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User manual of the DECISIVE decision support tool

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DECISIVE

A DECENTRALISED MANAGEMENT SCHEME FOR INNOVATIVE VALORISATION OF URBAN BIOWASTE

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A Decentralised Management Scheme for Innovative Valorisation of Urban Biowaste

D5.3 - User Manual of the DECISIVE Decision Support Tool

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PREFACE

This User's Manual was prepared within the framework of DECISIVE. It provides practical guidelines for the use of the DECISIVE Decision Support Tool available at https://dst.decisive2020.eu/. The tool aims at supporting the users in the selection of the most appropriate biowaste management option for a specific study zone.

Please, note that this report only describes the working procedure of the DST and is not supposed to describe the methodology behind the DST. The latter is described in the deliverable D5.1 "Methodology for planning of decentralized biowaste management behind the Decision Support Tool".

User's feedback for both the tool and the manual can be sent to the following email address: dst@decisive2020.eu

DISCLAIMER

Table of content

Abbreviations and Acronyms

AD	Anaerobic Digestion
BM_O	Biomass Output (from a pre-treatment process)
BP	Background Process
CF	Characterisation Factor
CHP	Combined Heat and Power
D	Deliverable
DST	Decision Support Tool
GHG	Greenhouse Gas
GIS	Geographic Information System
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
mAD	Micro Anaerobic Digestion
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
NA	Network Analysis
OPEX	Operational Expenditures
OSM	OpenStreetMap
REC_O	Recyclable Output (from a pre-treatment process)
REF_O	Refuse Output (from a pre-treatment process)
RW	Residual Waste
SSBW	Source Separated Biowaste (excluding garden waste)
SSGW	Source Separated Garden Waste (parts not included in the biowaste)
SSF	Solid State Fermentation
TII	Transport Intensity Index
WFD	Waste Framework Directive
WMZ	Waste Management Zone
WP	Work Package

Executive Summary

The present document constitutes the User Manual of the DECISIVE DST (released in September 2019). The User Manual starts with a description of the purpose of the tool (Section 2) and follows with a summary of the model architecture (Section 3). Sections 4, 5 and 6 describe the working procedure of the tool, i.e. the steps needed to carry out an assessment with the DECISIVE DST.

The main aim of the DST is assessing the performance of biowaste management options (including centralized and decentralized systems) in a specific area (e.g. municipality or district of a city). The results obtained with the tool will facilitate the comparison between the decentralised systems of biowaste valorisation proposed by DECISVE. To evaluate the performance of each biowaste management option, the tool uses various assessment criteria including environmental, economic, social and regulatory aspects.

The two aspects that differentiate the present DST from other existing ones are that concurrently assesses the three pillars of sustainability (environment, economy and social aspects) in a simplified manner and it considers within the assessment the spatial location of biowaste sources and facilities. The DECISIVE DST can also operate without spatial information using the *"Basic" mode* of the tool instead of the *"GIS" mode*.

The working flow of the DST is similar for both "*Basic*" and "*GIS" modes*. First, there is the *Getting Started* part where the user has the option to log in, sign up or recover username and password. Second, there are the definitions of the *Study Zone* and *WMZs*. Third, there is the *Definition of the Scenario*. After this first steps the user can define the *Spatial Inventory* or *Distance input* of the scenario. Finally, once the previous steps are defined, the *Mass Flow of the Scenario* and the *Assessment Results of the Scenario* are displayed.

- The *Study Zone Definition* is where the user selects the area of assessment with its biowaste generation points to be included in the assessment. Then, the user has the option to divide the total *Study Zone* into different W*aste Management Zones (WMZs)*, i.e. sub-areas of the study zone with the same type of biowaste management systems, in the *WMZs Definition*.
- Then the user models the technological pathway that represents the biowaste management scenario to be assessed in the *Scenario Definition*. This is done by selecting a process inventory for each biowaste management stage (generation, source separation, collection, treatment, transportation, final disposal and bio-based products use) that represents the specific situation to assess. The user can either use the waste process inventories already included in the *Waste Process Databases* of DST (i.e. inventories developed by the DECISIVE consortium) or create new inventories and save them in such databases before using them in the simulation.
- After the *Scenario Definition*, the user provides information regarding the collection and transportation distances of the scenario in the *Spatial input (or Distance input)* step.
- Finally, the tool calculates and displays two types of results for each scenario:
    - The *Mass Flow of the Scenario*, which refers to the amounts of biowaste, nutrients and macro-impurities that flow between the different biowaste management stages.
    - The *Assessment Results of the Scenario*, which shows the values of the assessment criteria for the specific *Study Zone* and *Scenario*. It includes: Climate Change, Economic Cost, Local Labour, Space Requirement, Sorting Time, Set of Energy Recovery and Transportation Intensity Indexes, and Compliance of Bio-based Product with the Regulation Limit.

There are three differences between the working procedures of the "*Basic*" and *"GIS" modes*:

I. With the *"Basic" mode* the *Study Zone Definition* only has to include the *Biowaste Generation Sources* used in the simulation, while for the *"GIS" mode* the user has to assign the spatial location of each biowaste source.
II. In the *Scenario Definition* the *"Basic" mode* requires the user assigning a waste process inventory to each waste management stage of the scenario (i.e. the geographical location does not have to be defined). Contrary, when using the *"GIS" mode* the spatial locations of the waste

facilities (including pre-treatment, treatment and final disposal) as well as the location where the bio-based products are used (e.g. agricultural land) must be provided by the user.

III. For the collection and transportation distances, the user will use the *Spatial Inventory Input* when working with the *"GIS" mode* to choose one of the two formulas for the calculation of distances and the "*Average Distance Input*" when working with the *"Basic" mode.*

1. Introduction

The DECISIVE project aims at increasing the recovery of nutrients and energy present in the biowaste generated in cities. The project proposes two holistic changes in the current biowaste management schemes adopted by European cities to achieve such goal. First, it suggests moving towards a circular economy in which organic matter and nutrients are returned to agricultural soil in the form of high quality bio-based products while minimizing the presence of pollutants. Second, it plans moving towards small decentralised production/recovery units, which are located closer to the biowaste generators. Thus, the objective of DECISIVE is implementing more flexible management systems, which are particularly suitable to local needs and can contribute to more resilient urban areas with a lower environmental footprint.

The project aims at developing:

1) A novel, eco-designed and marketable technology-package including a micro-scale anaerobic digestion treatment process (mAD) and a solid-state fermentation (SSF) process to produce valuable bio-based products such as bio-pesticides and bio-fertilisers from the digestate, as well as a Stirling engine to produce electricity and heat from biogas.
2) A Decision Support Tool (DST) for planning and reporting of decentralised biowaste management systems for urban areas.
3) Communication and training material to inform and engage urban biowaste generators (households, food service sector, and commercial activities) about the principles that inspired the DECISIVE project.
4) Characterization and analysis of two demonstration sites where the new technologies (micro-AD, SSF and Stirling engine) as well as the methods and tools will be implemented and tested; the two sites selected are in Lyon (France) and Catalonia (Spain).

The deliverable D5.1 "Methodology for planning of decentralized biowaste management behind the Decision Support Tool" describes the DST methodology (see the objective 2 above), while the present document constitutes its User Manual. Both documents refer to the version of the tool released in September 2019. English is the only language used in this first version of the tool.

The present User Manual starts with a description of the purpose of the tool (Section 2) and follows with a summary of the model architecture (Section 3). Sections 4, 5 and 6 describe the working procedure of the tool, i.e. the steps needed to carry out an assessment with the DECISIVE DST. Annex I includes a terminology Glossary.

2. Purpose of the DECISIVE tool

The main aim of the DST is assessing the performance of biowaste management options (including centralized and decentralized systems) in a specific *Study Zone*. The latter is the area where the assessment is focussed on (e.g. municipality or district of a city). The results obtained with the tool will facilitate the comparison between the decentralised systems of biowaste valorisation proposed by DECISVE (see objective 1 in Section 1) and other biowaste management options. To evaluate the performance of each biowaste management option, the tool uses various assessment criteria including environmental, economic, social and regulatory aspects (described in Section 5.5).

The DST, as the DECISIVE project, is centred on the biowaste fraction of the municipal solid waste. The DST includes the management of the materials considered within the definition of biowaste in the Waste Framework Directive. Point 4 of Article 3 of the Waste Framework Directive (WFD) defines Biowaste as the "*biodegradable garden and park waste, food and kitchen waste from households, restaurants, catering and retail premises and comparable waste from food processing plants".* Therefore, biowaste does not include waste paper or cardboard (e.g. newspapers) and wood waste (e.g. pieces of furniture), unlike the definition of "biodegradable waste" provided in Article 2(m) of the Landfill Directive (Council Directive 1999/31/EC).

The DST takes into account the impacts associated with all stages of the biowaste management system, (i.e. biowaste generation, source separation, collection from generation sources to the first waste facility,

pre-treatment, treatment, final disposal, bio-based products use as well as transportation between the different waste facilities). It accounts for the impacts related to emissions and resources consumed (e.g. electricity, fuel, machinery) within the biowaste management system as well as the avoided productions of the goods (material and energy) substituted by the outputs generated from the biowaste management system (i.e. bio-based products and energy), such as mineral fertilizers. The DST also considers the management of the micro- and macro-impurities that are thrown away together with the source separated biowaste due to sorting errors.

The target users of the DECISIVE DST are authorities, consulting firms and waste operators that can use the tool to simulate different biowaste management scenarios. Such scenarios consist of technological pathways used to manage the biowaste. Most of the users are expected to simulate a *Baseline Scenario* and one (or more) *Alternative Scenario(s)* and compare the results. The *Baseline Scenario* refers to the performance of the biowaste management system in place (or the one initially planned). The results of its assessment could help, for example, to identify the critical points of the current (or planned) management. The comparison among different alternatives with the baseline will inform about the existence of objective reasons to change the management system in place (or the planned one), based on the assessment criteria described in Section 5.5 (e.g. climate change and cost).

Although there are different DSTs available to assess the environmental sustainability of biowaste management systems, see Vea et al. (2018) for a complete review, none of them concurrently assesses the three pillars of sustainability (environment, economy and social aspects) in a simplified manner and considers within the assessment the spatial location of biowaste sources and facilities. These two aspects differentiate the present DST from other existing ones. It should be mentioned, however, that the DECISIVE DST can also operate without spatial information using the *"Basic" mode* of the tool instead of the *"GIS" mode*. These two modes are introduced in Section 3.

The DECISIVE DST gives freedom to build up scenarios (as well as process inventories) based on the users' wishes while respecting the working flow of the tool. The user is responsible for simulating scenarios in line with the reality and the given legal and technical constraints specific to the study zone under investigation. Users should dedicate special attention to understand the context of the project and consider it carefully while modelling the potential scenarios in the DECISIVE DST. One key aspect to consider is the effect of new biowaste management options on existing (and not saturated) biowaste management infrastructures in the surrounding area.

EXAMPLE 1: Imagine a project with two scenarios: 1) Baseline Scenario representing the biowaste management system in place in the Study Zone in which 100% of the biowaste generated is treated in Facility A and 2) Alternative Scenario representing a case in which Facility A only treats 75% of the biowaste generated in the Study Zone and the remaining 25% is treated with a DECISIVE technology scheme (i.e. mAD + SSF). Then, the user of the DECISIVE DST has to consider that in the Alternative Scenario, Facility A would receive less waste than currently (Baseline Scenario) and this would have some consequences for such facility. The user could either assume that the freed capacity in Facility A will be used for biowaste coming from another area (at no cost) or consider the extra cost associated with having Facility A working at a lower capacity than previously (by readjusting the inventory used in the DST for Facility A).

In addition, the user of the DST should be aware of the fact that the DECISIVE DST is meant to provide a first assessment of the scenarios modelled based on the data available in the DST and data introduced by the user. Simple assumptions and simplifications of real biowaste management systems were necessary when developing the DST, during the data processing as well as in the simulation phase. These should be considered when interpreting the results.

Finally, the user should also be aware that the DST evaluates the scenarios using a specific set of indicators (assessment criteria) that cannot capture all of the possible differences in the performance of the biowaste management scenarios.

EXAMPLE 2: If the main difference between two biowaste management scenarios is on the water consumption, the DST will show no difference between both scenarios since water is not a criterion embedded within the set of assessment criteria used in the DECISIVE DST (Section 5.5 describes the indicators included).

3. Model architecture

Figure 1 presents the model architecture of the DECISIVE DST. The user provides the information required by the DST for the simulation in the purple boxes, using the information available in the DST or adding new one in the different databases of the DST (orange boxes). With such information and the use of waste properties and factors included in the DST (yellow boxes), the tool calculates the assessment results (green boxes).

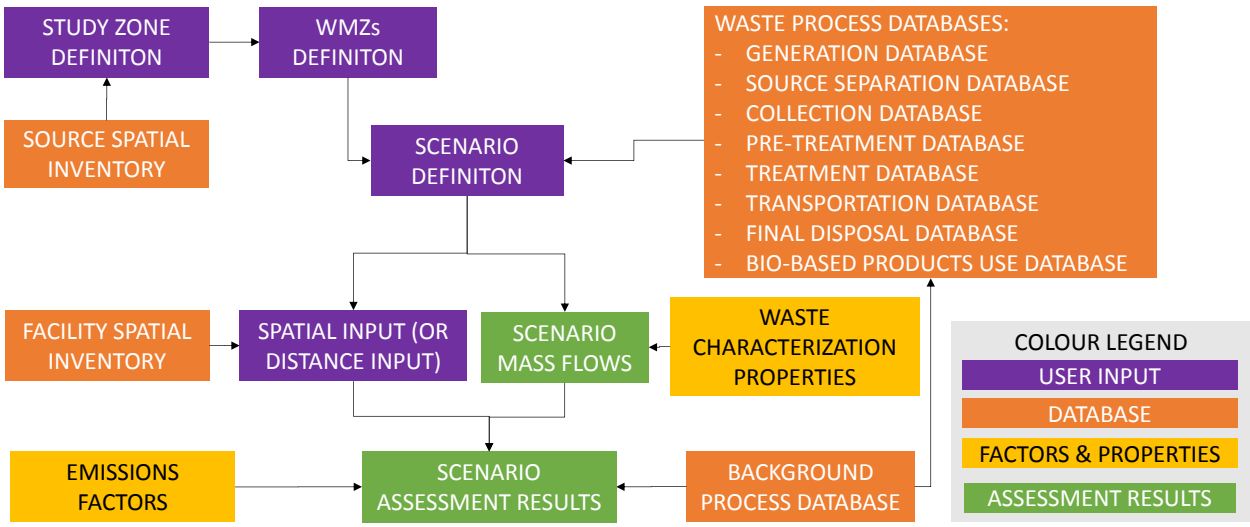

Figure 1: Representation of the DST architecture

The *Study Zone Definition* is where the user selects the area of assessment with its biowaste generation points to be included in the assessment. Then, the user has the option to divide the total study zone into different W*aste Management Zones (WMZs)*, i.e. sub-areas of the study zone with the same type of biowaste management systems, in the *WMZs Definition*.

EXAMPLE 3: Imagine a Study Zone where some biowaste generators carry out home-composting with their biowaste and the biowaste generated from other generators is collected with door-to-door collection scheme and brought to a centralised anaerobic digestion (AD) facility. This situation would be modelled with two WMZs one representing the decentralized management (home-composting) and another representing the centralized management (door-to-door and centralized AD).

Once the *Study Zone* and the *WMZs* are defined, the user models the technological pathway that represents the biowaste management scenario to be assessed in the *Scenario Definition*. This is done by selecting a process inventory for each biowaste management stage (generation, source separation, collection, treatment, transportation, final disposal and bio-based products use) that represents the specific situation to assess. The user can either use the waste process inventories already included in the *Waste Process Databases* of DST (i.e. inventories developed by the DECISIVE consortium) or create new inventories and save them in such databases before using them in the simulation. Thus the user will always be able to use the data available in the DST or its own data. The inventories created by the user will not be visible and accessible to other users unless specific permission is granted (see the Disclaimer

of the present deliverable). The latter applies to the inventories included in the 3 types of databases of the DST: *Waste Process Database, Background Process Database and Spatial Inventory Database*.

1) The *Waste Process Database* includes waste process inventories for the different waste management stages (generation, source separation, collection, treatment, transportation, final disposal and bio-based products use). The type of data in each inventory depends on the waste management stage described (i.e. a generation inventory includes different parameters than a transportation inventory), but all of them include: key characteristics, mass flow parameters, material and energy inputs and outputs, emissions, socio-economic aspects and capital goods.
2) The *Background Process Database* includes simplified inventories of *Background processes* that are external to the waste management system (WMS). The external processes generate products consumed in the WMS (e.g. diesel) or substituted by the bio-based products obtained with the WMS (e.g. avoided production of mineral fertilizers replaced by bio-based fertilizers produced in the context of the WMS). The waste process inventories include consumptions and substitutions of *Background Processes* as material and energy inputs and outputs. The user can not add or edit the *Background Processes* available in the DST.
3) The *Spatial inventories Database* includes two databases: *Source Spatial Inventory* and *Facility Spatial Inventory.* While the first lists the spatial locations of biowaste sources in the countries of the DECISIVE consortium, the second summarizes the spatial locations of different waste facilities in the countries of the DECISIVE consortium. The user can not add or edit the spatial locations available in the DST.

After the *Scenario Definition*, the user provides information regarding the collection and transportation distances of the scenario in the *Spatial input (or Distance input)* step. The user has to either provide information regarding the spatial location of sources and facilities or give directly the average distances. This will depend on the working modes chosen by the user. The DST has two working modes: "*Basic*" and "*GIS*".

When working with the *"Basic" mode*, the DST disregards the spatial aspects of the biowaste management scheme and calculates the assessment results with the average collection and transportation distances of the scenario provided by the user (*Average Distance* input). In the *"GIS" mode* the DST takes into account the spatial information of the biowaste sources and waste facilities (provided by the user) to calculate the collection and transportation distances of the scenario. The user can select sources and facilities from the *Spatial Inventory Databases* (i.e. *Source Spatial Inventory* and *Facility Spatial Inventory*) or add specific locations of sources manually in the map displayed in the DST.

Finally, the tool calculates and displays two types of results for each scenario:

1) The *Mass Flow of the Scenario*, which refers to the amounts of biowaste, nutrients and macro-impurities that flow between the different biowaste management stages. These amounts are calculated with the information given in the *Study Zone Definition*, the *Scenario Definition* and the *Waste Characterization Properties.* The latter includes the chemical properties of different biowaste and macro-impurities sub-fractions.
2) The *Assessment Results of the Scenario*, which shows the values of the assessment criteria for the specific *Study Zone* and *Scenario*. The assessment criteria are described in Section 5.5 and include: Climate Change (kg CO2-eq), Economic Cost (€), Local Labour (hours), Space Requirement (m^2), Sorting Time (h), Set of Recovery and Intensity Indexes, and Compliance of Bio-based Product with the Regulation Limit. The results are calculated with the *Scenario Mass Flow*, by relying on values in the waste process inventories, unit impacts of the background processes consumed in each waste process as well as the *Emission Factors*. The latter lists the Global Warming Potential of all emissions included in the tool.

Once the *Assessment Results* of one scenario are obtained, the user can simulate another scenario and when obtaining the assessment results of the second scenario proceed with the comparison outside the tool.

4. Working Procedure

Figure 2 represents the working flow of the DST for both "*Basic*" and *"GIS" modes*. First, there is the *Getting Started* part (grey boxes) where the user has the option to log in, sign up or recover username and password. Second, there are the definitions of the *Study Zone* and *WMZs* (yellow boxes). Third, there is the *Scenario Definition*. After this first steps the user can define the *Spatial Inventory* or *Distance Avarage input* of the scenario (grey boxes). Finally, once the previous steps are defined, the *Scenario Mass Flow* and the *Scenario Assessment Results* are displayed (purple box).

There are three differences between the working procedures of the "*Basic*" and "*GIS" modes* (blue text in Figure 2):

1. With the "*Basic*" *mode* the *Study Zone* definition only has to include the *Biowaste Generation Sources* used in the simulation, while for the *"GIS" mode* the user has to assign the spatial location of each biowaste source. Spatial locations have to be chosen using the *Source Spatial Inventory Database* or selecting their position on the map.
2. In the *Scenario Definition* the *"Basic" mode* requires the user assigning a waste process inventory to each waste management stage of the Scenario (i.e. the geographical location does not have to be defined). Contrary, when using the *"GIS" mode* the spatial locations of the waste facilities (including pre-treatment, treatment and final disposal) as well as the location where the bio-based products are used (e.g. agricultural land) must be provided by the user. The location of the *Generation* and *Source Separation Processes* in the *Scenario Definition* is not needed, since they are assumed to be those defined in the *Study Zone Definition*. The collection and transportation processes are not associated with specific spatial locations, but they have associated distances between the loading point (origin) and unloading point (destination). It should be clarified that in the DST collection and transportation processes are different. *Collection process* refers to the gathering of the waste from the different biowaste sources, loading, transport and unloading of the waste in a waste treatment facility. *Transportation process* refers to the transportation of the waste between waste facilities or the transfer of bio-based products from waste treatment facilities to locations where the bio-based products are used.
3. For the collection and transportation distances, the user will use the *Spatial Inventory Input* when working with the *"GIS" mode* and the "*Average Distance Input*" when working with the *"Basic" mode*. In the first case the user only has to choose one of the two formulas for the calculation of distances. The first option represents the case "single biowaste source to facility" in which the biowaste from each source is collected alone and brought to the waste facility (e.g. mAD) (Figure 44 - Left). The second option assumes that the collection is done from source to source and from the last source to the first waste facility (Figure 44 - Right). In the second case the user has to manually indicate the average distance for each collection and transportation process included in the *Scenario Definition*.

