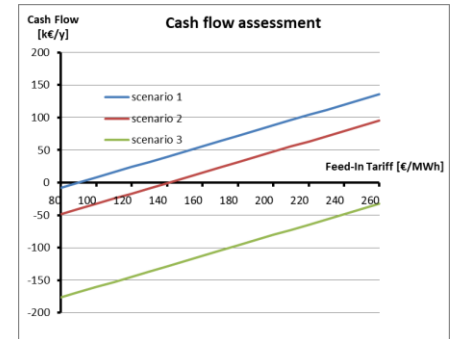
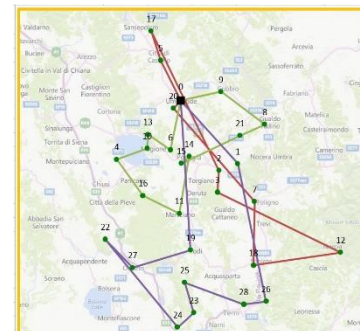
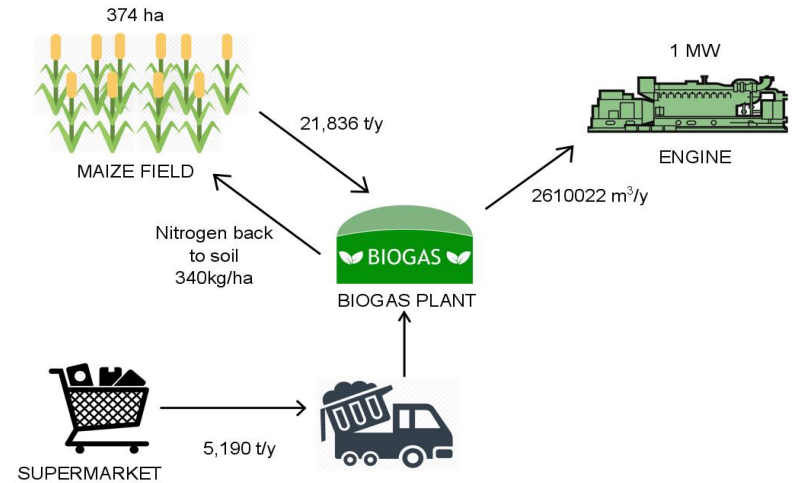
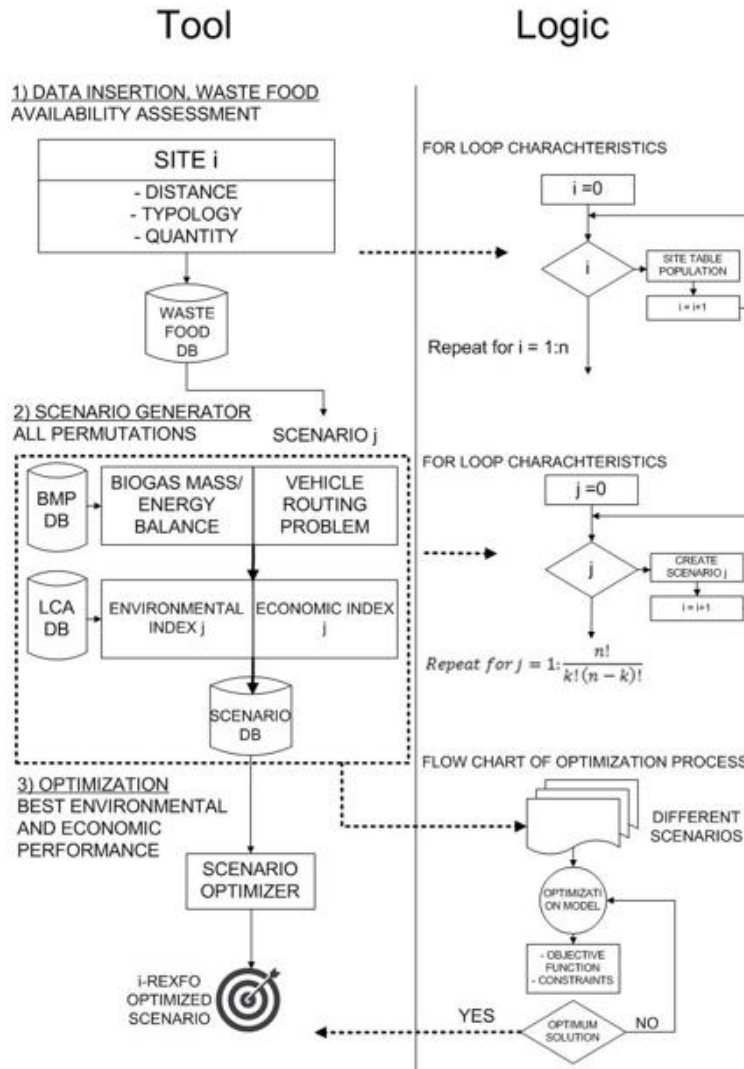


