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Innovative Eco-Technologies for Resource Recovery from Wastewater

INCOVER

Deliverable D4.3
DSS and ICT tool: guidelines on use and operation

Work Package 4

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Content

1. Goal of DSS

In this section the initiation and the main goals of the Decision Support System (DSS) are discussed.

1.1 Initiatives of the DSS

In the original proposal of INCOVER the DSS was meant to aggregate the environemntal, social and economic results calculated for the INCOVER technologies. It had to have a modular structure enabling to assess and model either the whole technology chain comprising the actual INCOVER technologies or several part of a technology chain that is planned to be substituted by INCOVER technologies. This foreseen structure is depicted in the figure below.

Figure 1. Planned modular structure of DSS
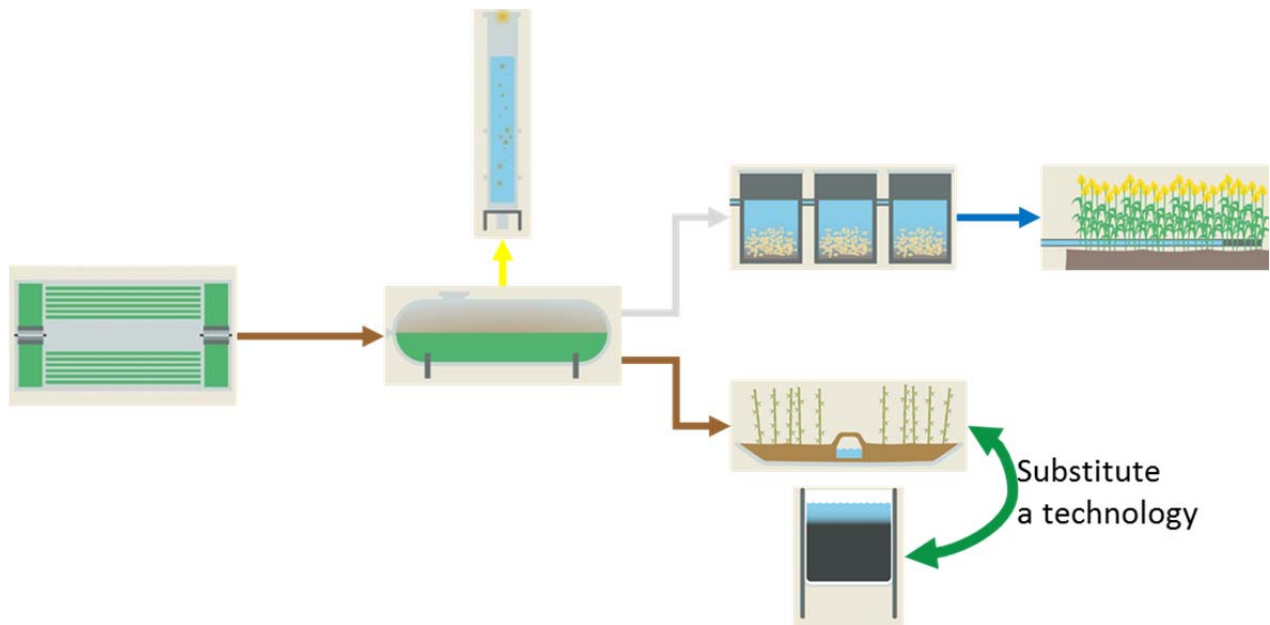
During the technology development in the project and because of the different initial situation of similar technologies at different sites (Almería, Chiclana, Agropolis, Leipzig, and Bad Königshofen) technologies got different sizes and altering input and output values. This of course, resulted in different performances and disproportionate economic and environmental performances that are no longer comparable with one another. In addition as a consequence, the linking of many technologies become also impossible.

An additional problem was the aggregation of results. LCA methodology offers at least three aggregation methods; however, the normalization is the most accepted due to its objective character. But even applying normalization the original character and information of the various environmental, social and economic indicators is lost because they are all aggregated to one dimensionless number. Since we wanted to provide the potential user with the diversity of environmental, social, and economic aspects, we decided to keep the different indicators and display them separately to the potential user. Of course, with this decision we pushed the task of decision

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making towards the user, whe finally should be in a position to have an overview of the situation and develop priorities among the provided social, economic and environemtal performances.

Last but not least, the great temporal and spatial variability of prices and because these values are usually well known by local planning engineers and economists, it urged us not to use predifined prices for the economic evaluation, but ask user about them as an input data.