In the *Scenario Definition* the user has to assign a waste process inventory to represent each stage of the waste management system. The inventory includes: Generation, Source Separation, Collection, Pre-treatment, Treatment, Transportation, Bio-based product Use and Final Disposal. In the *Scenario Definition* the user has the option to skip different processes. For example, it can be that with the collection truck the waste is directly brought to the treatment facility, skipping pre-treatment or it can also be that the transportation between pre-treatment and treatment is not included since both activities occur in the same location. A treatment unit can generated a bio-based product or/and a residue. The bio-based product can be sent to a "bio-based product use" or "Final Disposal" processes, while the residues should always be sent to a "Final Disposal" process. Bio-based products include digestate and biopesticides.

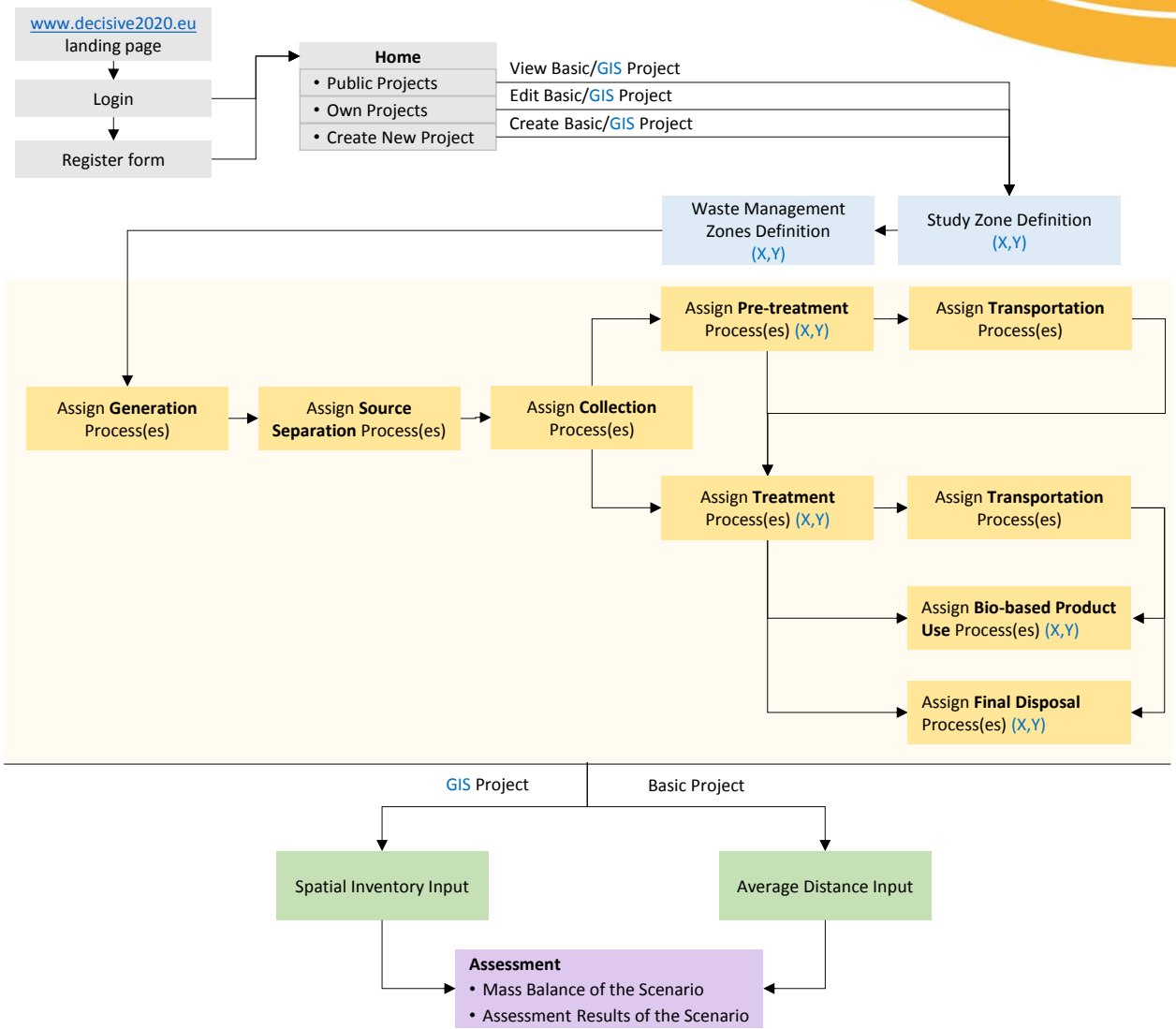

Figure 2: Representation of the working flow of the DECISIVE Decision Support Tool

4.1. Getting started

The homepage of the DECISIVE DST is illustrated in Figure 3 and has three main parts: a *Menu* in the left side, a *Project list* in the centre of the screen, and the option to *Create New Project* in the top-right corner of the screen. In the menu bar the user can select different options: *Projects List, Glossary, Emission factors, Waste Characterization Properties* and *Waste Process Documentation*. A description of each of these options is included below.

The user can go back to the home page by selecting *Projects List* in the menu**.** The DECISIVE DST has two main types of project: *Private projects* and *Public Projects*.

- The *Private Projects* tab lists all the projects created previously by the user. This type of projects can be: *viewed, edited, duplicated, shared* or *deleted* only by the user. In addition, the user has the option to *Upload file* to associate a documentation related to the specific project in form of pdf or compressed file and an option to *Download file* (only when a file was uploaded previously). The *Share* option is given to the user as a possibility to allow other users of the DECISIVE DST to see and use the specific project. Once the user selects this option, the administrators of the tool will evaluate the documentation of the project and the interest that other users could have on it and decide whether to share it with other users or not. While the administrators decide where to convert a *Private Project* to a *Public Project*, the project will remain blocked for edition. User are recommended to make a duplicate of the project before selecting the option “Share” if they want

to keep on working/editing the project. To share a project with other users the uploading of documentation is *compulsory*.

- The *Public projects* tab lists all the examples of projects created by the tool developers. *Public projects* can only be viewed or duplicated by the user and their documentation can be downloaded. If the users and the administrators of the tool decide to share a *Private Project* with other users, it will become a *Public Project* and appear under the corresponding tab.

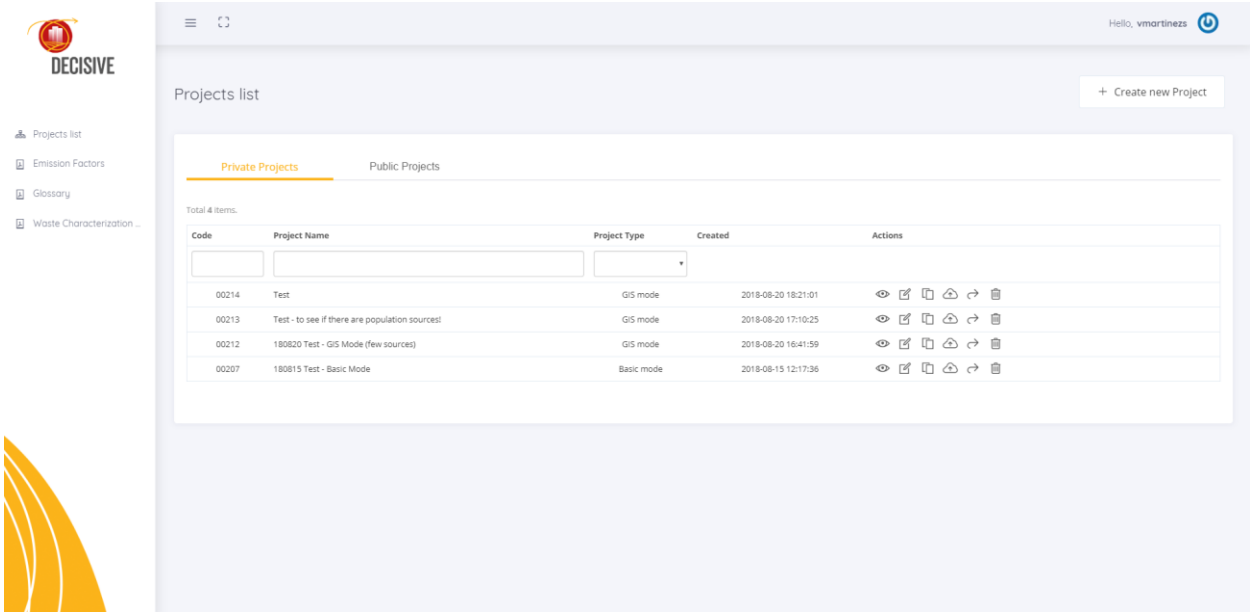

Figure 3: Home page of the DECISIVE DST. Source: https://dst.decisive2020.eu

Further options given in the menu list on the left-side of Figure 3 (i.e. *Waste Process Documentation, Glossary, Waste Characterization Properties and Emission Factors*) have informative values only and cannot be modified by the users. The *Waste Process Documentation* summarizes all the data used to develop the waste processes available in the DECISIVE DST. The *Glossary* lists key terms used in the tool together with their abbreviations and definitions (Annex I). The *Waste Characterization Properties* summarizes the chemical properties of the different biowaste sub-fractions and macro-impurities used for the calculations of mass flows. The *Emission factors* lists the Global Warming Potential of different emissions included in the tool.

When the user selects the *Create New Project* option (top right corner of Figure 3), the DST directs the user to the new project screen and asks to provide a name to the project and choose the project type: "*GIS*" or *"Basic" mode*. After that having named the new project (and selected the type), the user starts with the project definition using the *"Basic" mode* (described in Section 5) or the *"GIS" mode* (described in Section 6).

5. Basic Mode – Working Procedure

The working procedure in the *"Basic" mode* includes the main steps shown in Figure 2: 1) Study Zone Definition, 2) Waste Management Zone Definition, 3) Scenario Definition, 4) Average Distance Introduction, and 5) Assessment results. Each step is described in the following subsections.

5.1. Study Zone Definition

Figure 4 illustrates the *Study Zone Definition* of a project developed in *"Basic" mode*. This first step aims at selecting the *Biowaste Generation Sources* to be included in the assessment. To perform such selection the user has to add all the biowaste generation sources with the option *Add Biowaste Generation Source* (in the top right corner of Figure 4). The user can either create a new source (upper part of Figure 5) or copy one from the *Biowaste Generation Source Database* (lower part of Figure 5).

Such database includes sources created previously by the same user and sources added by the DECISIVE consortium.

When creating a new *Biowaste Generation Source* the user has to provide *Name of the Biowaste Generation Source, Type of Biowaste Generation Source* (e.g. restaurant), *Amount* of source (e.g. 1) and *Unit of the Amount* (e.g. Restaurant), Figure 5. The *Amount* represents the number of sources of the same type (e.g. 100 households or 5 restaurants) that will be simulated together, i.e. with the same inventories from generation to final disposal. In this step, the user only has to provide this amount, while in the next step (the *Scenario Definition)* the user will assign the appropriate inventory for *Generation Process*. The *Generation Process* will be based on the type of *Biowaste Generation Source* where the amount of biowaste generated is reported together with its composition. The user has freedom to build any type of *Biowaste Generation Source*, e.g. Population (type), 100 (amount), inhabitants (unit) or Population (type), 1 (amount), and building (unit). But this choice will determine which type of Generation Process can be assigned later on to this *Biowaste Generation Source*. In the first example, the *Generation Process* will report amount of biowaste per inhabitant, while in the second one the Generation Process should report the amount of biowaste per building (with a specific amount of inhabitants living in it).

If a group of generators are modelled as one source (e.g. 5 restaurants) all of them will have the same generation process associated, meaning that they should have same amount of biowaste generated (tonnes/year) and composition. If they have different sizes, they should be modelled as separated sources.

EXAMPLE 4: *In a Study Zone there are 5 mid-size restaurants whose biowaste is managed in the same way and 100 inhabitants whose biowaste is also treated in the same way. In the Study Zone Definition the user will have to add 2 Biowaste Generation Sources: 1) 5 restaurants and 2) 100 inhabitants. Then, in the Scenario Definition the user will have to assign a Generation Process associated with a mid-size restaurant to source 1) and another Generation Process associated with an inhabitant for source 2).*

When creating a copy, the user has to select the *Biowaste Generation Source* to copy, first select the option “add” and then “save”. An error will appear when saving without previously selecting the “add” option (Figure 6).

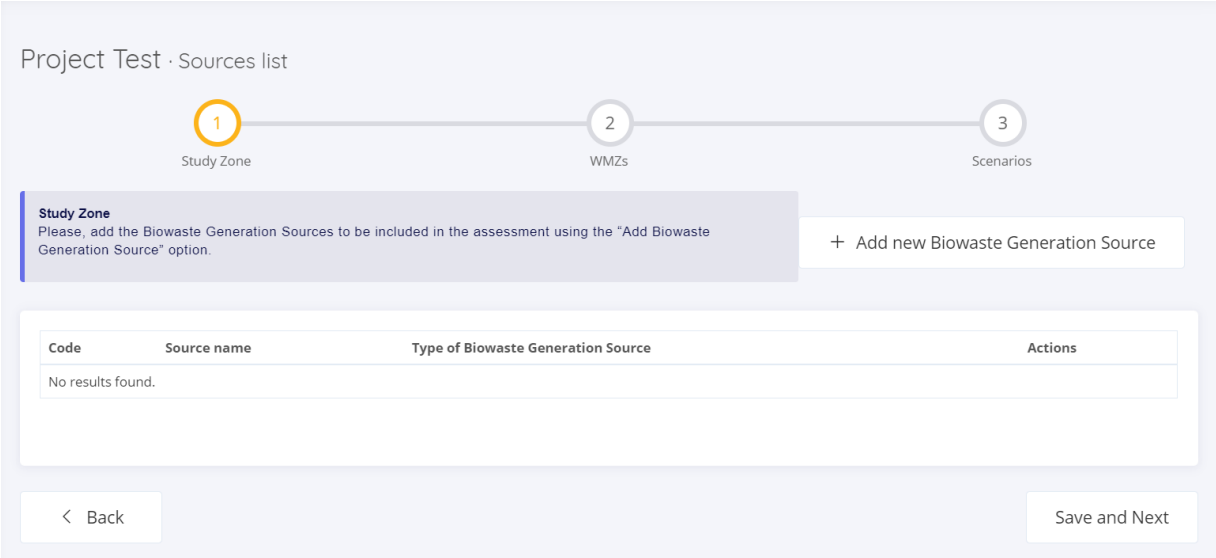

Figure 4: Study zone definition using the “Basic” Mode. Source: https://dst.decisive2020.eu

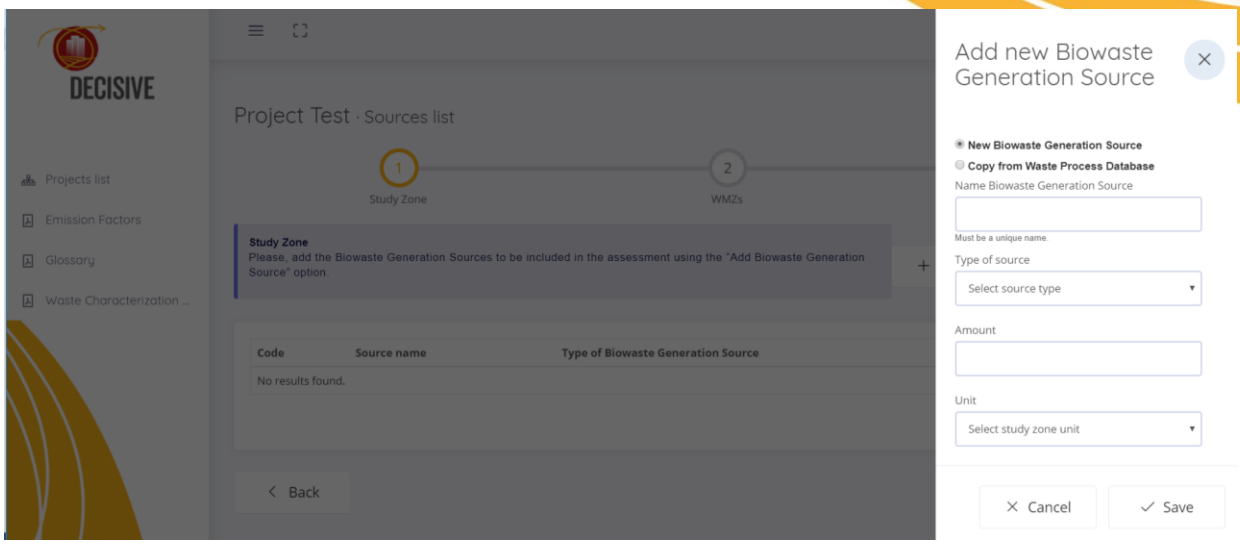

Figure 5: Adding a new Biowaste Generation Source using the "Basic" Mode. Source: https://dst.decisive2020.eu

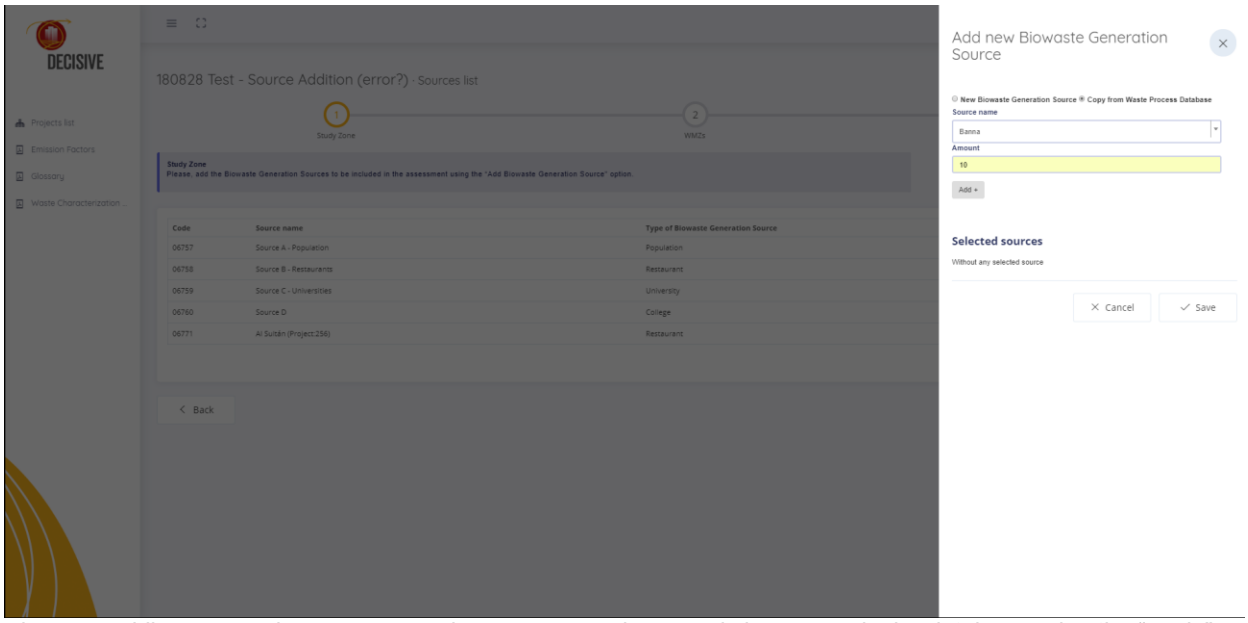

Figure 6: Adding a new Biowaste Generation Source copying an existing source in the database using the "Basic" Mode. Source: https://dst.decisive2020.eu

5.2. Waste Management Zones (WMZs) Definition

Once the user has defined the *Study Zone*, i.e. all the *Biowaste Generation Sources* included in the area to be assessed, the *Biowaste Generation Sources* have to be distributed between the *Waste Management Zones (WMZs)*. The zones are groups of *Biowaste Generation Sources* whose biowaste is managed in the same way (including collection, treatment, final disposal, etc.) but can have different *Generation* and *Source Separation Processes* associated. In the *"Basic" mode* this step is simply an aggregation of the sources without geographical zone assignment. In the *"GIS" mode* this step has a geographical component associated (see Section 6.2 for the *WMZs Definition* when using the *"GIS" mode* of the DST).

