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

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The objective of this paper is to present the development and design of an Excel tool needed to guarantee the long term optimization of food waste reduction in the framework of irexfo LIFE project. The tool will be used both in the demonstrative areas of implementation, Umbria Region (Centre Italy), and in the selected area for replicability and transferability. The objective of this work is the development of a user friendly package named transferability tool and consisting of a feasibility capable of evaluating both economic and environmental convenience of two types of chains:

- EFE chains, which mean Expired Food Energy chains;
- REF chains, which mean Reduction of Expired Food chains.

The transferability tool is designed to be tested in the first two years of the project in a pilot region (Umbria, Italy) and eventually used to transfer the i-REXFO approach to other European regions in the last year of the project. Moreover private commercial beneficiaries will be engaged as support to non-commercial beneficiaries.

The tool will be used to evaluate the feasibility of the REF and EFE chains for the stakeholders across the EU, who intend to implement these chains. It will provide first indications of the options available to reduce food waste when implementing i-REXFO model and its economic environmental and social impacts.
The tool is a calculator system developed by UNIPG characterized by two sections to evaluate the impacts of the chain implementation, starting by the food characterization, food availability, localization and typology (both expiring and expired). For both chains the tool will allow the optimization of the supply chain to minimize economic and environmental costs on a life cycle approach. The tool will help to design the i-REXFO approach by supporting key actors of both the EFE and the REF chains. The tool will contain a database of expired food properties that will be classified in food categories, according to the FAO classification and used in the EU project FUSION (Reducing Food Waste Through Social Innovation).
The database will be developed through literature data or laboratory test for Biochemical Methane Potential. This information will be essential to determine sludge dilution or concentration at the real plant. The analysis will be performed at the laboratories of the Biomass Research Center of the University of Perugia.
The database will provide methane yields from different food mixtures that are the base for the techno-economic and environmental design of EFE chains. Those will share the income produced from bioenergy sales with the REF chains, supporting their costs. The tool also calculates the investment cost, the transport cost (expressed in €/t), the saved disposal cost (expressed in €/t), energy production, environmental benefits and revenues, to allow the closing of the business plan.

TOOL DESCRIPTION

The tool developed by the Department of the University of Perugia is based on three main features:
1. A logistic optimization tool
2. A biogas yield calculator
3. An economic and environmental feasibility tool

For the logistics optimization it was used the software VRP Solver, developed by the University of Bath. It consists of the following Excel sheets: Locations; Distances, Vehicles, Solutions and Visualization. In the Locations sheet the coordinates (Longitude and Latitude) of each canteen have been reported. Data have been derived from the Bing Maps website.

The deposit from where the truck starts the route in this case is the biogas plant. So the software calculates at first the coordinates of the biogas plant and of the food waste suppliers, then the shortest route to collect all the waste food generated daily by the 5 supermarkets situated in the most relevant malls in the region and comes back to the starting point, which is the biogas plant. Once the locations are filled the spreadsheet will calculate the distances between each canteen and the biogas plant (data will be reported in the Distance Excel sheet). In The Vehicle sheet the characteristics of the used trucks will be inserted. In particular the capacity and the number of trucks used have to be specified. In the Solution Excel sheet the optimal route and its length are calculated.

The different types of food waste considered in this study were obtained from local supermarkets. The chemical–

physical properties were measured at the Analysis Lab of the Biomass Research Centre described in previous works [1], using a TGA 701 LECO for Proximate Analysis and Truspec CHN LECO for Ultimate Analysis. Moisture, Ash, Total Solids and Volatile Solids Content were determined according to UNI EN ISO 18134-2:2015, UNI EN ISO 18122:2016 and UNI EN 15148:2010; while the contents of carbon, hydrogen and nitrogen were determined according to UNI EN ISO 16948:2015. The characterization of the material was a preliminary step to analyse its biomethane potential in fact based on its proximate and ultimate analysis a mixture of inoculum and raw material was performed maintaining always a fixed concentration of volatile solids. The Biomethane Potential (BMP) assay can be used as an index of the anaerobic biodegradation potential as it is the experimental value of the maximum quantity of methane produced per gram of VS. This is analysed with the BMP test, which consists in measuring the bio-methane or biogas produced by a known quantity of substrates in batch conditions. The BMP tests were carried out in a multi-batch reactor system.