The arguments above formed the DSS to its current shape. Hopefully these circumstance provided a challenging environment to create a powerfull tool capable to assist maintenance and invenstment related decisions mainly in the wastewater treatment sector.

1.2 Goals of DSS

This calculation model was developed within the INCOVER project (https://incover-project.eu/) evaluating technologies developed for wastewater treatment and waste recovery. The ultimate goal of creating this Decision Support System was to provide easy understandable environmental indicators for various maintenance and investment projects, since this part of the information is usually not considered. In addition, although in many cases environmental prescriptions and regulations have to be kept and followed, they do not always support increasing environmental efficiency. Thus, just following the regulation does not guarantee a progressive approach toward sustainability and an easy and approximate calculation of environmental impacts for different investment options can assist decision making in this regard.

Otherwise, sustainability evaluation is done by life-cycle sustainability assessment (LCSA) that is a complicated, time consuming, and expensive calculation generally made by experts. This is also the reason why it is often neglected.

In Project INCOVER we had the opportunity to use some very important and relevant LCA database units, i.e. unit processes (see Table 1), that could be used to make a quick preliminary evaluation of investment and maintenance alternatives at hand. These unit processes build the bases of the DSS. Additionally, a simple economic calculation was also built in to the DSS based on the economic data given by the user.
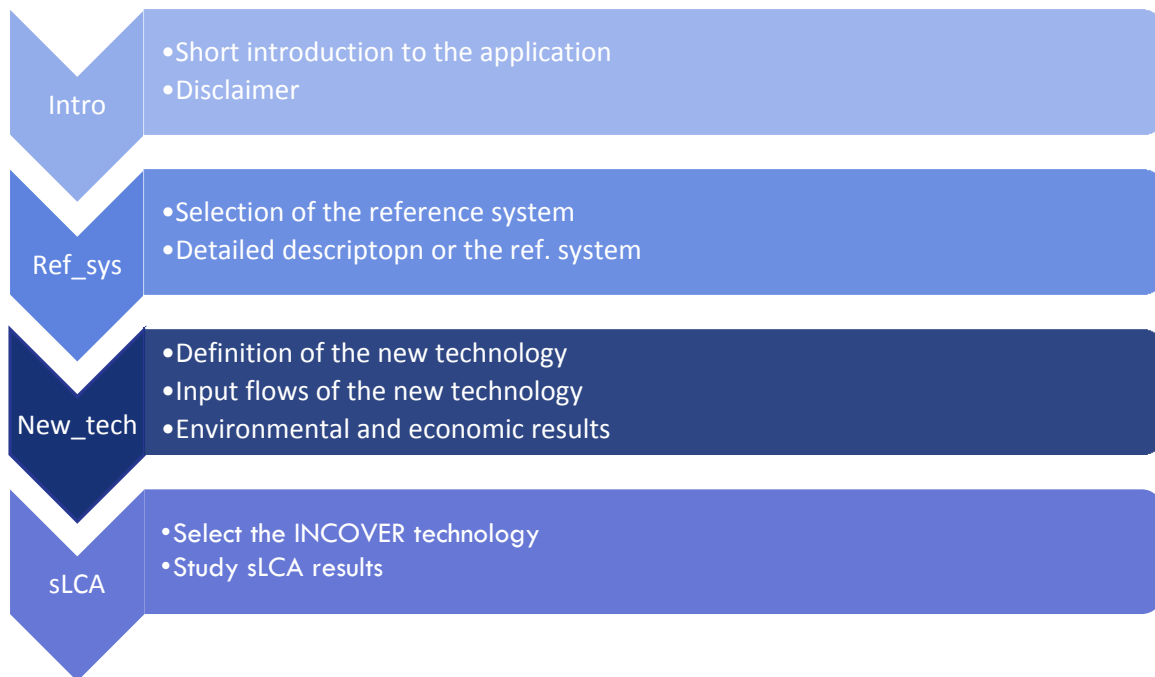
2. Structure of DSS

The DSS is a spreadsheet model programmed in Visual Basic where only the active sheets are accessible for the user. Data inputs and other commads are defined as command buttons on these active sheets.