EXAMPLE 5: In a Study Zone there are some biowaste generators doing home-composting and other biowaste generators whose biowaste is collected with door-to-door collection and brought to a centralised biowaste treatment facility. This would be modelled as two WMZs that co-exist in the Study Zone.

Each WMZ has to be defined individually. They characterize are exclusive components, i.e. one *Biowaste Generation Source* can only be included in one *WMZ* (Figure 7), meaning that all the biowaste generated in each *WMZ* can be handled in one way only. For the definition of a *WMZ*, the user has to give a name to the Waste Management Zone (e.g. area with home composting) and select the *Biowaste Generation Sources* that are included (Figure 8). All the *Biowaste Generation Sources* must be assigned to a WMZ. If this is not done by the user before selecting the option "Save and Next" of Figure 7, the tool will automatically create new *WMZ* with the *Biowaste Generation Sources* which were not assigned to any WMZ previously.

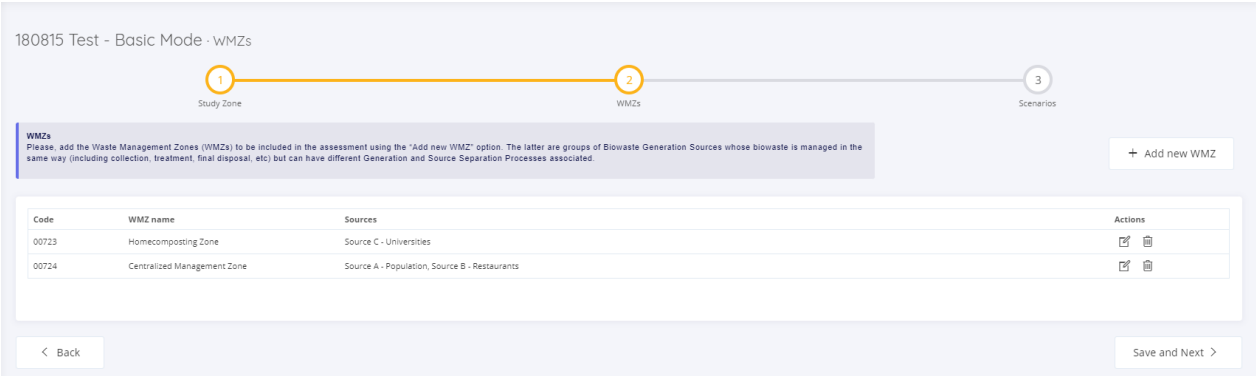

Figure 7: Definition of Waste Management Zones (WMZs) using the "Basic" Mode. Source: https://dst.decisive2020.eu

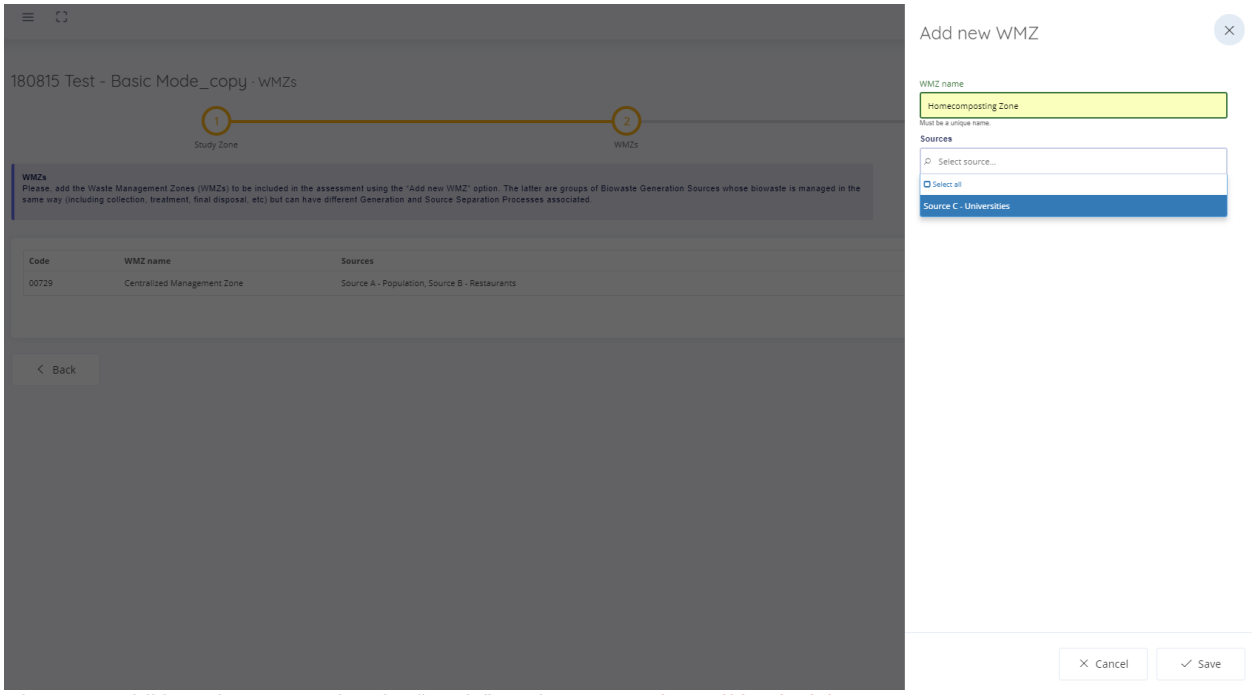

Figure 8: Addition of a WMZ using the "Basic" Mode. Source: https://dst.decisive2020.eu

5.3. Scenario definition

Once the *WMZs* of a project are defined, the next step is the *Scenario Definition*. The aim of this step is defining all technological pathways that the biowaste generated in each *WMZ* follows. The definition of the scenario is the "sum" of the definitions of each waste management stage (generation, source separation, collection, pre-treatment, treatment, transportation, final disposal and bio-products use) for all the *WMZs* included in the *Study Zone*. In this step the user has to choose waste processes from the Waste Process Database for each waste management stage. If the *Waste Process* required by the user does not exist in the *Waste Process Database* the user can create a new *Waste Process*.

To create a new *Scenario* the user has to select the option of *Add scenario* (Figure 9) and name it. The tool will automatically assign a code to the new *Scenario*. Then, the user has to proceed with the definition of the scenario (i.e. by selecting the *Waste Process(es)* for each phase of the scenario; Figure 10) and the average distance for the collection and transportation processes within the scenario (Figure 11). Transportation distances have to be characterized after all waste management stages are defined, as described in Section 5.4.

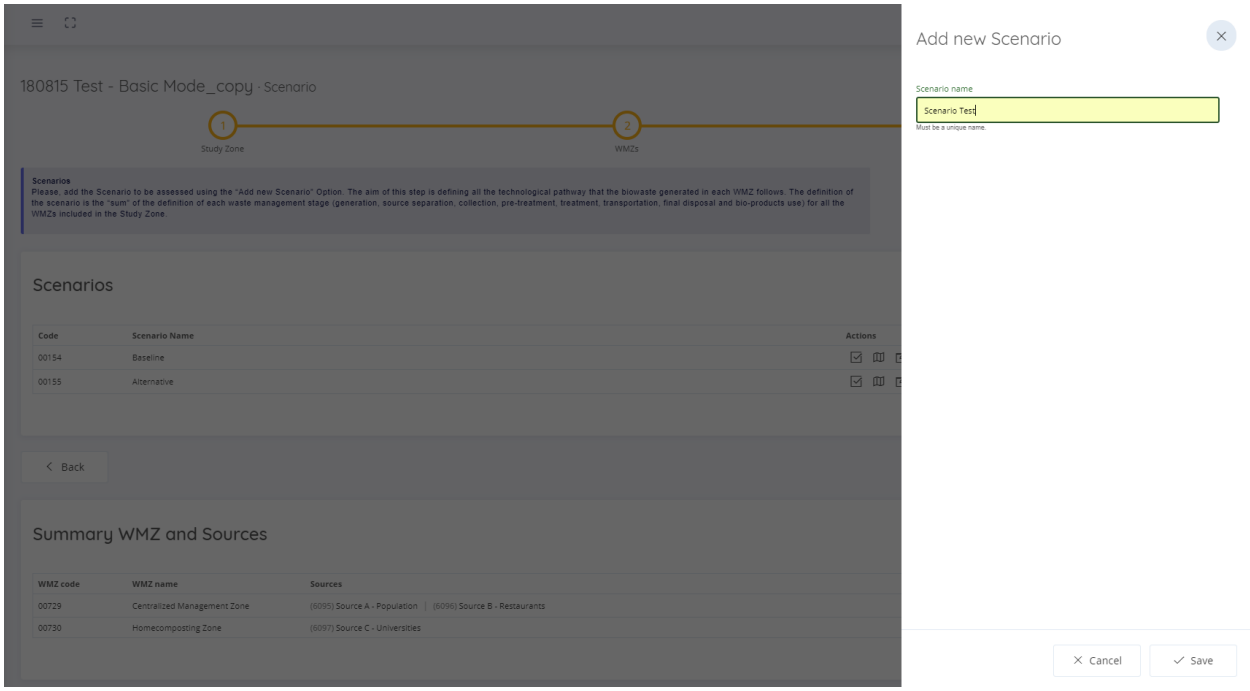

Figure 9: Inclusion of a new Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

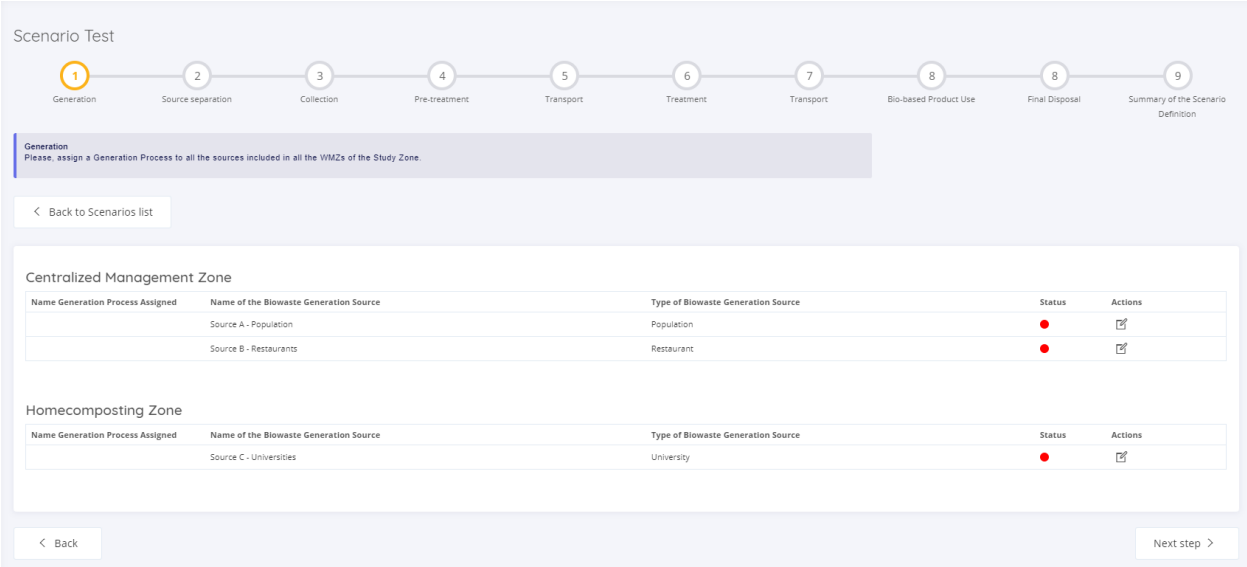

Figure 10: Definition of a new Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

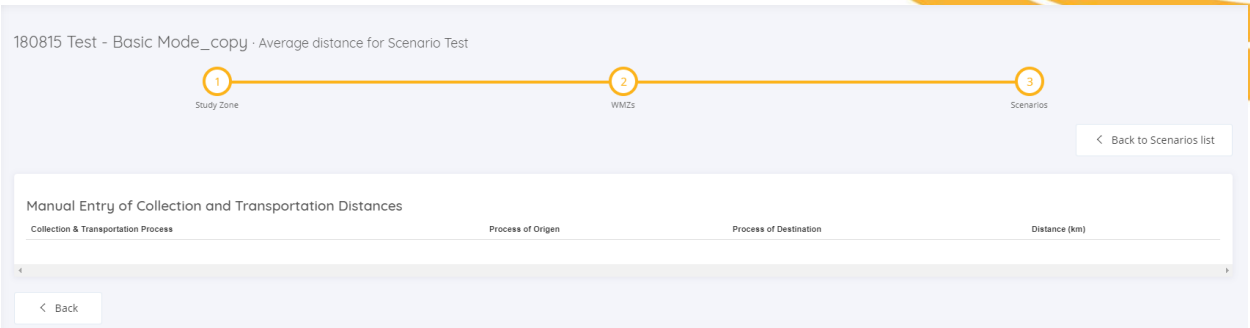

Figure 11: Manual entry of Collection and Transportation distances using the "Basic" Mode. Source: https://dst.decisive2020.eu

5.3.1. Generation

The starting point for the *Scenario Definition* is the assignment of a *Generation process* to each *Biowaste Generation Source* included in the *WMZ(s)* of the *Study Zone*. The assignment starts by clicking on the "*edit*" option provided for each source (Figure 12). The latter is the point of Generation referring to the information detailed in the *Study Zone Definition*. The *Generation process* is the inventory of a waste management phase. It accounts for the biowaste produced by a given type of biowaste source (e.g. households and restaurants) in terms of quantity of biowaste and composition, i.e. percentage of each biowaste sub-fraction (food waste, green waste, woody waste and other organic waste).

EXAMPLE 6: In a study zone of Hamburg there are 1 mid-size restaurant (serving 1000 meals/day) and 100 inhabitants located in 1 point source, i.e. there are 2 biowaste generation sources (restaurants, and inhabitants of an area). The biowaste generated in these two sources are represented with a Generation Process representing the biowaste generated in the restaurant serving 1000 meals/day and another Generation Process representing the biowaste generated by an inhabitant in Hamburg.

To assign a *Generation Process* to a *Biowaste Generation source* the user has the option to either perform a copy of a *Waste Process* of the database or create a new *Generation process*. If the second option is selected the user will be asked to give a name to the process and compile the information needed to define the inventory of the *Generation Process.*

As illustrated by Figure 13, the main fields of a *Generation Process* inventory are:

- *Generation Unit*: term that describes the main reference of the *Generation Process*; it can be: person, meal, bed, etc. The other fields of the inventory, such as the source size, refer to this unit. If the Generation Unit is meal, then the Source Size (and other fields) will refer to this meal as for example, 1000 meal/year.
- *Source Size*: amount of units included in the *Generation Process*. For example, it can be 1000 for a restaurant serving 1000 meals per year when the *Generation Unit* of such process is "meals". The *Source Size* relates to the volume of the activity, so this field will often be larger than 1 for *Generation Processes* representing the food service sector (e.g. 1000 meals/year), but it will always be 1 for household waste since the generation unit is "inhabitant". So for the household waste, the *Generation Process* will always refer to the biowaste generated by an inhabitant. Such amount (*Biowaste Generation Amount*) times the amount reported under the A*mount* field of the *Study Zone Definition* (i.e. inhabitants in the area) will give the amount of biowaste in the area.
- *Biowaste Generation Amount:* amount of biowaste generated per *Generation Unit*. It accounts for the total biowaste generation regardless of its separation at the point of generation, its collection scheme or treatment (see Deliverable 3.7). For example, it will include the amount generated and treated onsite, e.g. home-composting (even if it is not collected), as well as the amount generated and collected to be treated outside (included the amount collected separately and the biowaste collected together with the residual waste).

- *Biowaste Composition*: percentage of food waste, green waste, woody waste and other organic waste in the biowaste represented in this process. The sum of these percentages must be 100% and the cells will turn green if this happens. Contrary, if the sum of the percentages is lower than 100% the cells will turn orange and if it exceeds 100% the cells will turn red. Even if the user will be warned about this error, the DST will proceed with the calculations.

Once a *Biowaste Generation Source* has a *Generation Process* assigned, the status of this process will change to green (Figure 14). Then, the user can view or edit the process. When a *Biowaste Generation Source* does not have a generation process assigned, the status will appear in "red". In order to get the results of the Scenario, all the *Biowaste Generation Source* of the *Study Zone* need to have a *Generation Process* associated. The status will appear orange when there is a *Generation Process* assigned, but such process has an incomplete inventory. In this case, the DST will still work and proceed with the scenario definition. However, if the missing data in the inventory is crucial for the assessment calculation, an error will appear in the results screen. This legend of colours applies to the definition of all waste management stages in the *Scenario Definition*.

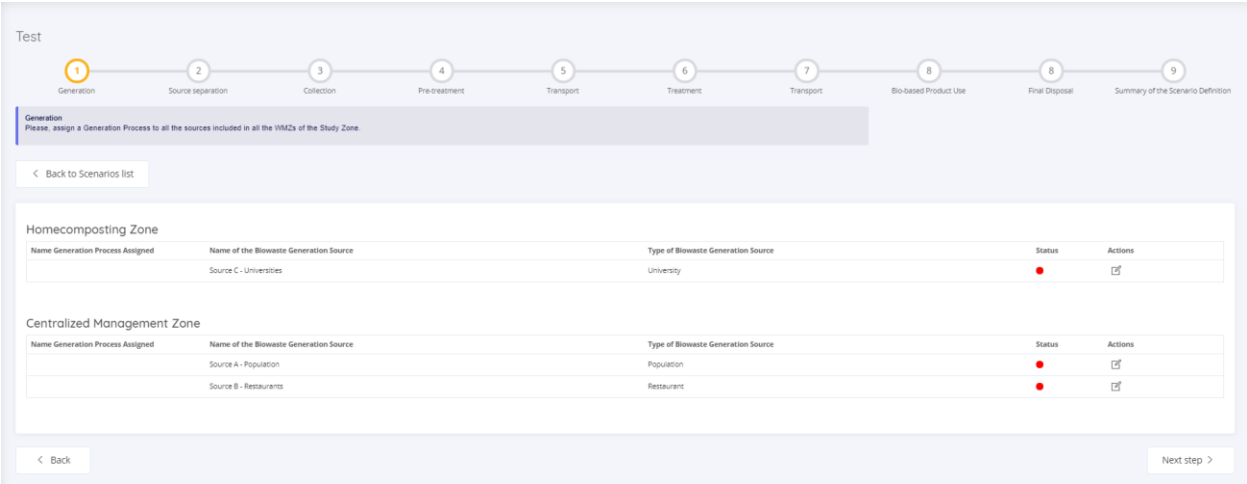

Figure 12: Definition of the Generation Stage of a Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

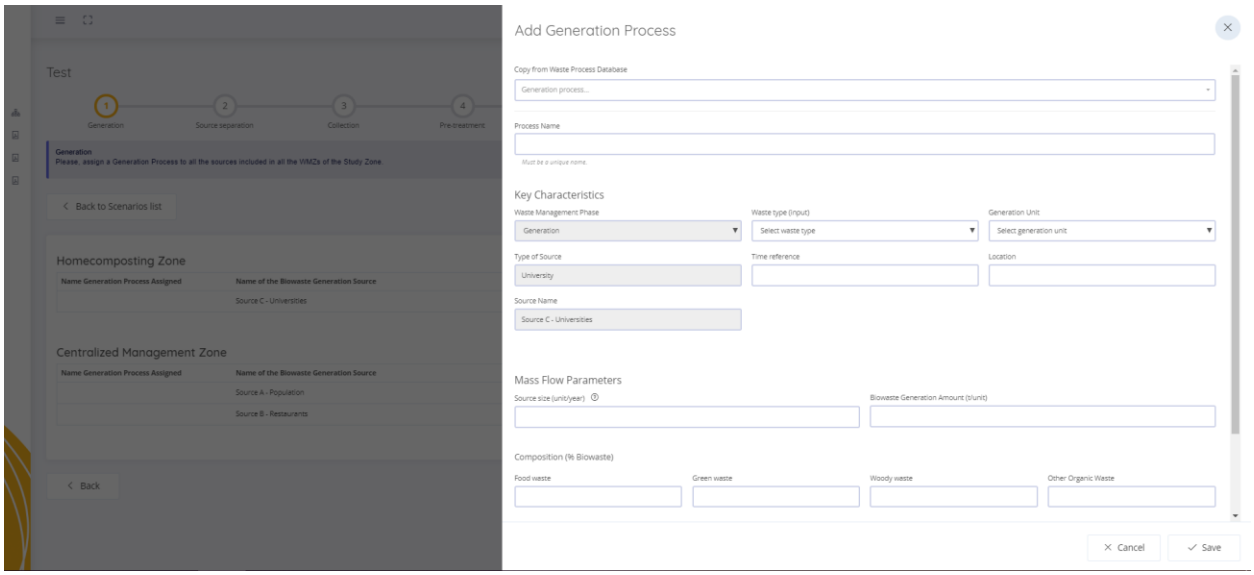

Figure 13: Assignment of a Generation Process to a source using the "Basic" Mode. Source: https://dst.decisive2020.eu

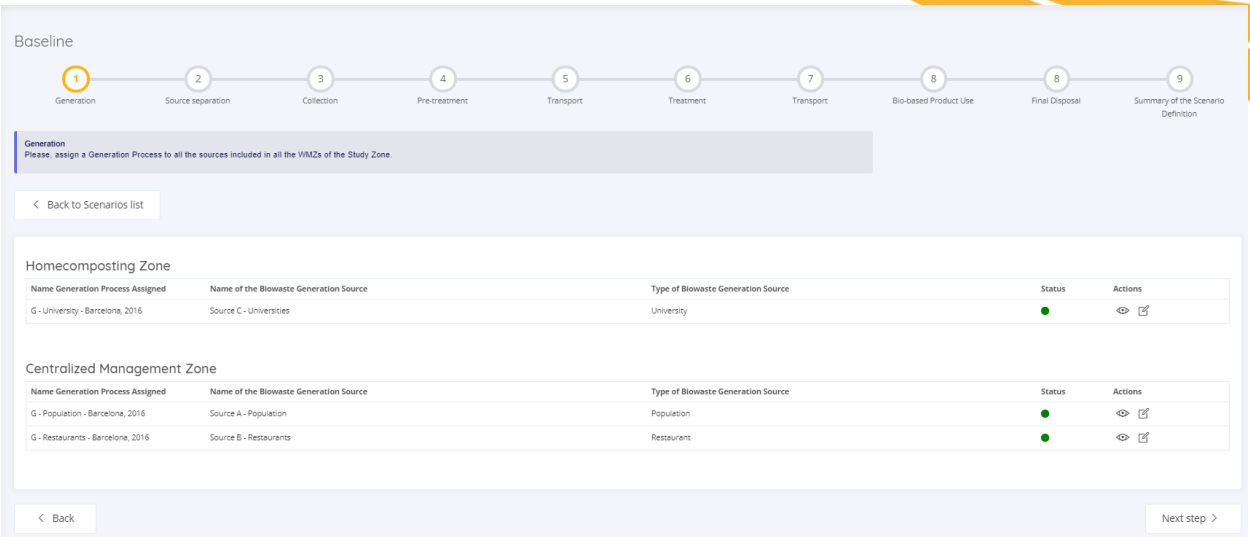

Figure 14: Definition of the Generation Stage of a Scenario after assigning Generation Processes to all the sources using the "Basic" Mode. Source: https://dst.decisive2020.eu

5.3.2. Source Separation

After assigning *Generation Processes* to the *Biowaste Generation Sources* the user can define the *Source Separation stage,* i.e. how the biowaste is discarded at the place of generation. *Source Separation Processes* represent sorting activities taking place at the point of generation for different types of biowaste source (e.g. households, restaurants).