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2. DESIGN





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INTRODUCTORY PAGE

The screenshot shows a web browser window displaying the introductory page of the i-REXFO project. The page has a green background and features the text "i-REXFO" in large white letters, where the 'E' is replaced by a white spoon and fork icon. Below this, the text "increase in reduction and recovery of expired food" is written in a smaller white font. At the bottom center, there is a white circular button with the word "Start" in black text. The browser's address bar shows the URL "https://irexfo2.pythonanywhere.com". The Windows taskbar at the bottom of the screen shows various application icons and the system tray with the date "31/03/2021" and time "00:11".



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PROJECT INITIALIZATION

A screenshot of a web browser displaying the i-REXFO application. The browser address bar shows 'irexfo2.pythonanywhere.com/irexfo'. The page has a green header with 'i-REXFO' on the left and 'New Project', 'Account', and 'Logout' on the right. Below the header, there is a 'Create new Project' button. Underneath, there are two input fields: the first contains 'Project1' and the second contains 'Test'. The Windows taskbar at the bottom shows the search bar with the text 'Scrivi qui per eseguire la ricerca', several application icons, and the system tray with the date '31/03/2021' and time '00:11'.



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PROJECT INITIALIZATION

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DATA UPLOAD 1

The screenshot shows a web browser window with the URL `irexfo2.pythonanywhere.com/project/1/customer/new?`. The page title is 'i-REXFO' and the navigation bar includes 'Start' and 'About' on the left, and 'New Project', 'Account', and 'Logout' on the right. The main content area is titled 'New Supermarket' and contains the following form fields:

- Name:** A text input field.
- Food Type:** A list of checkboxes:
 - Fruit & Vegetables
 - Meat & Fish
 - Bread & Sweets
 - Canned food
 - Frozen food
 - Maize
- Address:** A text input field.

Below the address field, there is a red button labeled 'Add Quantities each Month' and a green button labeled 'Save'.

The Windows taskbar at the bottom shows the search bar with the text 'Scrivi qui per eseguire la ricerca', several application icons, and the system tray with the date '31/03/2021' and time '00:22'.



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DATA UPLOAD 2

The screenshot shows a web browser window with the URL `irexfo2.pythonanywhere.com/project/1`. The page has a green header with the text 'i-REXFO Start About' on the left and 'New Project Account Logout' on the right. The main content area is divided into two sections:

- Progetto: Project1**: This section contains two data entries, each with an 'Update' button.
 - misto**: Fruit & Vegetables Meat & Fish
 - supermercato2**: Bread & Sweets Canned food
- Follow this Steps**: A vertical list of four steps, each in a blue button with a plus sign:
 - 0) Add a Depot for this project +
 - 1) Add a Customer to current project +
 - 2) Total Quantity
 - 3) Locations
 - 4) Optimization

The Windows taskbar at the bottom shows the search bar with the text 'Scrivi qui per eseguire la ricerca', several application icons, and the system tray with the date '31/03/2021' and time '00:12'.



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DATA VISUALIZATION

The screenshot shows a web browser window displaying a data table for a project named 'supermercato2'. The table contains 7 rows of data, each representing a week. The columns include Bread & Sweets, Canned food, Total Waste Quantity, Methane Yields (m3), Profit(€), Electricity (kWh), Avoided maize (kg), and Avoided nitrogen (kg). The data is consistent across all weeks.