The DSS has four active sheets: "Intro", "Ref_sys", and "New_tech". On the "Intro" worksheet the user can read an introduction to the application and the disclimer of the dataset providing company Think Step. The worksheet "Ref_sys" is designed for selecting the reference technology. This is of utmost importance, because the reference technology is the technology with the results of the new technology are compared with. Without this comparison, the sustainbility results are hard to understand and interpret, because sustainabilty assessment is only possible in relative terms, i.e. not absolut but relative sustainability can be assessed. This relativeness is provided by the reference

system. In the worksheet "New_tech" the new technology can be defined and this page also contains the environmental and economic results of the conparison. These results are presented in tables and in case of LCA calculations also in charts. On the next sheet ("sLCA") the results of the sLCA calculation are depicted. The stucture of DSS is summarized in the figure below.

Figure 2. Structure of DSS

Intro
- Short introduction to the application
- Disclaimer

Ref_sys
- Selection of the reference system
- Detailed descriptopn or the ref. system

New_tech
- Definition of the new technology
- Input flows of the new technology
- Environmental and economic results

sLCA
- Select the INCOVER technology
- Study sLCA results

3. Users' guide

In this section a step-by-step description of the DSS is provided concerning its use and the interpretation of the results.

Important! Since the application uses macros, before you proceed with calculations, please allow the use of macros in excel! For this go to File→Options→Trust Center Settings command→Macro Settings tab→Click Disable all macros with notification. With this setting when a message bar asks about to enable or disable macros while opening the DSS, click enable.

3.1 Worksheet "Intro"
This Worksheet is only for information: short user guide and disclaimer. There are two buttons: Next and Close. With the Next button the user can navigate to the next worksheet and with the Close button the file can be closed.

3.2 Worksheet "Ref_sys"
In this worksheet the user can select the reference system. You can do this by clicking on the button "Select reference system". With this a dialog box appears where with a drop-down menu the user can select the appropriate reference system. An optimal reference system is the one that has the same function as the new technology, e.g. both clean wastewater, and has the similar size, e.g. 300 m^3/day. This is why the size of the reference technology is also given next to its name. The list of

reference systems available is given in Table 1. For a better comparability of sizes, this list already comprize the size of the technology too. However, this list can be extended when the user clicks on the button "Record my technology" in the worksheet "New_tech" (see later for a detailed description).

Table 1. Reference systems

Conventional wastewater treatment plant, flow rate: 30,137 m^3/day
High-rate algae pond with pretreatment and settler, flow rate: 300 m^3/day
Sequencing batch reactor with sludge settler, flow rate: 300 m^3/day
Biogas production: 900 Nm^3/day
Algae-based biogas upgrade with HRAP, flow rate: 0.05 m^3/dy
Pressure swing adsorption: 26,920.7 m3/day
Raw sewage sludge incineration
Evaporative system for digestate and sludge, flow rate: 0.427 m^3/day
Willow zero-discharge system for wastewater, flow rate: 4 m^3/day
Sludge Treatment Wetland, flow rate: 0.0225 m^3/day
Planted filter for outlet water from a HRAP with Phragmites australis, flow rate: 4 m^3/day
Planted filter for outlet water from a HRAP with Arundo donax, flow rate: 4 m^3/day
Planted filter with Phragmites Australis for municipal wastewater, flow rate: 4 m^3/day
Conventional chlorination, flow rate: 8 m^3/day
A. niger-based citric acid production
Solar anodic oxidation: 8 m^3/day

When the best suited reference technology is selected the name, the size, the life span and the reference flow[1] of the technology immediately appears on the worksheet. In addition, the input and output qualities of the selected reference technology is also depicted. With this information the user can build a picture of the technical performace of the technology. As the last information block, a short description of the technology is given with a photo.

There are two additional buttons on this worksheet: Next and Back. With the Next button the user can navigate to the next worksheet and with the Back button the user can go back to the previous page. The stucture of the sheet is depicted in Figure 3 below.

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[1] The reference flow is the total amount of utility the technology can provide during its entire life span. This is calculated by multiplying the daily flow rate with the life span of the technology and with the number of days per year.

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Figure 3. The "Ref_sys" worksheet with the drop down menu of the selectable technologies

3.3 Worksheet "New_tech"

This worksheet builds the main part of the application DSS. On the "New_tech" worksheet the user is invited to define the composition of the new technology using different material and energy flows. This list of flows comprises the most common building materials and process additives that are used in wastewater treatment (WWT). This list is provided in Table 2.

The user is asked to define the amount and the cost for these material and energy flows in a dialog box. To open this dialog box the user has to click on the button "Data input". The dialog box is depicted in Figure 4.