One key aspect to be defined in the inventory of a *Source Separation Process* is the number of *Waste Outputs*. Typically, there will be 2 outputs, i.e. the biowaste generated in a source is separated in two streams: Source-Separated Biowaste (SSBW) and Residual Waste (RW) (Figure 16). This means that part of the biowaste generated will be in the waste output SSBW and the remaining, the non-separated biowaste, will be in the RW. But there can also be other options. For example, only one *Waste Output* could be generated, i.e. when biowaste is not separately collected and is thrown away only as RW. Another possible case refers to the presence of three outputs: SSBW, RW and Source-separated Garden Waste (SSGW).

Once the user defines the waste outputs of the Source Separation Process, then the weight of each of the four biowaste sub-fractions constituting the biowaste (i.e. food waste, green waste, woody waste and other organic waste) should be distributed between the different waste outputs defined in the "waste output" field (e.g. SSBW and RW). The sum of the percentage for each biowaste sub-fraction in all the waste outputs must be 100%.

EXAMPLE 7: In a household

- *60% of the Food Waste is thrown away in the SSBW bin, while the remaining 40% is in the RW*
- *80% of the Green Waste, Woody Waste and Other Organic Waste is thrown away in the SSBW and the remaining percentatges in the RW.*

The importance of defining the number of waste outputs of a *Source Separation Process,* and its composition (using the mass transfer coefficients defined above), is due to the fact that they have different downstream managements. Thus, the different waste outputs (e.g. SSBW and RW) will be linked to different waste processes in the subsequent steps of the *Scenario Definition*.

Moreover, this stage is of central importance since the macro-impurities (e.g. non-biowaste fractions such as paper, plastic, etc) are included into the model during the *Source Separation Process*. The DST considers the overall content of macro-impurities in the SSBW (in wet weight) and the composition of

such macro-impurities. However, the DECISIVE DST does not account for the macro-impurities in the residual waste (RW) since this would require considering the whole waste management systems, an option that is beyond the aim of the DECISIVE project. Indeed, DECISIVE focusses on Biowaste only.

In analogy with the previous step, each *Biowaste Generation Source* should have a specific *Source Separation Process* assigned to it. Therefore, the user has to select the option *Add Source Separation* (Figure 15) and then either copy a process from the database (upper part of Figure 16 – button: copy from library) or create a new *Source Separation Process* (upper part of Figure 16 – button: fill data) by compiling the information required for the inventory of this type of process.

Once a *Source Separation process* is added to the scenario, the user has to assign the appropriate *Generation Process* (Figure 17). For example, a *Source Separation process* representing the sorting made in a restaurant will be linked to the *Generation processes* of the restaurants included in the scenario definition. To establish a link, the user has to click on the small output arrow of a process and click again in the small input arrow of the other waste process. The arrow can be deleted by clicking on top of it. Once the links between a specific process and the previous along the waste management system are defined, the status of the process will become green (Figure 18).

In the screens where links are established (e.g. Figure 17) the user has the option to move the position of the different waste management stages by clicking on top of the title (e.g. source separation) and dragging it around the screen in order to improve the visualization of the links between *Waste Processes*. Linked *Waste Processes* cannot be deleted, unless they are first unlinked in these type of screens.

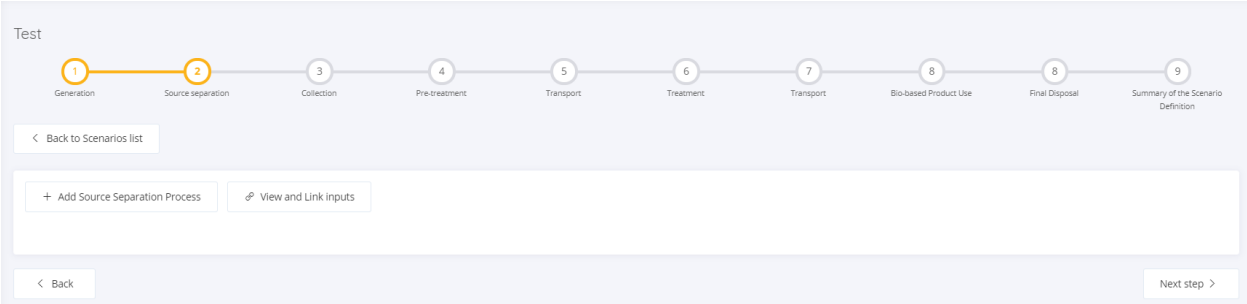

Figure 15: Definition of the Source Separation Stage of a Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

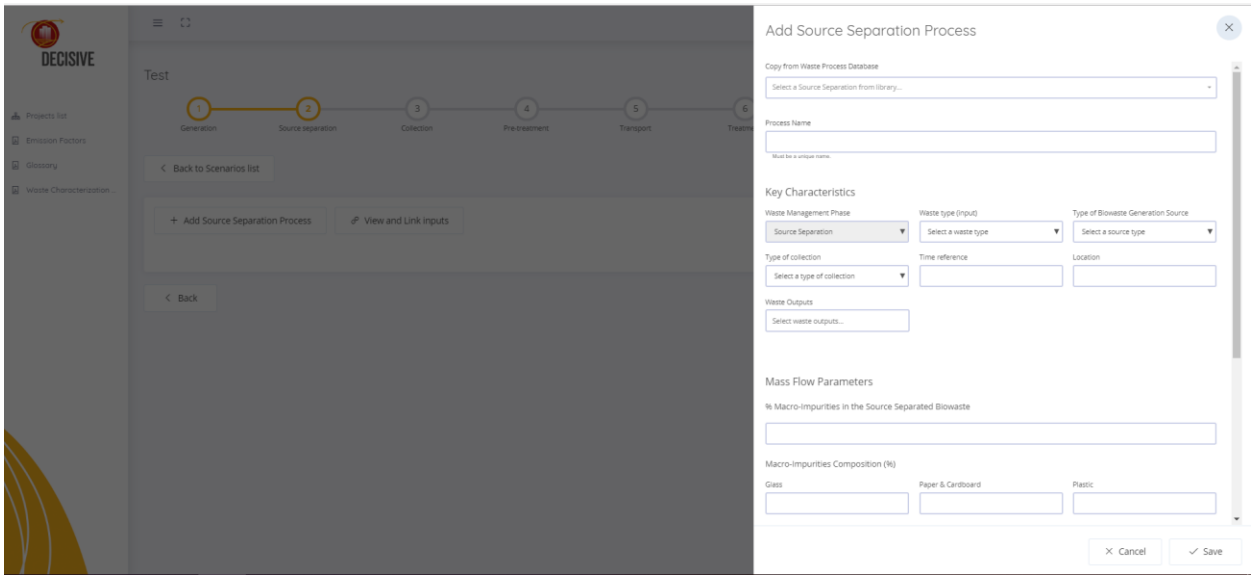

Figure 16: Definition of a Source Separation process for a Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

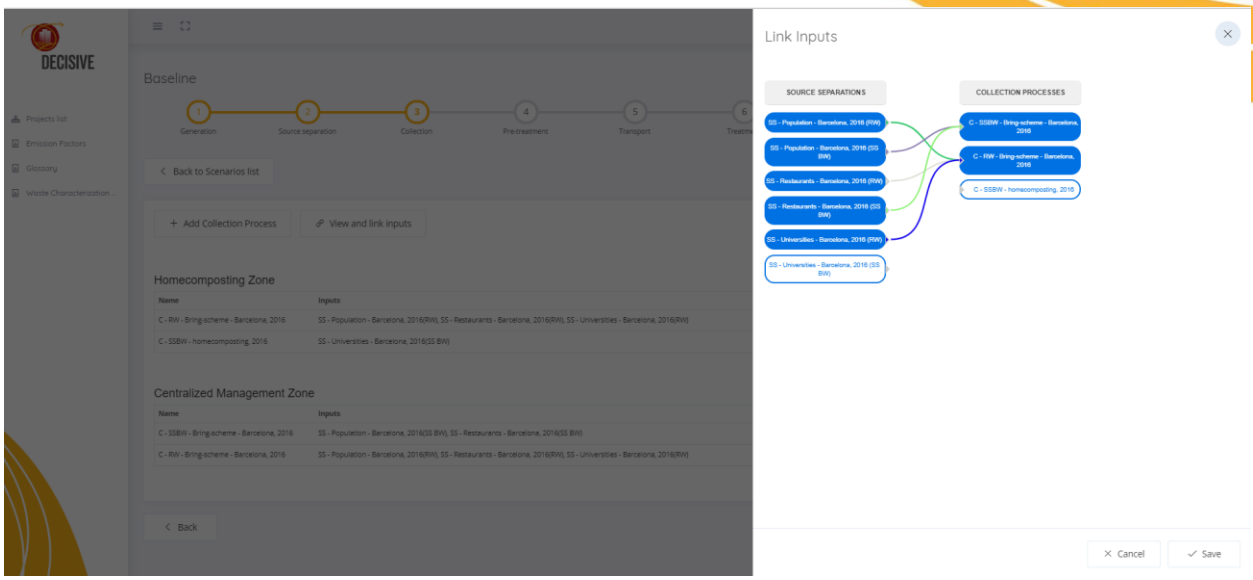

Figure 17: Assignment of an added Source separation process to the Generation processes included in the previous phase Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

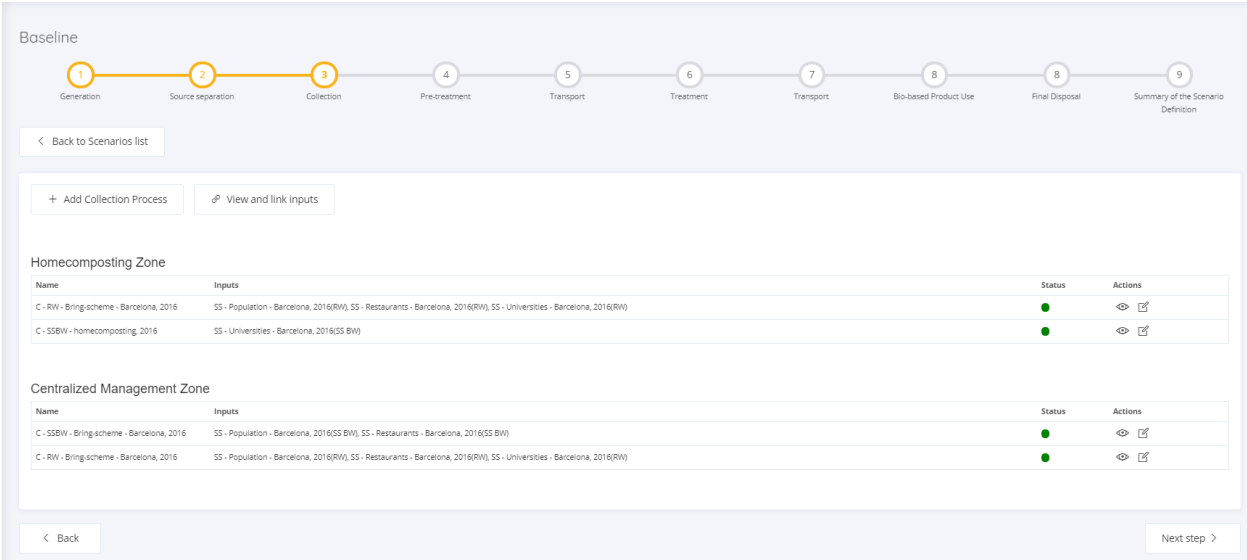

Figure 18: Definition of the Source Separation phase for a Scenario after assigning Source Separation using the "Basic" Mode. Source: https://dst.decisive2020.eu

5.3.3. Collection

After having characterized the *Source Separation* stage the user can define the *Collection* stage (Figure 19-Figure 22). First, the user has to add the *Collection Process* in the Scenario by copying a process from the Database or creating a new process (Figure 20). Then the user has to link the added *Collection Processes* to the waste outputs of the *Source Separation Processes* defined in the previous step (Figure 21).

The *Collection Processes* represent the gathering of the waste from the different collection points and its transference to the waste facility. The inventory of a collection process mainly includes trucks, combustible and labour associated with the waste transfer from sources to waste facilities. The collection inventories are defined with reference to tonne * km, i.e. the unit impacts of such inventories are later multiplied by the tonnes of waste times the distance along which the waste is transferred.

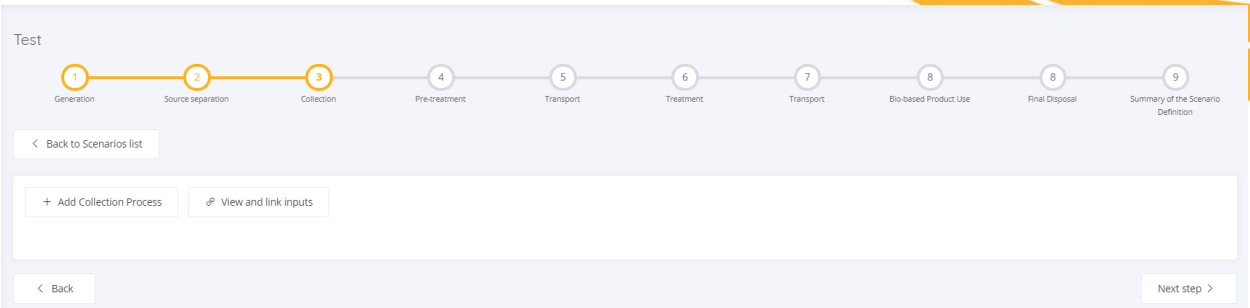

Figure 19: Definition of the Collection Stage of a Scenario before adding Collection Processes using the "Basic" Mode. Source: https://dst.decisive2020.eu

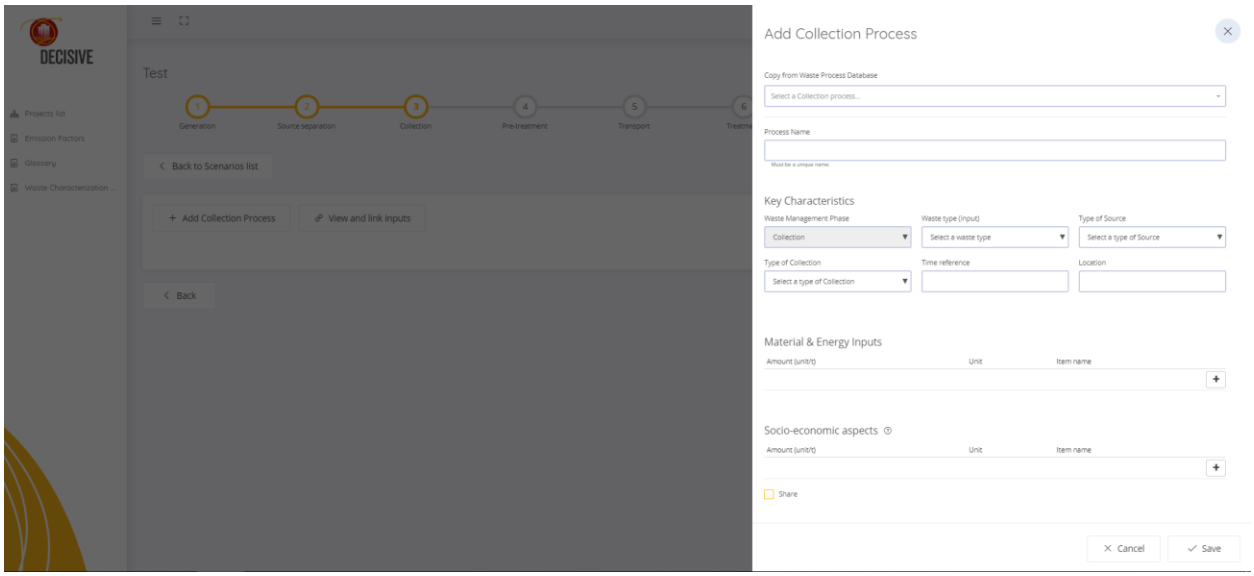

Figure 20: Definition of a Collection process for a Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

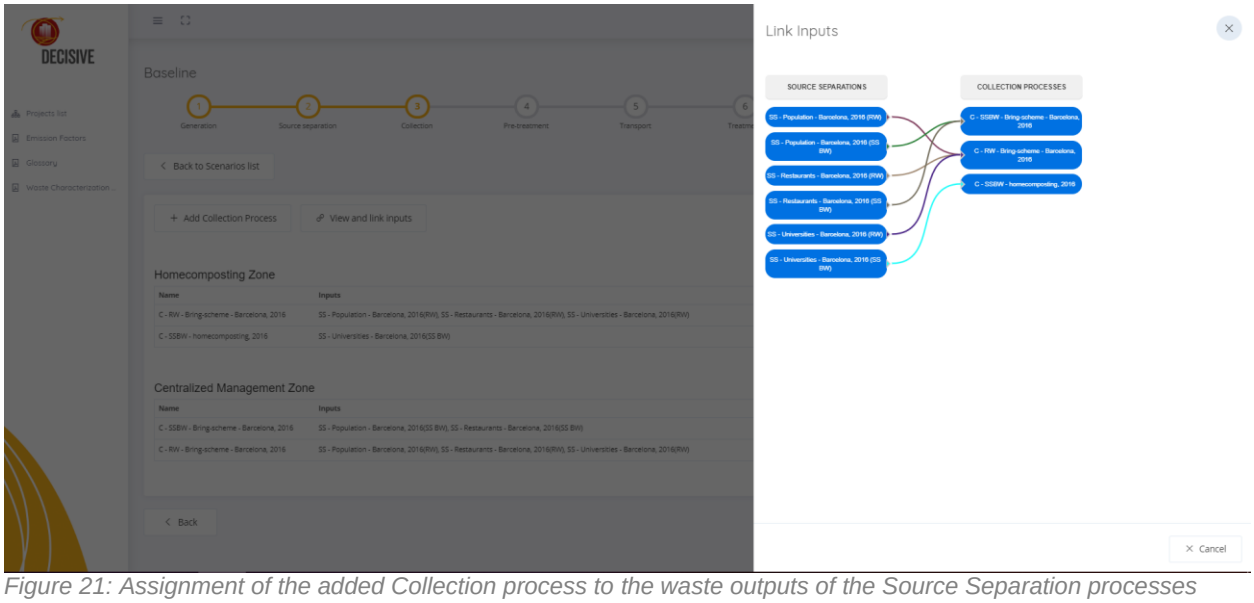

Figure 21: Assignment of the added Collection process to the waste outputs of the Source Separation processes included in the previous phase of the Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