Week	Bread & Sweets	Canned food	Total Waste Quantity	Methane Yields (m3)	Profit(€)	Electricity (kWh)	Avoided maize (kg)	Avoided nitrogen (kg)
1	0.75	1.0	1.75	918.75	650.587	4066.167	6.125	0.088
2	0.75	1.0	1.75	918.75	650.587	4066.167	6.125	0.088
3	0.75	1.0	1.75	918.75	650.587	4066.167	6.125	0.088
4	0.75	1.0	1.75	918.75	650.587	4066.167	6.125	0.088
5	0.75	1.0	1.75	918.75	650.587	4066.167	6.125	0.088
6	0.75	1.0	1.75	918.75	650.587	4066.167	6.125	0.088
7	0.75	1.0	1.75	918.75	650.587	4066.167	6.125	0.088



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CALCULATION OF THE TOTALS

i-REXFO - Total Quantity

irexfo2.pythonanywhere.com/project/1/total?#total_waste

i-REXFO Start About New Project Account Logout

Total quantity

Project1

Methane Yields (m3) Avoided maize (kg) Avoided nitrogen (kg) Electricity (kWh) Profit(€) Food Waste

Methane Yields (m3)

Week	misto	supermercato2
1	277.5	918.75
2	277.5	918.75
3	277.5	918.75
4	277.5	918.75
5	277.5	918.75
6	277.5	918.75
7	277.5	918.75

Scrive qui per eseguire la ricerca

ITA 00:14 31/03/2021



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LOCATIONS

The screenshot shows a web browser displaying the 'i-REXFO - Locations' page. The browser address bar shows the URL 'irexfo2.pythonanywhere.com/project/1/locations?'. The page has a green header with 'i-REXFO' and navigation links 'Start' and 'About'. On the right side of the header, there are links for 'New Project', 'Account', and 'Logout'. The main content area features a map of the Perugia region, Italy, with a blue line representing a route. A white callout box over the map identifies a 'Biogas production plant' near Perugia. Below the map, there is a section titled 'Locations' with a sub-heading 'Project1' and the text 'List of Depots and Customers with geographic coordinates'. The Windows taskbar at the bottom shows the search bar with the text 'Scrivi qui per eseguire la ricerca', several application icons, and the system tray displaying the time '00:16' and date '31/03/2021'.



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FINAL RESULTS

The screenshot shows an Excel spreadsheet with a table of data and a summary dialog box. The table has columns AT, AU, AV, and AW, with rows 142 to 164. The summary dialog box, titled 'irexfo', contains the following data:

Quantity	Value
Annual Profit (€)	994591
Annual carbon footprint (kgCO ₂ eq)	547427
Annual water footprint (m ³)	148889
Annual ecological footprint (ha)	198518
Annual energy demand (MJ)	446666
Profit splitting quota	
Biogas plant (€)	933035
Charity (€)	59555
Communication Campaign (€)	50000
Avoided Food Waste (t)	49630



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i-REXFO Partners

 University of Perugia (CO)

 A + Srl. Outsourced marketing

 Biogáz Unió ZRT.

 Solidarietà Caritas Onlus

 Associazione di Volontariato

SAN MARTINO

 ECOPARTNER srl

 Hungarian Food Bank

Association

 Noesis snc

 Primetime Kommunikation A/S

 Regione Umbria

 Azienda Agricola Iraci Borgia



Communication strategy in IT

Transferability (EFE chain)

Pilot action on REF (charity)

Pilot action on REF (charity)

Pilot action on EFE

Waste pre-treatment

Transferability (REF chain)

Reporting and administration

Communication, good practice

Legislation and permit

Pilot action on EFE (biogas plant)





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<https://www.facebook.com/iREXFO/>

<https://twitter.com/iREXFO>



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Increase in the REDuction and REcovery of EXpired FOOd

www.irexfo.eu



budget:

2,324,915 Euro

Duration

September, 2017 - February, 2021



LIFE 16 ENV/IT/000547



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