First, the user is should name the new technology. Next, the life span and the flow rate of the technology has to be defined. In order to enable a good comparison with the selected reference system the differene between the reference flows of the two compared technologies shouldn't be bigger than 50%. If it is bigger, an additional dialog box appears with the message "For the comparability of the systems the flow rates have to be similar! Define an other flow rate closer to the reference system's flow rate." In this case click OK and define an other flow rate. Bear in mind that the reference flow is calculated by multipling the flow rate (unit/days) with the life span of the system and with the numbers of days per year. To control the process of defining the appropriate flow rate and life span the user can immediately compare the typed values on the result sheet where the two reference flows of the technologies, unit/lifetime, has to be similar. See figure 5 for this instruction.

In case no reference flow is defined the results will show "#DIV/0!".

Table 2. LCA unit processes for defining the technology

Circulating pump 250-1000W, kg
PVC Pipe, kg
HDPE Pipe, kg
Glass fibre reinforced pipe, kg
Concrete with concrete pumping, kg
PVC film, kg
PP film, kg
Glass fibre reinforced polyamide, kg
Photovoltaics, electric installation for 3kWp module, at building, kW
Electricity grid mix EU 28, MJ
Electricity from photovoltaic, MJ
Process steam from natural gas, MJ
Polyacrylamide, kg
Polyether polyol, kg
Limestone flour, kg
Sodium silicate, kg
Process water, kg
Polyaluminum chloride, kg

Figure 4. Data input dialog box

As a next step, the user is asked to fill in the first colum where the material and energy flows of the new technology are required. Please, be aware of the dimensions predifined for each flow. There are

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two main life phases important: construction and operation. In case of construction, the amounts required for the initiation of the technology are to be defined and the calculation adjusts these amount to the total life span of the technology. For example, in case of pumps the user types the total weight of the pumps used in the technology, but because pumps usually have a life-cycle of only 10 years and if the system functions for 20 years, the weight of the pump will be automatically multiplied by 20/10=2. This means that reinvestment is automatically calculated by the programme.

When filling out the material and energy inputs of your technology it can be helpful to have a look at the same material and energy inputs used for the reference technology. It gives you a hint about the order of magnitude of these possible inputs. You can find this information on the third column under the Results caption.

Figure 5. Selecting similar flow rates

In the second column of the data input dialog box the cost of the material and energy flows, transportation, and personnel has to be given. To create a fair economic comparison between the reference and your technology, it is necessary to define costs for every flow of both technologies. To see which flows are defined for the reference system, please have a look at the third column under the result caption again. Thus, the user should define costs not just for the new but also for the reference technology.

In addition, the user can provide a short description of the newly defined system and provide characteristic input and output indicators describing the technical performance of the technology. To make these inputs understandable for others, the user is asked to give the dimension as well, e.g. COD 800 [mg/L]. When this dialog box is filled in, click OK to show the results or Cancel to delete the inputs made so far.

The defined input data is presented for comparison in a table format on the first three columns of this worksheet "New_tech". In this table the second column gives the values for the newly defined technology. However, it is important to mention right here, that these input material and energy flows do not always cover all the necessary flows and so the economic and environmental

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calculations are less precise. Consequently, these calculations are suitable for a rough estimation only.

Below this input data table, if cost data ware also defined, CAPEX and OPEX results appear for both technologies. In this case, the cost data defined by the user are also applied for the reference technology to satisfy a proper comparability also in economic terms.

The environmental results are depicted on the reight side of the sheet both in table and in diagrams. The table also signals which value is better (green) and wich worse (red). Since the results give environmental impats the lower the value the better is the result.

There are three additional buttons available on this sheet: "Record my technology", "Finish and close", "Back", and "Next to sLCA". With the "Record my technology" button the user can save the new technology as a reference system and all the inputs and results will be saves to the list of the reference systems. Consequently, when returning to the "Ref_sys" page, among the reference systems in the drop-down menu the user can select the newly saved technology as well. However, when the new technology is once saved modifications are no longer possible. With the "Finish and close" button the Excel file is closed without saving the results! The "Back" button allows to return back to the "Ref_sys" worksheet. The button "Next to sLCA" navigates you to the worksheet with the results of the social life cycle assessment.

3.4 Worksheet "sLCA"

Here you can choose from a drop down menu in blue color the INCOVER technology you are interested in. The results appear immediatelly on the screen. From this sheet you can navigate back to the sheet "New_tech" or close the application.

4. Disclaimer

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