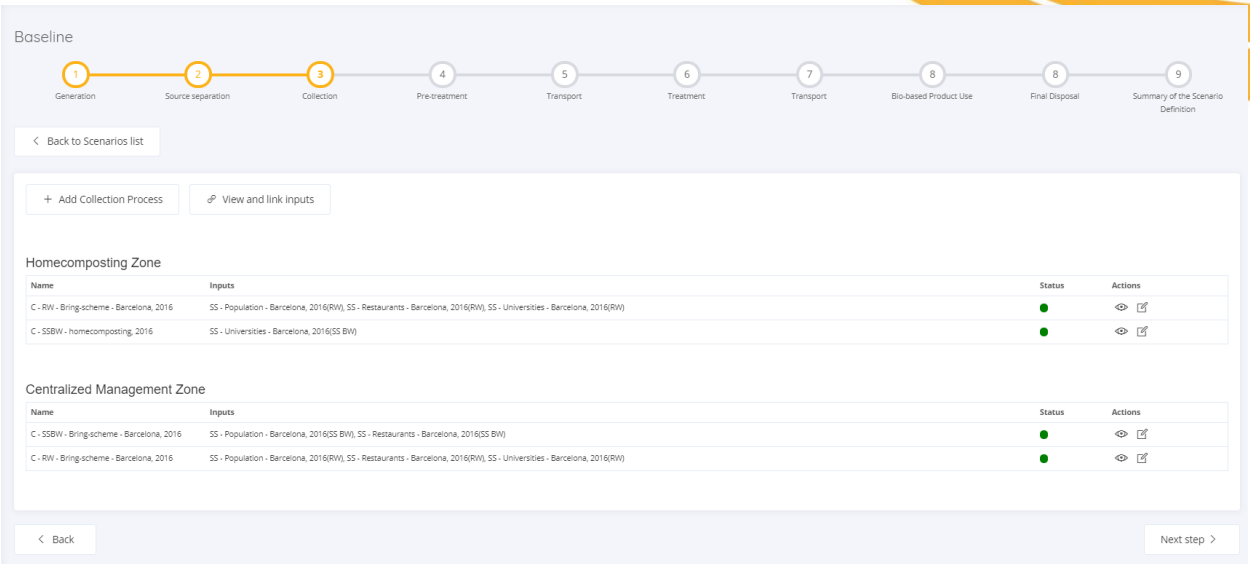

Figure 22: Definition of the Collection phase for a Scenario after assigning Collection Processes using the "Basic" Mode. Source: https://dst.decisive2020.eu

In the DECISIVE DST the definition of the *Collection* phase cannot be skipped. This is the case of most of the current biowaste management systems in cities. However, there is the case of home composting in which collection does not exist because generation, source separation, treatment and bio-based production and use all occur in the same place. To simulate such case the user will have to add a *Collection Process* with no consumptions. Even if the process status appears orange, the DST will run. Then, in the "Average Distance Introduction" the user will have to define 0 as the distance travelled by the *Collection Process*.

The collection processes can be independent for each WMZ but can also be shared between WMZs.

EXAMPLE 8: Imagine a Study Zone with a WMZ where biowaste generators do home-composting and another WMZ where biowaste is collected with door-to-door collection and brought to a centralised biowaste treatment facility. The collection processes are independent from each other for the SSBW, but the collection of the RW could be shared between WMZs (i.e. be the same for both WMZs).

5.3.4. Pre-treatment

Once the *Collection* stage is defined the user can provide further details concerning the *Pre-treatment* stage. The *Pre-treatment processes* represent a physical distribution of waste input into different waste outputs, for example a manual sorting occurring before an AD or a transfer station. The inventories of *Pre-treatment processes* include the distribution of the input biowaste sub-fractions and macro-impurities between three waste outputs: Biomass Output (BM_O), Recyclables (REC_O) and Refuse (REF_O), together with all the consumptions associated with the pre-treatment. *Pre-treatment Processes* do not include chemical or biological transformations.

The inventories of the *Pre-treatment Processes* can use parameters for its definition. Direct emissions and material and energy inputs can be defined either per tonne of input (as for all items included in the *Waste Process* inventories) or using a waste parameter related to the input waste. *Treatment, Final Disposal Processes* and Bio-based *Products Use processes* can also use parameters in the definition of their inventories

EXAMPLE 9: In a Treatment Process representing an AD with electricity recovery the electricity generation per tonne of input waste can be expressed as function of the Biomethane Potential (BMP) of the input waste.

The waste parameters are always related to the input waste and they as used as multiplication factors (i.e. the amount used in the inventory will always be multiplied with the value of the waste parameter). The value of the parameter is calculated based on the mass flow of the scenario. The waste input parameters are pre-determined by the tool developers and cannot be modified by the user. They are the following ones:

- Biomethane Potential - BMP (m^3 CH_4/tonne wet weight).
- Lower Heating Value - LHV (kWh/tonne wet weight).
- Nitrogen content – Nin (tonne N/tonne wet weight).
- Carbon content – Cin (tonne C/tonne wet weight).
- Potassium content – Kin (tonne K/tonne wet weight).
- Phosphorus content – Pin (tonne P/tonne wet weight).

As mentioned in Section 4, this is the first stage of the waste management system that can be skipped in the *Scenario Definition*, i.e. if the waste management to be simulated does not include a pre-treatment stage the user can move on to define the *Treatment* stage by selecting the option "*Next Step*" (Figure 23). Otherwise, the user has to add the *Pre-treatment Process* (Figure 24) and then link such process to the *Collection processes* connected to it (Figures 24). This means that *Collection Processes* can be either linked to *Pre-treatment Processes* or directly to *Treatment Processes*.

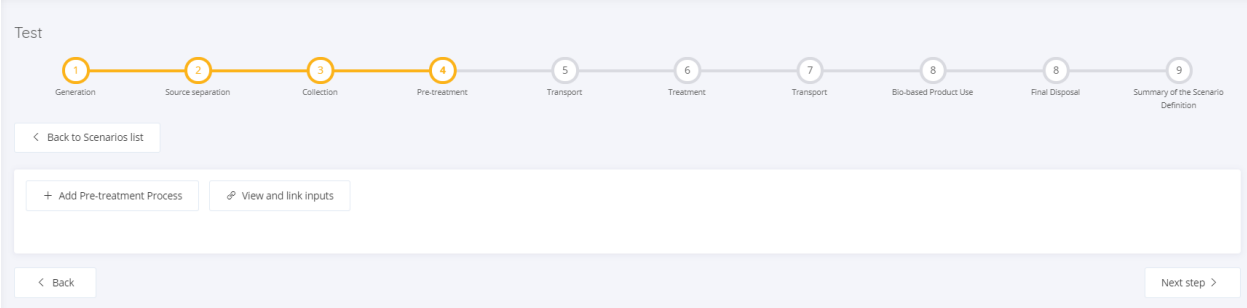

Figure 23: Definition of the Pre-treatment Stage of a Scenario before assigning Pre-treatment Processes using the "Basic" Mode. Source: https://dst.decisive2020.eu

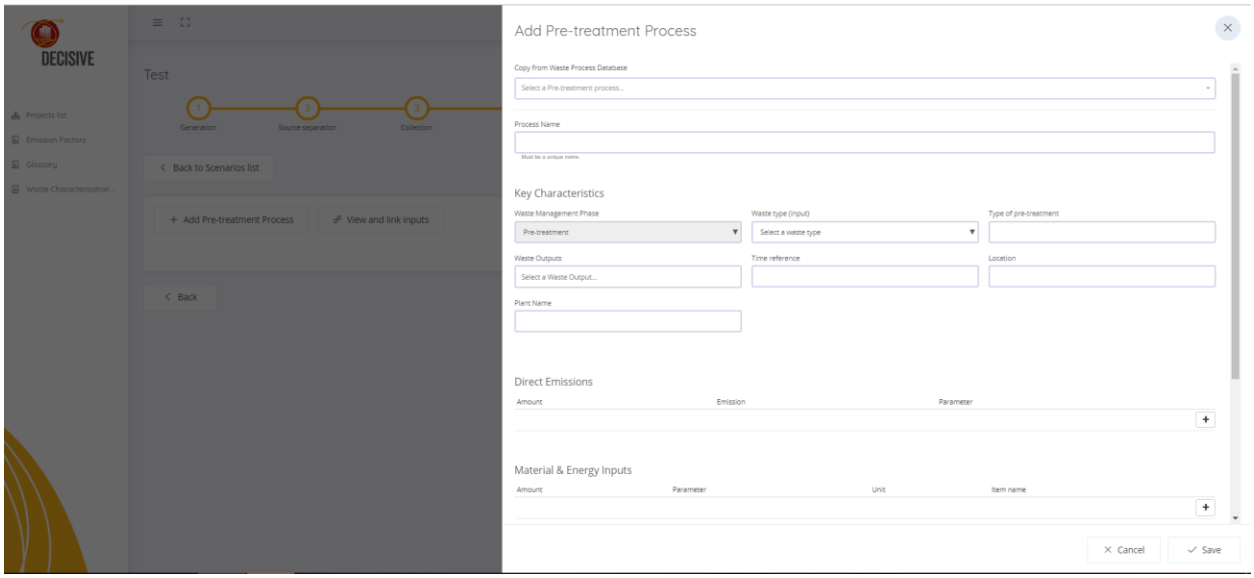

Figure 24: Definition of a Pre-treatment process for a Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

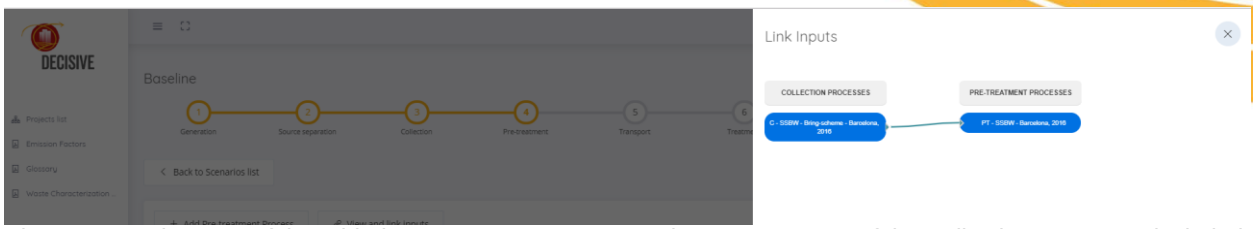

Figure 25: Assignment of the added Pre-treatment process to the waste outputs of the Collection processes included in the previous phase of the Scenario using the "Basic" Mode. Source: https://dst.decisive2020.eu

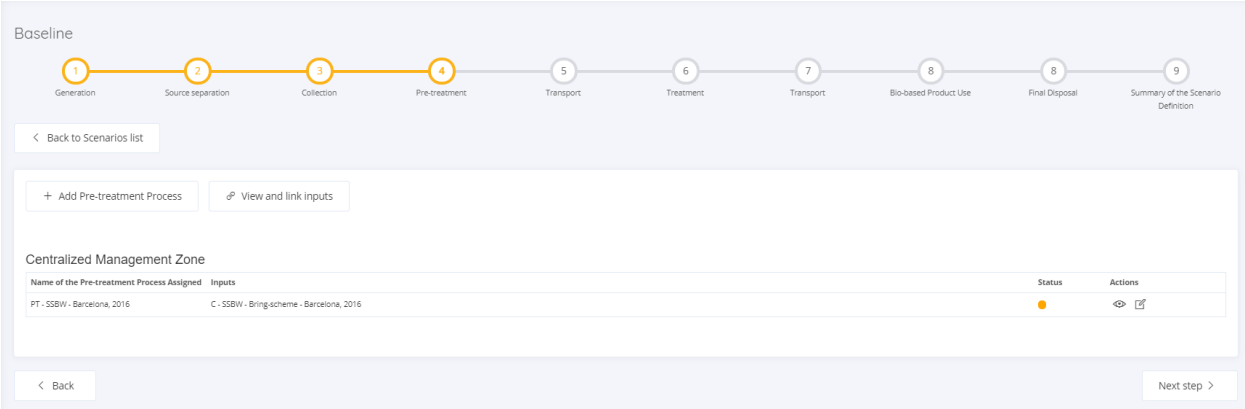

Figure 26: Definition of the Pre-treatment Stage of a Scenario after assigning Pre-treatment Processes using the "Basic" Mode. Source: https://dst.decisive2020.eu

5.3.5. Transportation

After the definition of the *Pre-treatment* phase the user follows with the definition of the first *Transportation* stage (Figure 27). Transportation activities relate to the transportation of waste between facilities or/and transportation of bio-based products from the waste facility where it has been generated to the place where the products will be used. This first *Transportation* stage represents the link between pre-treatment and treatment facilities that are expected to manage the waste outputs from the pre-treatment. If *Pre-treatment* and *Treatment* occur in the same place, this stage is not necessary and its definition should be skipped by selecting the option "*Next Step*" in the bottom left of Figure 27. If the *Scenario* does not include a *Pre-treatment* phase the *Transportation* stage is not necessary either, since the *Collection* phase can be used to bring the waste from the source to the first waste facility (in this case a *Treatment* facility).

Figure 28 describes the information included in the inventories of *Transportation Processes*. These types of processes are similar to collection processes. They are also expressed in terms of tonne * km and mainly include: trucks, combustible and labour associated with the waste transportation. To complete the transportation phase definition the newly added *Transportation processes* should be linked to the corresponding waste output of the *Pre-treatment processes* previously defined.

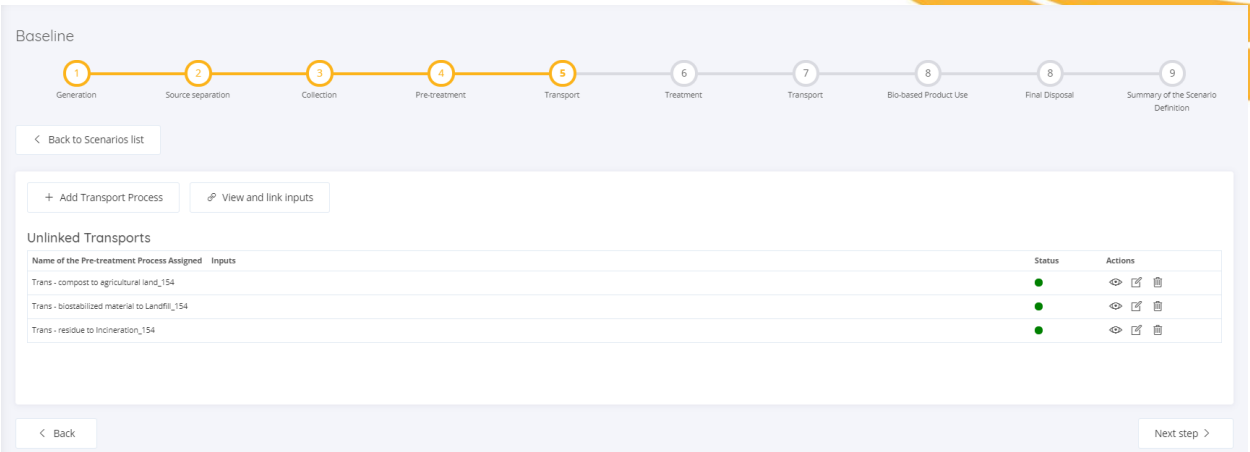

Figure 27: Definition of the first Transportation Stage of a Scenario before assigning Pre-treatment Processes using the "Basic" Mode. Source: https://dst.decisive2020.eu

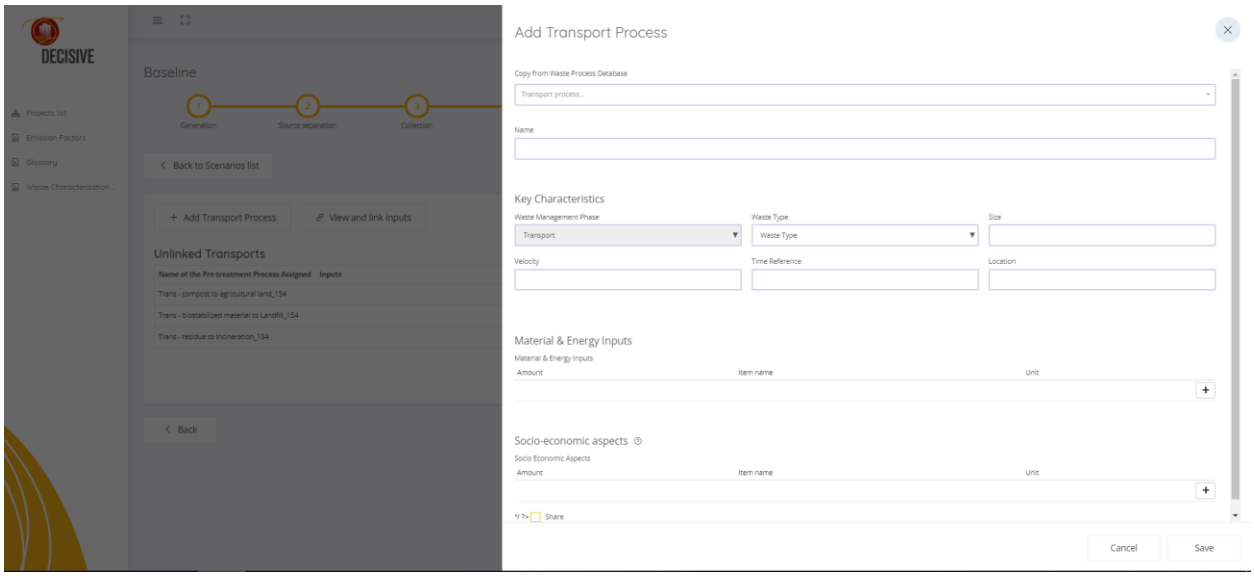

Figure 28: Definition of the Transportation process using the "Basic" Mode. Source: https://dst.decisive2020.eu

5.3.6. Treatment

Once the *Collection, Pre-treatment* and *first Transportation* stages have been defined (or skipped, in the case the last two waste management stages do not apply) the user can define the *Treatment* stage (Figure 29). *Treatment processes* represent *recovery or disposal operations, including preparation prior to recovery or disposal* (point 14 of Article 3 of the WFD). Treatment processes can be Biowaste Treatment exclusive for source-separated biowaste as well as Treatment options for unsorted biowaste in the residual waste. Treatment can refer to either single operations or combination of operations, such as the combination mAD, SSF and Stirling Engine. It could be that available data to build separate inventories for pre-treatment and treatment (i.e. one inventory for pre-treatment and another inventory for treatment) are not available, then both *Waste Processes* could be modelled together as a *Treatment Process*.

To assign a *Treatment Process* to the *Scenario* the user has first to add a process using the option "*Add Treatment Process*" and then link such process to the corresponding outputs of the previous waste management stages with the option "*View and Link inputs*". To create a *Treatment Process* the user can either copy an existing Treatment process (giving it a new name) or compile all the information requested to define a Treatment inventory (Figure 30).