Here are shown the three screenshots of the final tool.

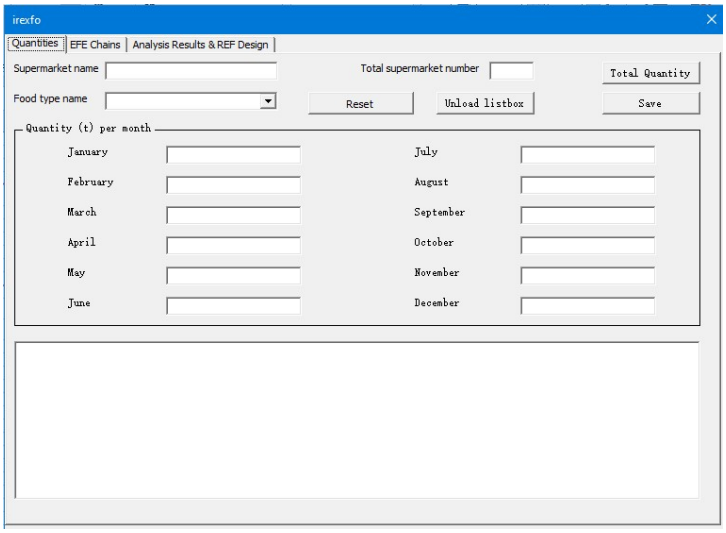

Figure 1: Assessment of FW production and biogas yields

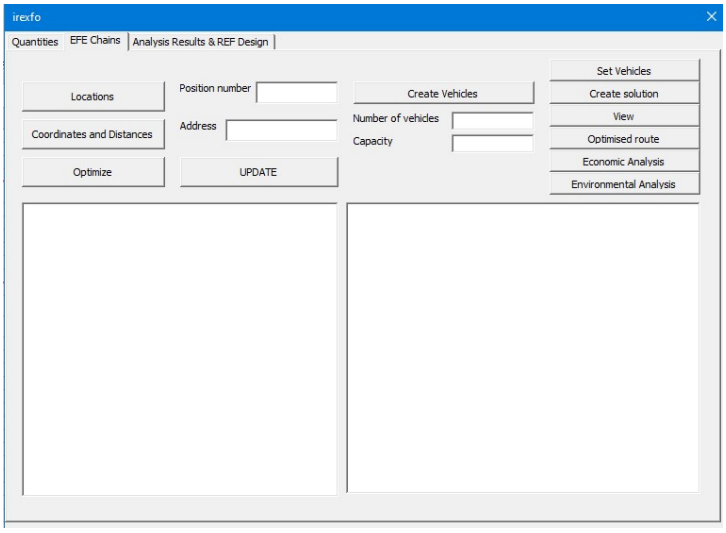

Figure 2: EFE chains desing tool

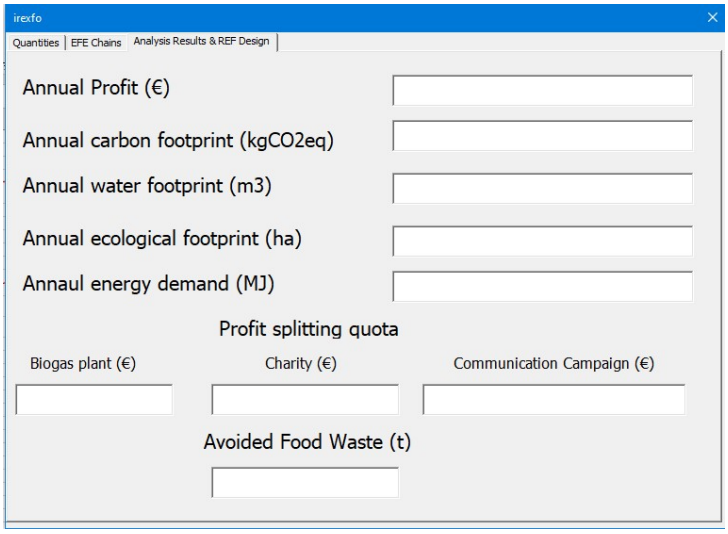

Figure 3: Analysis of results & REF chains design tool

Bibliography

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