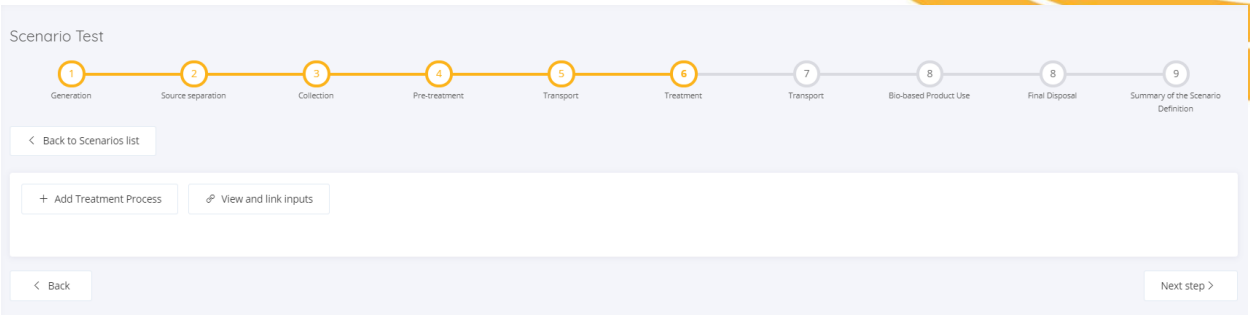

Figure 29: Definition of the Treatment Phase using the "Basic" Mode. Source: https://dst.decisive2020.eu

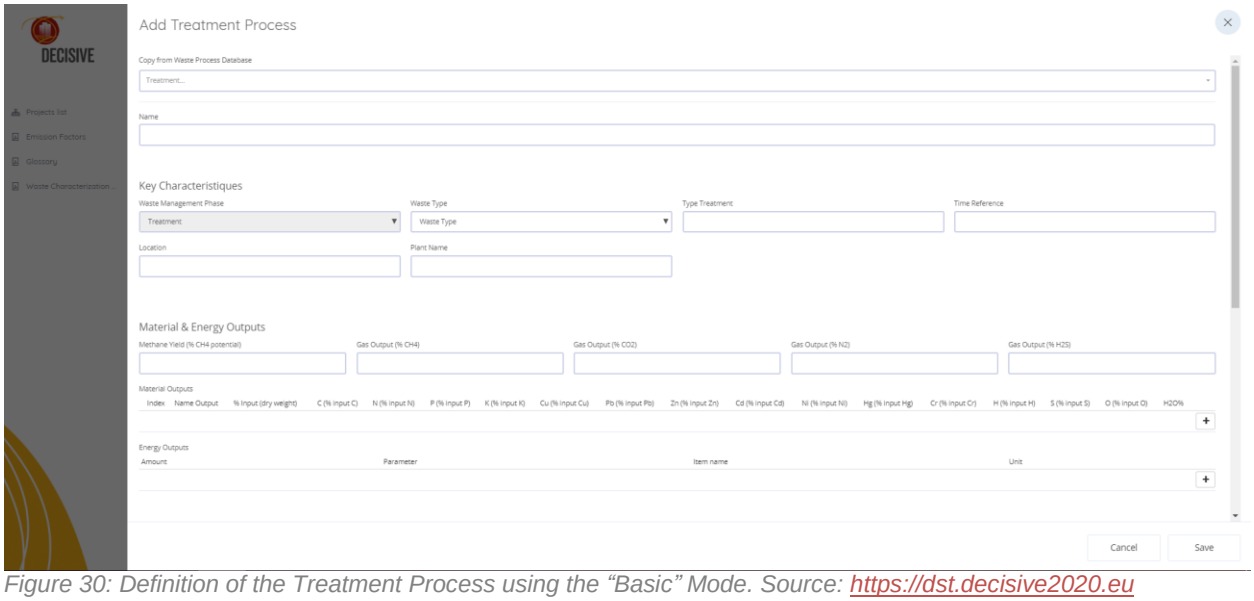

Figure 30: Definition of the Treatment Process using the "Basic" Mode. Source: https://dst.decisive2020.eu

The inventories of *Treatment Processes* include energy and material productions that are represented as negative values to distinguish them from the consumptions (positive values). Therefore, they must be interpreted as process revenues.

EXAMPLE 10: Imagine a *Treatment Process representing an AD with electricity recovery. The amount used to represent the electricity generated per tonne of input waste will be a negative value. Such value will be multiplied by the Biomethane Potential (BMP) of the input waste (if such parameter is used in the definition by the user) or by 1 if the user select the option "None" in the definition of the energy output.*

5.3.7. Transportation

After the *Treatment* phase the user will have to define the second *Transportation* stage (Figure 31). This second *Transportation* stage represents the link between: (1) the Treatment and the Final Disposal (for transport of residues), and (2) the Treatment and the Bio-based Product Use (for bio-based products transportation). This stage is not needed if the *Treatment* occurs in the same place of the *Final Disposal* or *Bio-based Product Use*. The options "*Final Disposal*" or "*Bio-based Product Use*" can be directly selected to skip the definition of the second *Transportation stage* (Figure 31).

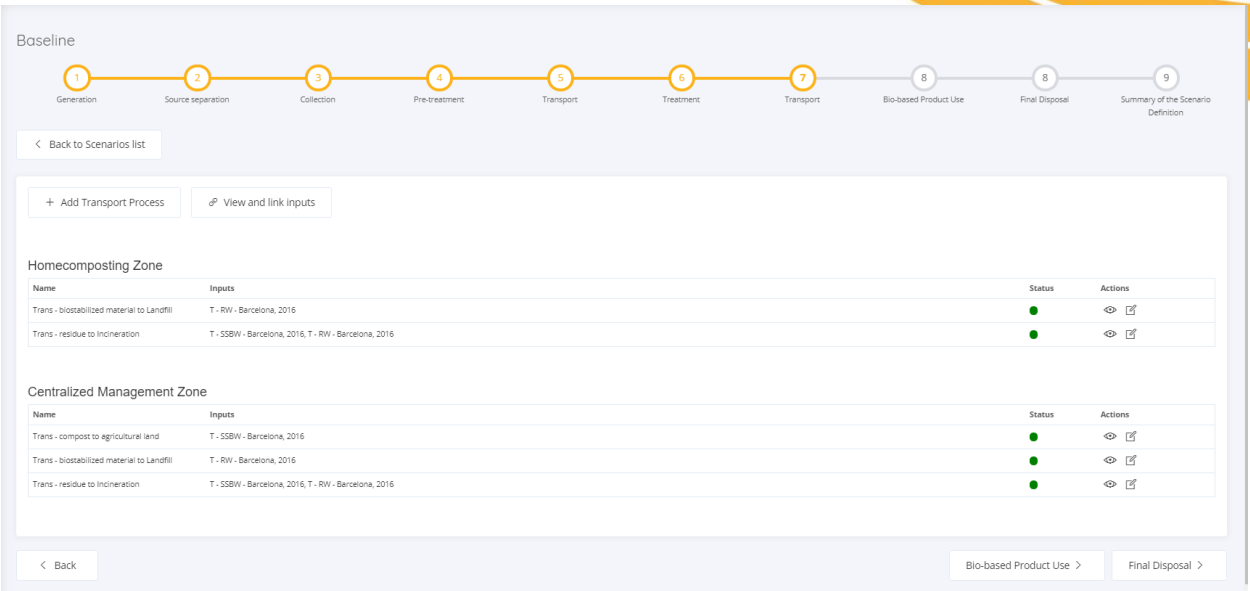

Figure 31: Definition of the second Transportation phase after assigning Transportation Processes using the "Basic" mode. Source: https://dst.decisive2020.eu

5.3.8. Bio-based Products Use

Once the *Treatment* has been defined *and the second Transportation* stage has been defined or skipped the user can define the *Bio-based Product Use* stage (Figure 33). The *Bio-based Product Use Processes* represent the utilization of bio-based products generated mainly from biowaste (e.g. compost or biopesticide). The inventory of this type of process also includes the avoided production of the conventional products that are substituted (e.g. mineral fertilizers) by the bio-based products (e.g. compost) and allow the use of customized parameters (as described for *Treatment* in Section 5.3.6).

EXAMPLE 11: N_2O emissions from compost use on agricultural land constitute 3.5% of the nitrogen content of the compost (Boldrin et al. 2009). This emission can be introduced as function of the parameter Nitrogen Content (Nin) related to the input product in the Bio-based Product Use Process.

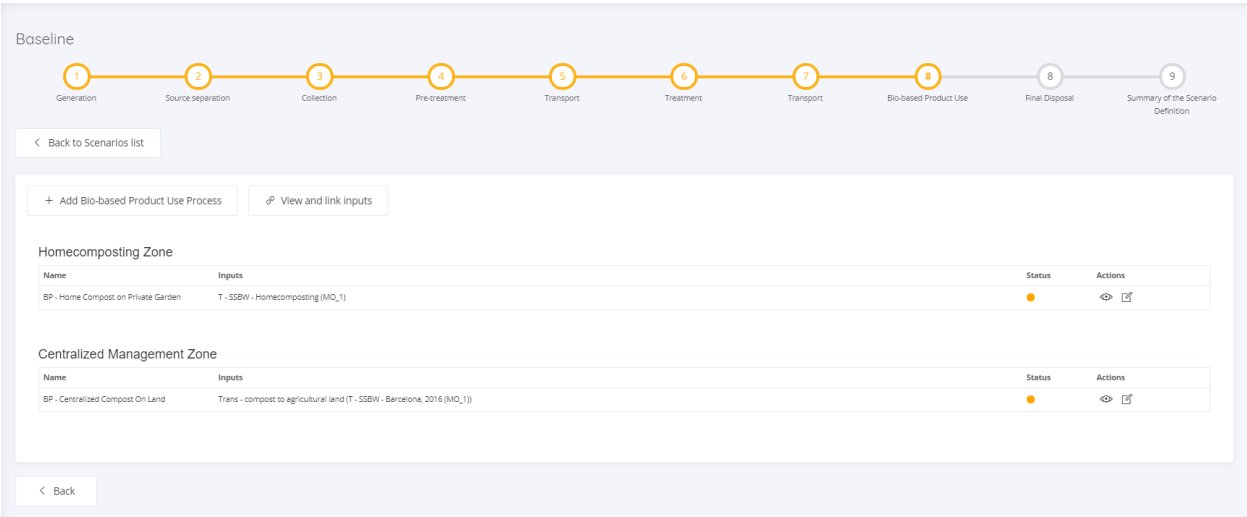

Figure 32: Definition of Bio-based Product Use phase using the "Basic" Mode. Source: https://dst.decisive2020.eu

5.3.9. Final Disposal

Finally, the user can define the *Final Disposal* stage (Figure 33). *Final Disposal Processes* in DECISIVE DST represent “any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I – Glossary sets out a non-exhaustive list of disposal operations” (point 19 of Article 3). The two main *Final Disposal* activities included in the DST are incineration (with ash management) and landfilling (with leachate treatment).

Final Disposal Processes refer to the last fate of the waste. All impacts connected to the management of waste outputs should be integrated within the same inventory. As for the case of the *Treatment Processes*, also the *Final Disposal Processes* can have different numbers of residues and energy outputs. The definition of the emissions and energy outputs can be done with parameters (see description in Section 5.3.6) or per tonne input (using “none” as parameter). The negative values stand for avoided productions.

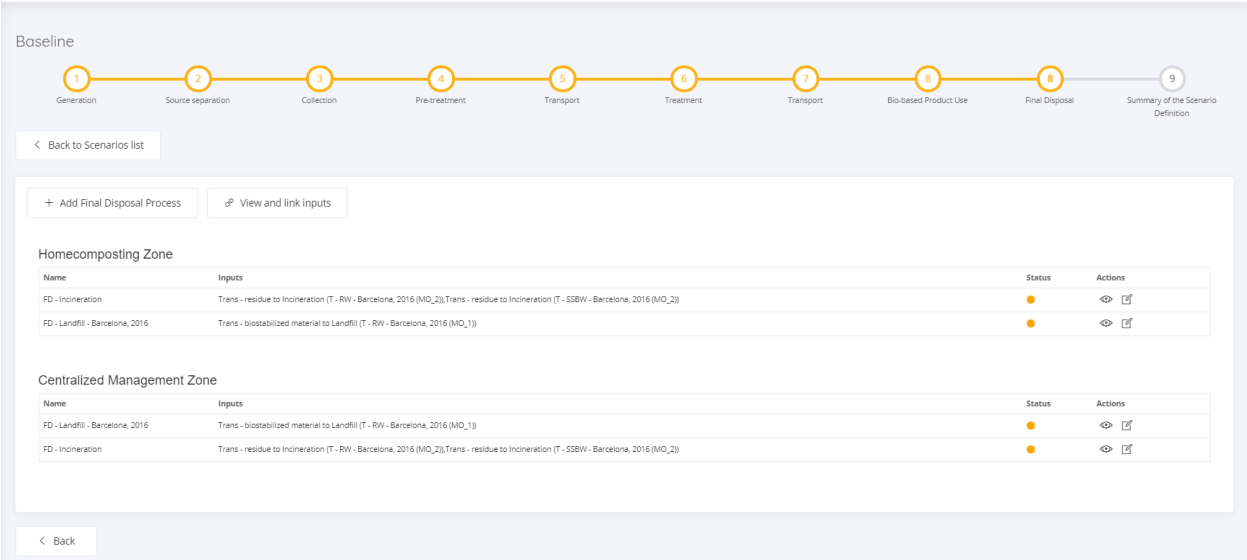

Figure 33: Definition of the Final Disposal phase using the “Basic” mode. Source: https://dst.decisive2020.eu

5.3.10. Summary of the Scenario Definition

At any time, the user can check the status of the scenario definition in the bottom “Summary of the Scenario Definition” by selecting the last filled circle in the upper part of the window (Figure 34).

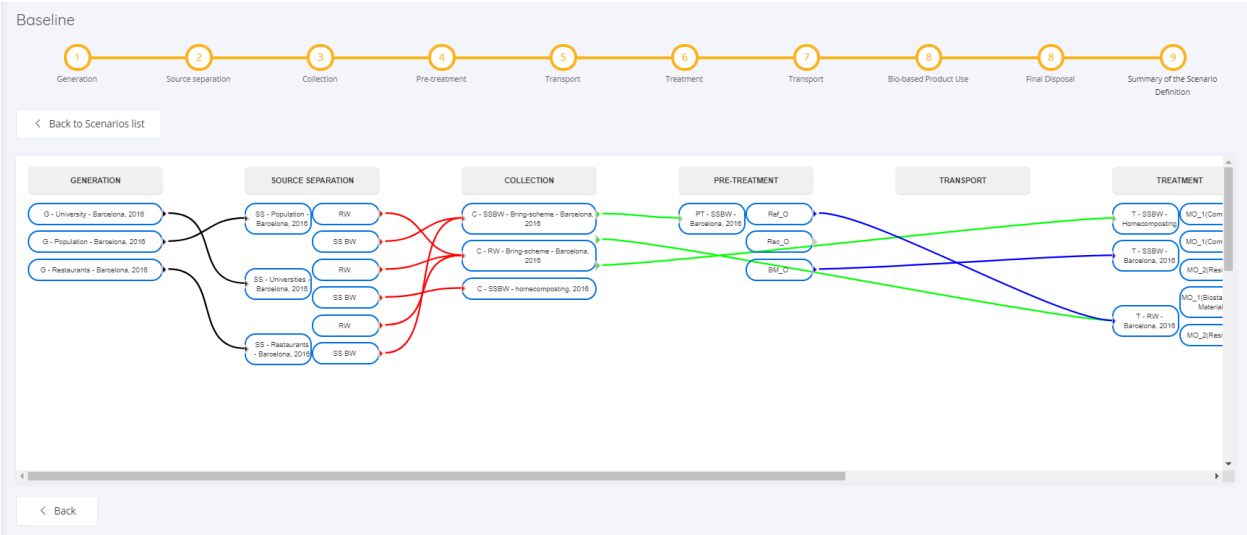

Figure 34: Summary of a Scenario Definition using the “Basic” Mode. Source: https://dst.decisive2020.eu

5.4. Average Distance Input

Once all *Waste Processes* of the *Scenario* are defined the user has to add an estimate of the collection and transportation distances in km. To provide such information the user gets an overview with: (1) all collection or transportation processes in the *Scenario Definition*, (2) the processes of origin (where the waste is loaded on trucks), and (3) the processes of destination (where the waste is unloaded from the truck). The user can add the distances manually (Figure 35). After saving the distances, the DST will proceed with the calculation results of the assessment. It should be noted that if these distances are not saved, the results botton shown in Figure 36 will not appear.

The DST sums all the distances associated to the same *Collection and Transportation Process* to calculate the total distance travelled by each *Collection and Transportation Process*. This total distance is latter used to calculate the assessment results of this waste management stage.

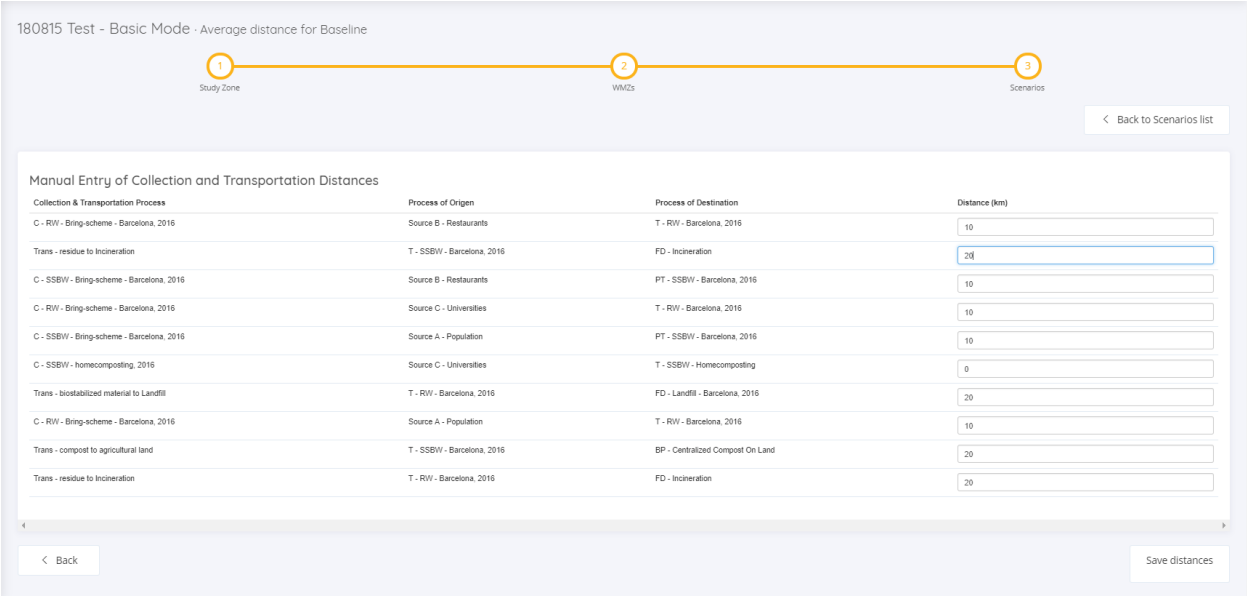

Figure 35: Definition of the average distance for all the collection and transportation processes using the "Basic" Mode. Source: https://dst.decisive2020.eu

5.5. Assessment

Once the *Study Zone,* the *WMZs,* the *Scenario* and the *Average Distances* are provided by the user the tool calculates the *Scenario Mass Flow* and the *Scenario Assessment Results*. The results are visualized using one of the actions under results in the *Scenario List* (Figure 36). These icons will only appear if all the previous working steps have been completed.

The first icon under the results column shows the *Summary of the Scenario Definition.* The second icon shows a radar diagram displaying the assessment indicators described in Section 5.5.2. The last icon can be used to download an Excel file with 2 main tabs: 1) the *Scenario Mass Flows* and 2) the *Scenario Assessment Results*.

After the creation of a *Scenario* the user has the option to *delete* it. However, all the links created during the definition of a *Scenario* must be deleted before proceeding with the removal of the *Scenario*. As mentioned previously, this is also the case of all the *Waste Processes* defined in each stage of the *Scenario Definition*, first the links of such *Waste Processes* should be removed and then the *Waste Process* can be removed.

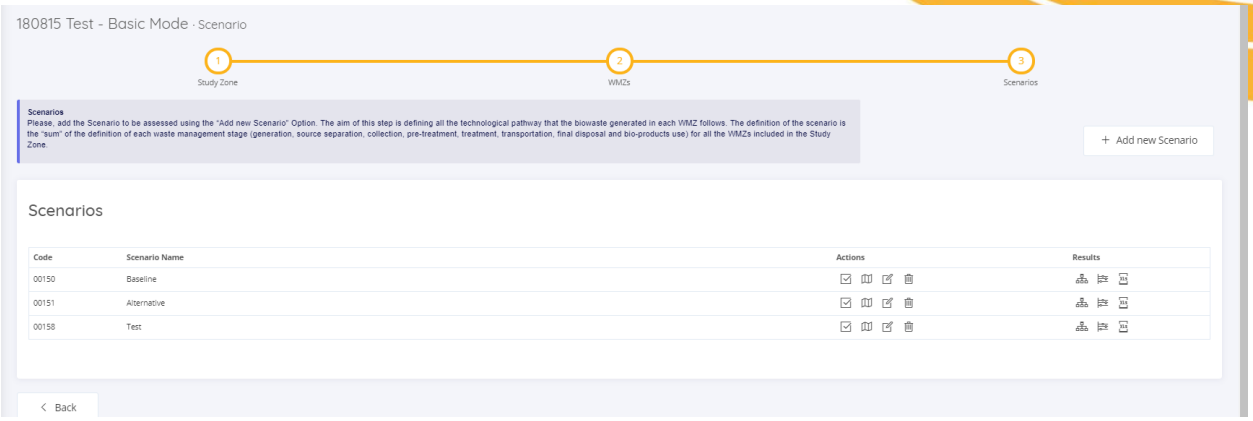

Figure 36: Scenario List where the user can select the type of results to visualize. Source: https://dst.decisive2020.eu.

5.5.1. Scenario Mass Flow

The *Scenario Mass Flow* reports:

- **Total Mass Flow in wet weight** (tonnes), i.e. how the biowaste and macro-impurities are distributed between the different steps of the scenario. This representation includes the flow in the first stages of the scenario (from generation to pre-treatment), which consists of biowaste and macro-impurities of the source-separated biowaste. This amount can have different fates, becoming either a residue or a product in the treatment phase. The total mass flow in each waste management stage includes biowaste, macro-impurities, residues and/or bio-products.
- **Nutrients flows** (tonnes), i.e. how the resources included in the biowaste sub-fractions in form of carbon, nitrogen, phosphorus, and potassium are recovered/used in the biowaste management scenario. This excludes the nutrients content of the macro-impurities fractions, since the focus is on the nutrients included in the biowaste.
- **Heavy metals flows** (kg), how the heavy metals (copper, lead, zinc, cadmium, nickel, mercury and chromium) included in the biowaste are transferred between the different waste management stages. This excludes the heavy metals content of the macro-impurities fractions, since the focus is on the biowaste sub-fractions.

The « Scenario Mass Flow » of the excel file that can be downloaded from the DST shows all the flows described above for all the *Waste Processes* included in the *Scenario*. In addition, the *Scenario Mass Flow* shows the values of all the waste parameters (listed in Section 5.3.4). Such vales are shown both for the input waste and outputs of each *Waste Process*.

5.5.2. Scenario Assessment Results

The *Scenario Assessment Results* report the values of a set of indicators:

- **Climate Change Impact (kg $CO_{2\text{-eq}}$)**, which includes direct emission of the biowaste management system and indirect emissions related to *Background Processes*.
- **Economic Cost (€)**, which includes CAPEX, OPEX and Revenue of the Scenario.
- **Local Labour (hours)**, which includes only the labour directly related to the waste management system. It excludes labour related to the production of background processes such as electricity, etc.
- **Space Requirement (m^2)**, which includes private space at the source of generation to separate the waste (and decentralised treatment, e.g. mAD), public space for containers and collection

routes, industrial space where centralised plants are located and agriculture land needed to spread the bio-based product according to EU Nitrates Regulation (91/676 /EEC).[1]

- **Sorting Time (h)**, which represents the amount of time used by the biowaste generators to sort their biowaste at the point of generation.
- **Set of Indexes:**
  - **Electricity Ratio:** ratio between the amount of electricity production and the sum of electricity production and consumption.
  - **Thermal Ratio:** ratio between the amount of heat produced and sum of heat produced and consumed.
  - **Transport Intensity Index (km * t):** sum of km * t. It refers to both biowaste collection and transportation.
- **Compliance of Bio-based products Use with the Regulation Limit:** This indicator informs about the compliance of the bio-based products generated with the heavy metals content limits set by the JRC[2]. The tool simply states whether the Bio-products are above or below the legal threshold.

5.5.3. Comparison of Scenarios

The user can compare the results of different scenarios simulated within a project, but this has to be done outside the tool. First, the simulation of the different scenarios must be performed separately (e.g. first the Baseline and then the Alternative scenarios) in the tool. After the execution of all simulations, the assessment results must be exported and then the comparison can be performed outside the DECISIVE DST. Figure 37 shows an example of representation useful to compare the assessment results of two Scenarios.

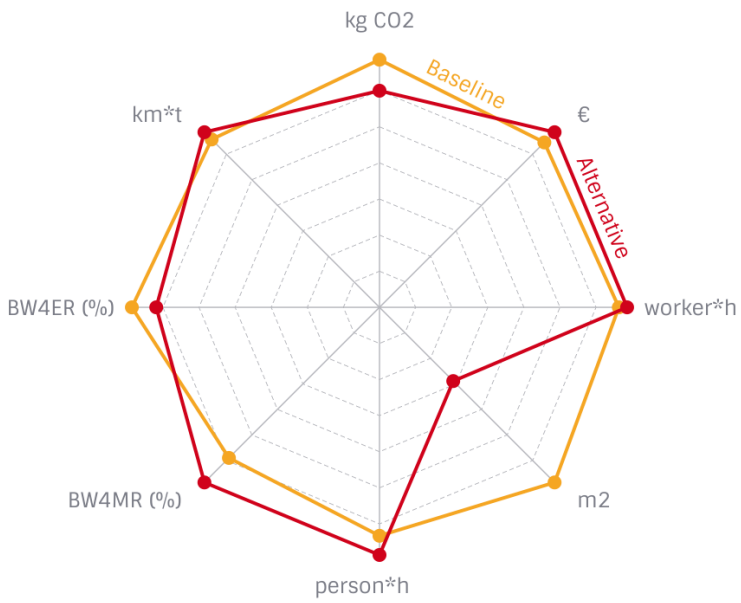

Figure 37: Representation of the assessment results of two scenarios, Baseline (yellow) vs. Alternative scenario (red). This figure was performed with a software different than the DECISIVE DST.

6. GIS Mode - Working Procedure

[1] Space requirement considers a limit for spreading the Nitrogen included in biofertilizer products. The maximum limit is 170 kg TN/ ha.

[2] Legal thresholds for heavy metals (expressed as mg of heavy metal per dry-weight kg of bio-product): 400 mg Zn/ kg dry weight, 100 mg Cu/kg dry weight, 50 mg Ni/kg dry weight, 1.5 mg Cd/kg dry weight, 120 mg Pb/kg dry weight, 1 mg Hg/kg dry weight, and 100 mg Cr/kg dry weight

The working procedure of the *"GIS" mode* follows the same five main steps as the "*Basic"* mode. The main differences are related to *Study Zone Definition* and *Average Distance Introduction*. The following subsections describe all the working steps of *"GIS" mode*.

6.1. Study Zone Definition

Figure 38 illustrates the *Study Zone Definition* of a project using the *"GIS" mode*. First, the user has to draw a polygon in a map representing the *Study Zone* (Figure 38). Subsequently, the tool establishes a link between the coordinates of the polygon and the database "*Source Inventory (GIS)*". The Source Inventory (GIS) were built using two open-access and free datasets that cover the entire EU territories: OpenStreetMap[3] (OSM) database and GHS population grid[4].

The tool displays in a map the location of the biowaste sources within the selected polygon (Figure 39). If the selected polygon has too many sources a warning message will be displayed stating that the size of the study zone should be smaller. Even if the warning message does not appear, we recommend working in the *"GIS" mode* with small *Study Zones* due to the cumbersome process of dealing with many *Biowaste Generation Sources* in the *Scenario Definition* step.

The user can zoom in and out to see various levels of detail of the *Biowaste Generation Sources.* Blue drop marks represent single *Biowaste Generation Sources* while the round marks represent aggregations of *Biowaste Generation Sources*. The colour of the round marks (yellow and green) depends on the density of sources in the point. When the user zooms in, the green rounds marks, first, become yellow rounds (grouping less sources than the green round marks). Further zoom can be used to convert the yellow round marks blue drop marks. To see and edit the information of a single *Biowaste Generation Source,* the user has to select the corresponding blue drop in the map.

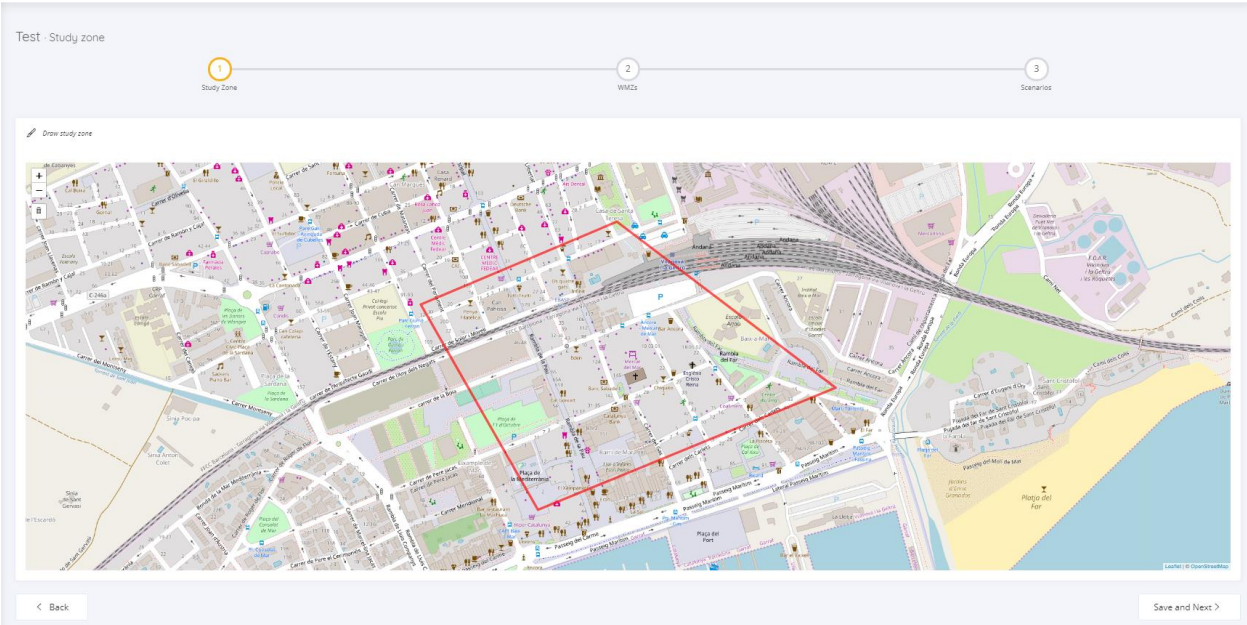

Figure 38: Study Zone definition of a GIS project in the DECISIVE DST before being saved using the "GIS" mode. Source: https://dst.decisive2020.eu

[3] Official website: https://www.openstreetmap.org
[4] Official website: http://data.jrc.ec.europa.eu/dataset/jrc-ghsl-ghs_pop_eurostat_europe_r2016a

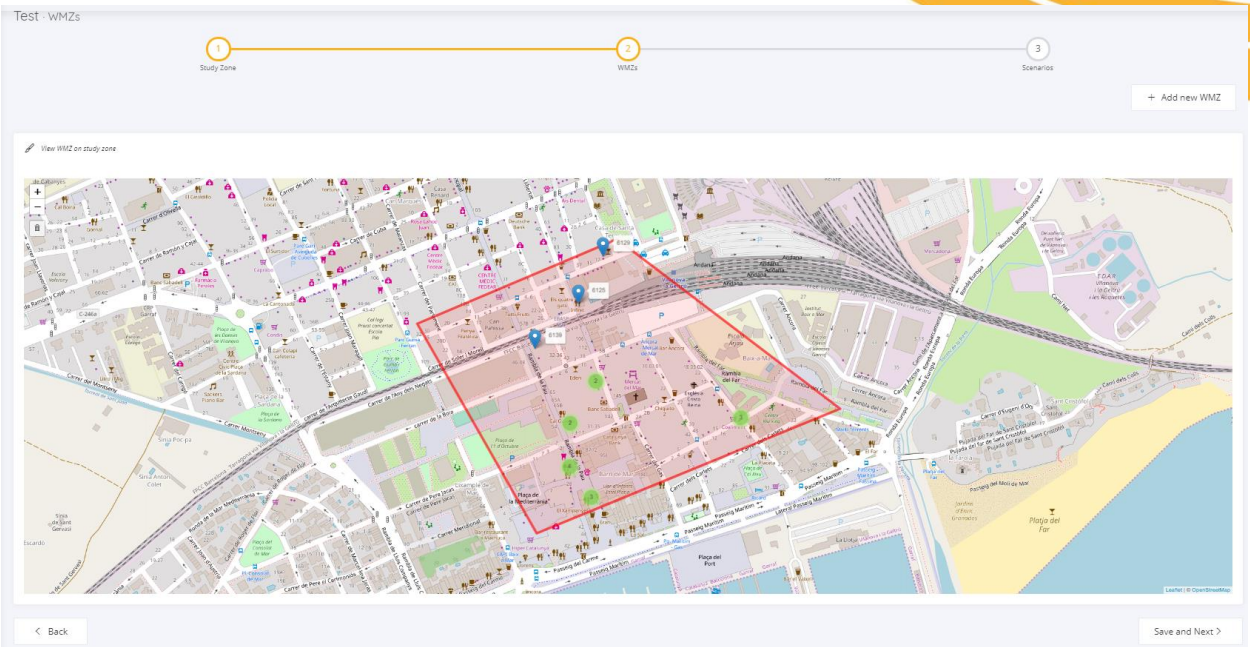

Figure 39: Study Zone definition of a GIS project in the DECISIVE DST after being saved using the "GIS" mode. Source: https://dst.decisive2020.eu

6.2. Waste Management Zones (WMZs) definition

Once the *Study Zone* has been defined the user has the option to split such area into different *WMZs* (Figure 40) using the option *Add new WMZ* (it is shown in the top-right corner of Figure 39). This partition can be avoided by selecting the option *Save and Next* (bottom-right corner of Figure 39).

There is no need to mark all the partitions. If the user draws a *WMZ* smaller than the *Study Zone* the DST creates automatically another *WMZ* with the remaining part of the *Study Zone.* After having saved the *WMZs* the DST displays in the map the *Biowaste Generation Sources* included in each *WMZ* together with the list of source names (bottom of the screen).

In case of overlapping of WMZs, the DST will assign the *Biowaste Generation Sources* located in the overlapped zone in the WMZ that was first defined. In this case, the user will get the following message: "*One or more sources are included in more than one WMZ. To proceed, the DST uses the first assignation defined by the user, i.e. the sources located in the overlapped zone are assumed to be included only in the WMZ defined first*."

The user can also add a *Biowaste Generation Source* in the *WMZ* (with the *Add Biowaste Generation* option) by selecting the top-right bottom of the screen (Figure 40). For that the user has to provide same information as reported in Section 5.1 and Figure 5 as well as selecting a spatial position in the map (see Figure 41). Please note that the addition of new *Biowaste Generation Source* can only be done once a *WMZ* has been defined. Otherwise an error will appear in the DST.

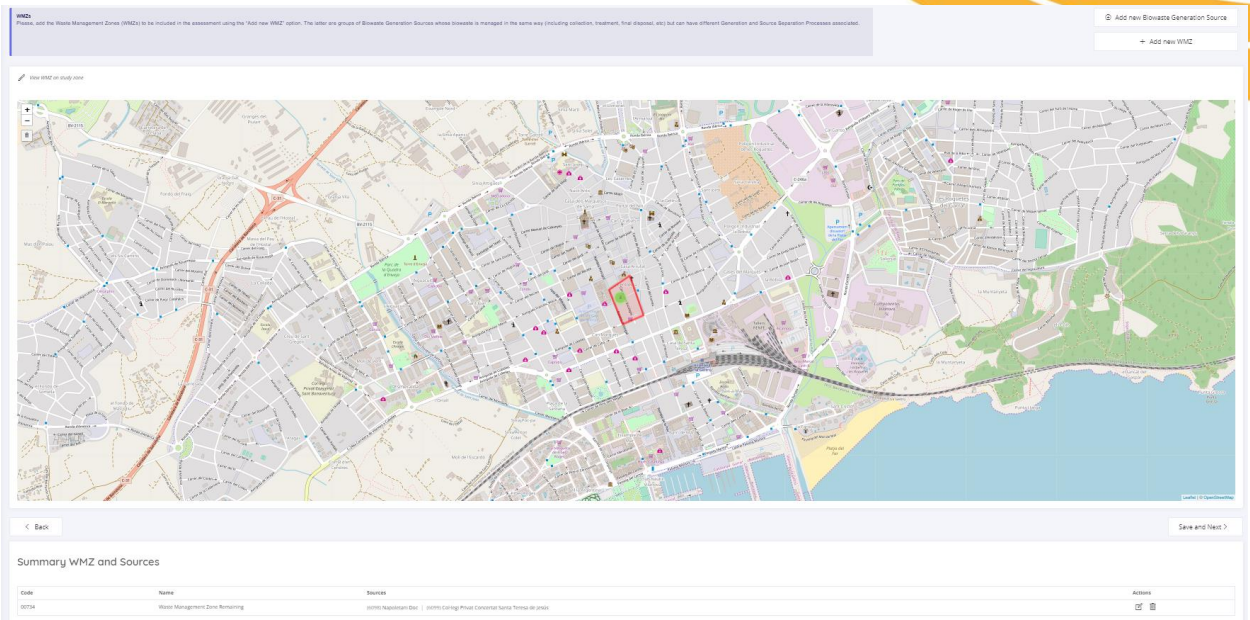

Figure 40: Definition of the WMZ in a GIS project in the DECISIVE DST using the "GIS" mode. Source: https://dst.decisive2020.eu

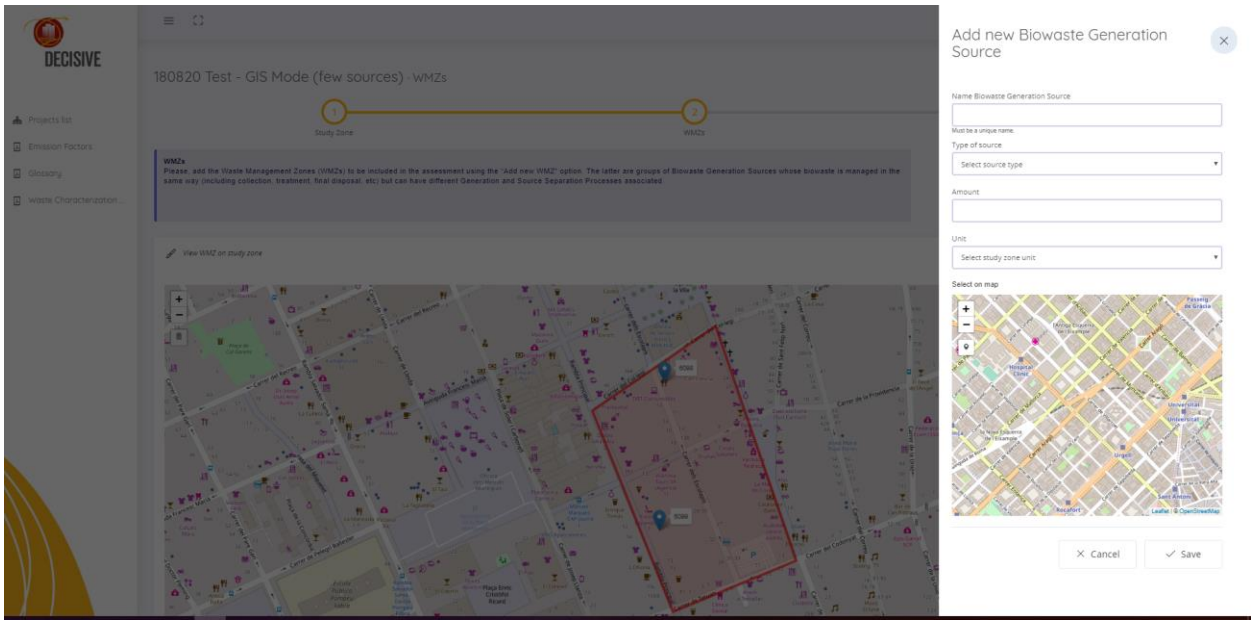

Figure 41: Definition of a new Biowaste Generation Source in a WMZ in a GIS project using the "GIS" mode. Source: https://dst.decisive2020.eu

6.3. Scenario definition

Once the *WMZs* are defined the user has to define the *Scenario* to be assessed by adding the different *Waste Processes.* The *Scenario Definition* using the *"GIS" mode* is done for the in the same way as described in the Section 5.3 for the *"Basic" mode*. The only difference is that when creating a *Waste Process* (other than collection and transportation) or a copy from the *Waste Process Database* the user has to assign specific coordinates (see example of Pre-treatment in Figure 42).

The user can select spatial locations listed in the *Facility Spatial Inventory* of the DST. This inventory was developed using the E-PRTR database and completed with OSM information and includes: incineration of non-hazardous waste, landfills, recycling facilities, and waste transfer stations.

The user cannot select of other points in the maps than the ones included in the *Facility Spatial Inventory* of the DST. Users can, however, select existing facilities, closed by the desired positions, to get an approximation of the distance.

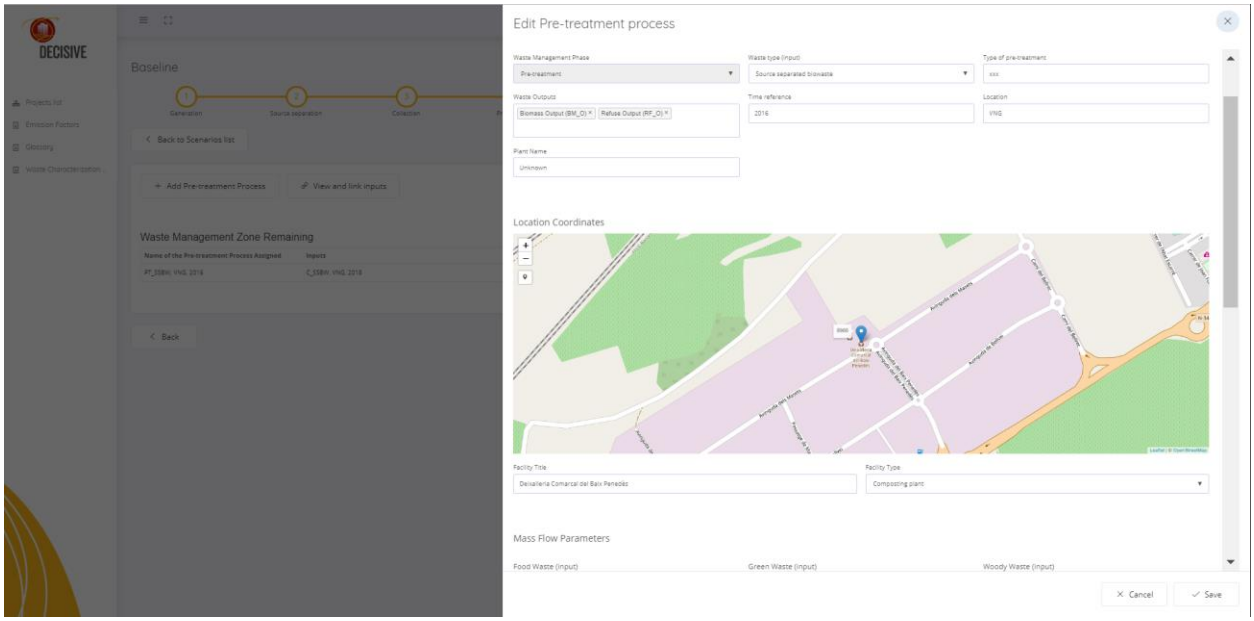

Figure 42: Definition of a Pre-treatment process for a Scenario in a GIS Project using the "GIS" mode. Source: https://dst.decisive2020.eu

6.4. Average Distance Introduction

In the *"GIS" mode* the tool calculates the collection (i.e. from sources to waste facilities) and transportation (i.e. between waste facilities or from waste facilities to bio-based product use) distances based on: (1) the spatial locations of the *Biowaste Generation Sources* given in the *Study Zone Definition*; and (2) the locations of the facilities given in the *Scenario Definition*. For each collection and transportation process defined in the *Scenario* the tool searches for the location of origin and destination to estimate the "Euclidian distance" (also called "Flying distance" or "Straight line distance") between them and ignores the actual road network.

The user can choose between two options to calculate collection distances. The option must be defined in the small box "*Choose Collection Distance Calculation*" under the *Study Zone* map (Figure 43). Figure 44 illustrates the two possible ways to calculate collection distances in the tool. The first option represents the case "single biowaste source to facility" with a star-like structure. In this first option the waste from each source is collected alone and brought to the waste facility (e.g. mAD) (Figure 44 - Left).

The second option implements a chain-like approach. It assumes that the collection is done, first, from source to source and, then, from the last source to the first waste facility (Figure 44 - Right). The distance of the first part of the chain-like structure (i.e. distance between sources) is calculated as the average distance between each source and the rest. The distance of the second part of the chain-like approach (i.e. distance between the last source where the waste is collected and the waste facility) is calculated as Euclidian distance between the last source the facility. It is assumed that the last source collected is the closest to the facility, i.e. the one with the minimum air distance to the facility.

The DST calculates distances with these approaches and the user has also the option to modify such distances by adding other values manually. After having saved the changes the DST uses the last values in the table for assessment calculations (Figure 45).

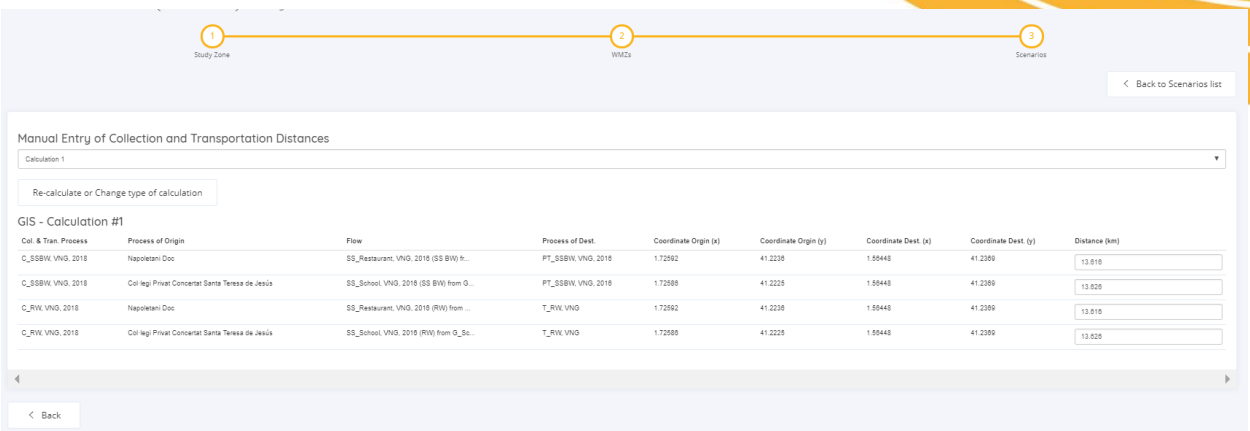

Figure 43: Selection of the collection mode in the Spatial Inventory definition of a Scenario using the "GIS" mode. Source: https://dst.decisive2020.eu

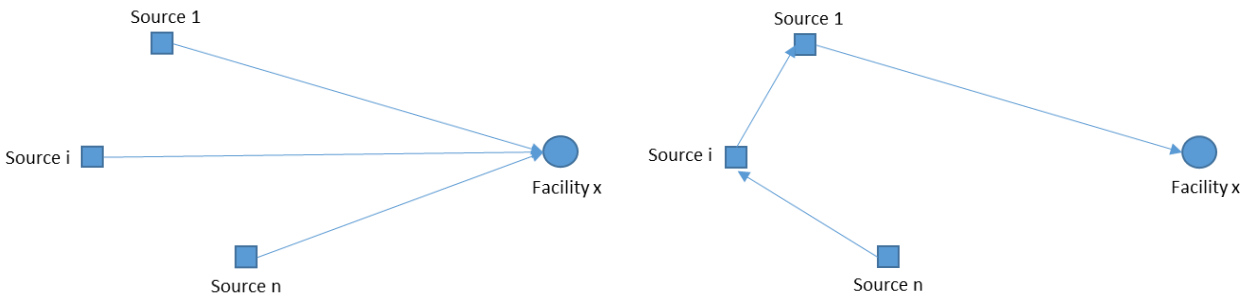

Figure 44: (Left) Collection from single biowaste source to facility (star-like structure). (Right) The schematic representation visualizes the collection between biowaste sources and from the last biowaste source to the first waste facility (chain-like structure).

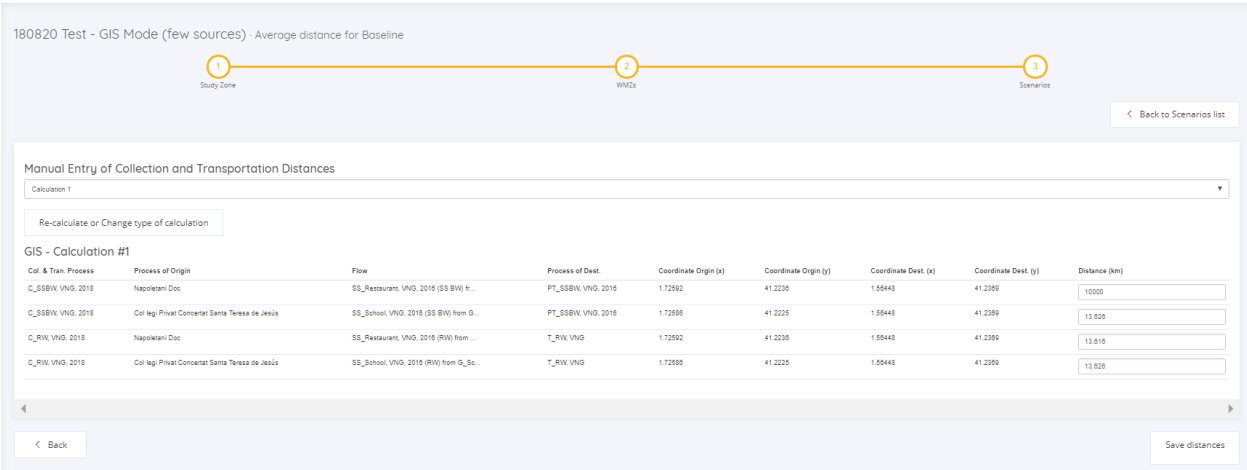

Figure 45: Manual modification of the collection and transportation distances of a Scenario using the "GIS" mode. Source: https://dst.decisive2020.eu

6.5. Assessment

Once the *Study Zone*, the *WMZs*, the *Scenario* and the *Average Distances* are defined by the user the tool shows the results of the assessment in the format shown for the *"Basic" mode* (Section 5.5). As for the *"Basic" mode*, the results icons will only appear if all the previous working steps have been completed.

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Annex I - Glossary

Term	Abbreviation	Definition	Source
Anaerobic digestion	AD	Waste treatment process taking place in absence of oxygen in which organic matter is degraded by a microbial population producing biogas (methane and carbon dioxide) and digestate.	D5.1
Assessment criteria		Set of indicators used to evaluate the performance of the biowaste management system in the DST tool.	D5.1
Background Process	BP	External processes (of the Waste Management Systems) used to produce goods that are consumed in biowaste management systems or substituted by the outputs products of the biowaste management system, such as energy and fertilizers.	D5.1
Basic Project		Evaluation done with the DECISIVE DST that includes one or more scenarios for a specific waste management zone in which the Geo-locations of the biowaste generation sources and facilities are not taken into account.	D5.3
Bio-based product		Goods and energy produced from biowaste as main feedstock.	D5.1
Bio-based Product Use	BPU	Activity representing the utilization of bio-based products such as using compost on land for soil amendment.	D5.3
Bio-fertilizers		Fertilizer produced from biowaste as main feedstock. It is a type of bio-based product.	D5.1
Biogas		Gas output of the anaerobic digestion process mainly made of methane and carbon dioxide.	D5.1
Biomass Output	BM_O	Biomass Output from a pre-treatment process.	D5.3
Bio-pesticides		Pesticides produced from biowaste as main feedstock. It is a type of bio-based product.	D5.1
Biowaste		Biodegradable garden and park waste, food and kitchen waste from households, restaurants, catering and retail premises and comparable waste from food processing plants.	Point 4 Article 3 WFD
Biowaste generator		Households, restaurants or any type of activities that produce biowaste.	D5.1
Biowaste for Energy Recovery	BW4ER	Ratio of biowaste sent to treatment (for energy recovery such as anaerobic digestion) to biowaste generated (network analysis indicator).	D5.3
Biowaste for Material Recovery	BW4MR	Ratio of biowaste sent to treatment (for material recovery such as composting and anaerobic digestion) over the biowaste generated (network analysis indicator).	D5.3
Biowaste sorting efficiency		Percentage of biowaste generated and disposed in the selective bin for biowaste.	D5.1
Biowaste Source Separation		Waste management stage in which biowaste is discarded at the place of generation in a dedicated bin for biowaste.	D5.1
Biowaste Generation Source		Same as biowaste generator.	D5.1
Biowaste sub-fractions		Components of the biowaste such as food waste, green waste, woody waste and other organic waste.	D5.1

Term	Abbreviation	Definition	Source
Biowaste Treatment		Biowaste Treatment represents *recovery or disposal operations, including preparation prior to recovery or disposal* exclusively for source-separated biowaste.	Point 14 Article 3 WFD
Capital Expenditure	CAPEX	Money spent by an organization to purchase capital goods such as buildings, vehicles, equipment and land.	D5.1
Capital Expenses		Same as capital expenditure.	D5.1
Capital good		Tangible asset to produce goods or services by an organization (e.g. buildings, equipment and machinery).	D5.1
Centralized system		Waste management system based on large-scale facilities that are often far from the waste generators.	D5.1
Characterisation Factor	CF	Contribution of a specific type of emission (e.g. methane) to an environmental impact category (e.g. climate change).	D5.1
Chemical contaminant		Same as micro-impurity.	
Chemical impurity		Same as micro-impurity.	
Climate Change		Environmental impact category that represents the change in climate patterns mainly due to the increased levels of atmospheric greenhouse gases.	D5.1
Collection chain		It includes generation, source-separation and collection of biowaste.	D5.1
Collection of non-separated biowaste		*Gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport to a waste treatment facility* (point 10 of Article 3 of the WFD) in which biowaste is not kept separated from other waste types.	D5.1
Collection of source-separated biowaste		*Gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport to a waste treatment facility* (point 10 of Article 3 of the WFD) in which biowaste is kept separated from other waste types.	D5.1
Composting		Waste treatment process in which a microbial population decomposes the organic matter in aerobic conditions (in presence of oxygen) to produce compost.	D5.1
Decentralized systems		Waste management system based on small-scale facilities that closer to waste generators than in the case of centralized systems.	D5.1
DECISIVE facilities		Term that includes micro-scale Anaerobic Digestion (microAD), Solid State Fermentation (SSF) and Stirling engine.	D5.1
Demonstration sites		Physical places in which the DECISIVE facilities and concept will be tested during the DECISIVE project. One site is located in the premises of UAB (Catalonia, Spain) and the other in the premises of Refarmers (Lyon, France).	D5.1
Digestate		Material remaining after degradation of the organic matter in the anaerobic digestion process.	D5.1
Direct emissions		Emissions occurring in all the stages of the waste management system excluding the background processes.	D5.1

Term	Abbreviation	Definition	Source
Disposal		*Any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I sets out a non-exhaustive list of disposal operations*.	Point 19 Article 3 WFD
Energy recovery		Any recovery operation in which waste is converted into heat, electricity or fuel.	D5.1
Final Disposal	FD	Same as Disposal.	D5.1
Food waste		Any food and inedible parts of food removed from the food supply chain to be recovered or disposed of (it includes composting, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarding to sea). DECISIVE deals only with the food waste generated in the last stages of the food supply chain, i.e. retail, food preparation and consumption.	Fusions (2014)
Garden waste		Waste generated in gardens, parks and other locations (cemeteries, roadsides, dykes etc.). Garden waste can be further divided into green waste, a part that is easily digestible by anaerobic microorganisms, and woody waste, which is poorly digestable (woody waste) under anaerobic conditions.	D5.1
Gate fees		Also called tipping fee, it is a charge received at a waste treatment facility for handling a given amount of a specific type of waste.	D5.1
Generation	G	Waste management stage in which the biowaste is produced as a result of food preparation, food consumption, pruning, grass cutting, etc.	D5.1
Generation of Biowaste		Same as Biowaste Generation.	
Generation Sources		Same as Biowaste Generator.	
Geo-localization		Geographic position of a specific object.	D5.1
GIS Project		Evaluation done with the DECISIVE DST that includes one or more scenarios for specific waste management zones in which the Geo-locations of biowaste generation sources and facilities are taken into account.	D5.3
Green waste		In the scope of DECISIVE this term refers exclusively to the soft, compactable and the most easily digestible parts of the garden waste. It includes grass cuttings, leaves, flowers, herbs, etc.	D3.5
Impurities		General term that includes macro- and micro-impurities.	D5.1
Incineration		Waste treatment process that involves combustion of waste with or without energy recovery, generation of ashes and flue gas cleaning technologies.	D5.1
Indirect emissions		Emissions generated by background processes related to the waste management system.	D5.1
Landfill		Disposal site where waste is buried.	D5.1
Life Cycle Assessment	LCA	Method to assess the environmental impacts associated with the complete life cycle of a product or service.	D5.1

Term	Abbreviation	Definition	Source
Life Cycle Costing	LCC	Method to assess the economic impacts associated with the complete life cycle of a product or service.	D5.1
Life time		It refers to the technical life time of equipment and plants used in the waste management system. It represents the period of time for which a piece of equipment or machinery can be used.	D5.1
Macro-impurities		Non-biowaste fractions (such paper, plastic and metals) that are discarded in a wrong way into the biowaste bin and can be, in some cases, mechanically removed in the waste management.	D5.1
Material contaminant		Same as micro-impurity.	
Material recovery		Same as recycling.	
Mechanical separation		Waste treatment process in which the waste is separated into different sub-fractions using mechanical equipment.	D5.1
Micro-impurities		Chemical contamination that cannot be mechanically removed and is caused by food contaminants, contaminated green waste, or by the presence of macro-impurities in the source-separated biowaste stream.	D5.1
Micro-pollutants		Same as micro-impurity.	
Micro-scale anaerobic digestion	mAD	Small scale anaerobic digestion. In the context of the DECISIVE project the annual input capacity for a micro-scale anaerobic digestion is below 200 t/year.	D4.1
Operational Expenditures	OPEX	Ongoing cost for an organization to run its activity.	D5.1
Operation Expenses		Same as operational expenditure.	
Physical impurity		Same as macro-impurity.	
Pre-treatment	PT	In the DECISIVE DST it represents a waste management activity that involves physical redistribution of waste fractions into different waste outputs (e.g. mechanical and manual sorting). This type of process does not include chemical or biological transformation.	D5.3
Private space of the generator		Space in the premises of the waste generator used to source separate waste or waste management insitu (e.g. homecomposting). It is measured in m^2.	
Project		Evaluation done with the DECISIVE DST that includes one or more scenarios for specific waste management zones.	D5.3
Recycling		*Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.*	Point 17 Article 3 WFD
Recyclables Output	REC_O	Recyclable Output stream from a pre-treatment process.	D5.3
Refuse Output	REF_O	Refuse Output stream from a pre-treatment process.	D5.3

Term	Abbreviation	Definition	Source
Residual waste	RW	For DECISIVE project residual waste refers to mixed municipal waste collected in areas where separate collection of biowaste is implemented.	D5.1
Revenue		Income of an organization to carry out its activity.	D5.1
Scenario		Technological pathways to handle the biowaste (i.e. set of waste processes that simulate the biowaste management of an area).	D5.1
Solid-State Fermentation	SSF	Emerging technology for the bioconversion of organic solids into value-added products such as bio-pesticides.	D4.5
Source Separated Biowaste	SSBW	Biowaste discarded in a dedicated bin for biowaste at the place of generation.	D5.3
Source Separated Garden Waste	SSGW	Biowaste discarded in a dedicated bin for garden at the place of generation.	D5.3
Source Separation	SS	Same as Biowaste Source Separation.	
Study Zone	SZ	Area for which the assessment is carried out. It can have different geographical scales, from region to municipality districts.	D6.1
Target users		The intended users of the DST that are mainly competent waste authorities, waste consultants and waste operators.	D5.1
Technical life time		Same as Life time.	
Technology-specific emissions		Emissions that are exclusively related to the waste treatment technology, regardless of the input biowaste. Note that several types of emissions are both technology-specific and biowaste-specific such as methane emissions in a composting process.	Deliverable D5.1
Transport	Trans	Transfer of waste and/or residues between facilities or bio-products from waste facilities to places where the products will be used onsite.	D5.3
Transport Intensity Index	TII	Index that estimates how intensive the system is in terms of transport. It is based on the distances travelled by the biowaste generated in the study zone during management. It is one of the network analysis indicators included in the assessment criteria of the tool.	D5.1 based on Font-Vivanco et al. (2012)
Transportation		Same as Transport.	
Treatment		Recovery or disposal operations, including preparation prior to recovery or disposal.	Point 14 Article 3 WFD
Waste charges		Fee paid by the waste generator for the service of managing its waste. It can include waste treatment charge and waste collection charge.	D5.1
Waste collectors		Organization (private or public) responsible for the collection of the waste.	D5.1
Waste Framework Directive	WFD	Directive 2008/98/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of the 19 November 2008 on waste and repealing certain Directives.	
Waste generators		Households, restaurants or any type of commercial activities that produce waste as a consequence of their activities.	D5.1
Waste Management System		Combination of activities necessary to handle waste.	D5.1

Term	Abbreviation	Definition	Source
Waste Management Zone	WMZ	Sub-areas of the study zone with the same type of biowaste management systems.	D5.1
Waste-specific emissions		Emissions that are mainly related to the elemental composition of the biowaste input in a specific waste treatment process. Note that several types of emissions are both technology-specific and biowaste-specific such as methane emissions in a composting process.	D5.1
Waste valorisation		Same as Material and Energy Recovery.	D5.1
Woody waste		The ligno-cellulosic (wood-rich) part of the garden waste which includes twigs, branches, etc. The woody waste is rigid, bulky and difficult to digest by anaerobic microorganisms without prior special pre-treatment.	D3.5

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