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project Ô

D7.1: Selection toolbox design and development strategy; description of selection toolbox functionalities

V.4 – 08.2019

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Deliverable Review and Approval

The individuals listed below are not directly involved in the preparation of this deliverable and will review the present document.

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Deliverable Development and Review Process

	Key Event	Deadline	Done by
1	Submission of Draft Deliverable to reviewers	*01/08/2019*	*27/08/2019*
2	Initial Review and Comments obtained	*15/08/2019*	*05/09/2019*
3	Uploading and submission of Final Deliverable on Participant Portal	*30/08/2019*	*26/09/2019*

Executive summary

This document describes the main characteristics of Project Ô's Technology Selection Toolbox. A general overview of the conceptual design and the software architecture is presented in order to provide the reader a clear understanding of the scope of the tool. One of the main strengths of the tool is how it integrates different types of data and technologies, which allows to carry out water treatment simulations and data analysis. The platform can be connected to a database of water treatment technologies to provide information about the available technologies and equipment for certain networks/locations.

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1 Introduction

Project Ô, and specifically Work Package 7, has the aim of assessing the economic and operational sustainability of water circular use, within specific water regulatory conditions, and how it interfaces with a circular economy business model, more business driven and where water is one of the resources to be shared. The main outcome of WP7 is a set of tools to facilitate user engagement and to underpin collaborative business opportunities between different stakeholders along the value chain.

A key output of WP7 is the Design of a Technology Selection Toolbox for water treatment technologies. It is meant to be a single dynamic online platform which will be used by water treatment facilities and water system managers for the identification of the best technology solution and/or system of solutions to treat a specific water stream. It will also empower small communities and SMEs to implement virtuous practices for on-site circular use (or re-use) of water. The toolbox will provide technical, economic, environmental and regulatory information reported in a graphical way that enables the comparison between alternatives and facilitates their final decision.

Accessed from the project website, it is composed of a set of modules displaying fact sheets consisting of charts, tables and other information gathered. Ultimately, the selection toolbox will be one of the key components conforming the Users Collaborative Platform to be developed in Project Ô as part of the same work package (WP7).

This deliverable presents the first functional version of the Technology Selection Toolbox, which builds upon the current state-of-the-art technologies for Used water treatments and foresees the integration of the innovative technologies in Project Ô portfolio. The toolbox will evolve towards a more technology-oriented tool along with the development of the project and will rely on the technical and economic information that is being developed by consortium partners. This first functional version is coded in VBA (Visual Basic for Applications) and includes a simple user interface, which would be transferred to a web-based tool once integrated in the Users Collaborative Platform in task T7.2.

2 Basic structure and content of the toolbox

The toolbox consists of 8 main elements:

1. **Input block**. The "SUMMARY AND INSTRUCTIONS" tab works as the tool's input block, where the users are meant to introduce their specific water type to be treated and water quality data, such as water source, flow to site, solids particle size, Biochemical Oxygen Demand (BOD5), Total Suspended Solids (TSS), Total Phosphorous (TP), metals, among others.
2. **Instructions**. The tool offers a set of instructions in the "COMPANY" tab, outlining a step by step guide on how to use the tool for obtaining optimal results. Moreover, in the data input tab, the tool also presents warnings when the selected information is incorrect and/or wrongly placed e.g. combination of treatment and source type not compatible.
3. **Catalogue**. Under the tab "Data", the selection toolbox gathers a variety of technologies for every treatment stage and water process type. For each technology, the removal rate of the different Key Performance Indicators (KPI)[1] are stated, which is a crucial aspect for calculating the overall output KPI content depending on the technology selection and input data. The result of this calculation will be compared against the regulations limit values to evaluate their legal compliance.
4. **Process selection**. Based on the input data, the tool will automatically select the suitable water treatment process stages, which will be displayed on the left-hand side of the tab "SUMMARY AND INSTRUCTIONS". The selection will be graphically illustrated in the form of a Process Flow Diagram in the tab "PFD".
5. **Technical and economic data**. A more detail information of the process and technology selection is shown under the tab "process data" for the technical aspects, and the tab "Economic data" for the CAPEX and OPEX.
6. **Regulatory data**. The legal limit values of the considered KPIs are stated in the tab "Permits", both for Used water and Clean water. The data will then be used for comparison purposes of the treatment selected, to assess if the output aligns with the current legal requirements; if it does not then a different or additional set of water treatment technologies should be selected. The tool allows to add on technologies or modify the selection made to look for a better solution so that the output water parameters are within the regulatory limits.
7. **Interface**. The performance results of the different technology selections are shown in form of infographics in the tab "Graphs". It is featured in a user-friendly approach that enables the comparison between alternatives and facilitates their final decision. The charts present the water treatment performance of the different train of technologies chosen in each selection, comparing the KPIs against the limit values set by the regulations.
8. **Back end**. All the codes and formulas to run the toolbox are stored in the back-end side of the engine, protected under password.

[1] KPIs defined in the Annex

3 Technical content

The aim of this work is to develop an easy to use tool which can assist in the selection of appropriate technologies and processes required for water treatment. Below, a step-by-step user guide is presented for facilitating the optimal use of the tool.

1. Within the '**SUMMARY & INSTRUCTIONS'** tab, complete column J (light blue cells) of the input sheet with the relevant information. If the data to entered is for used water, the clean water cells should be empty as shown in the figure below and vice versa.

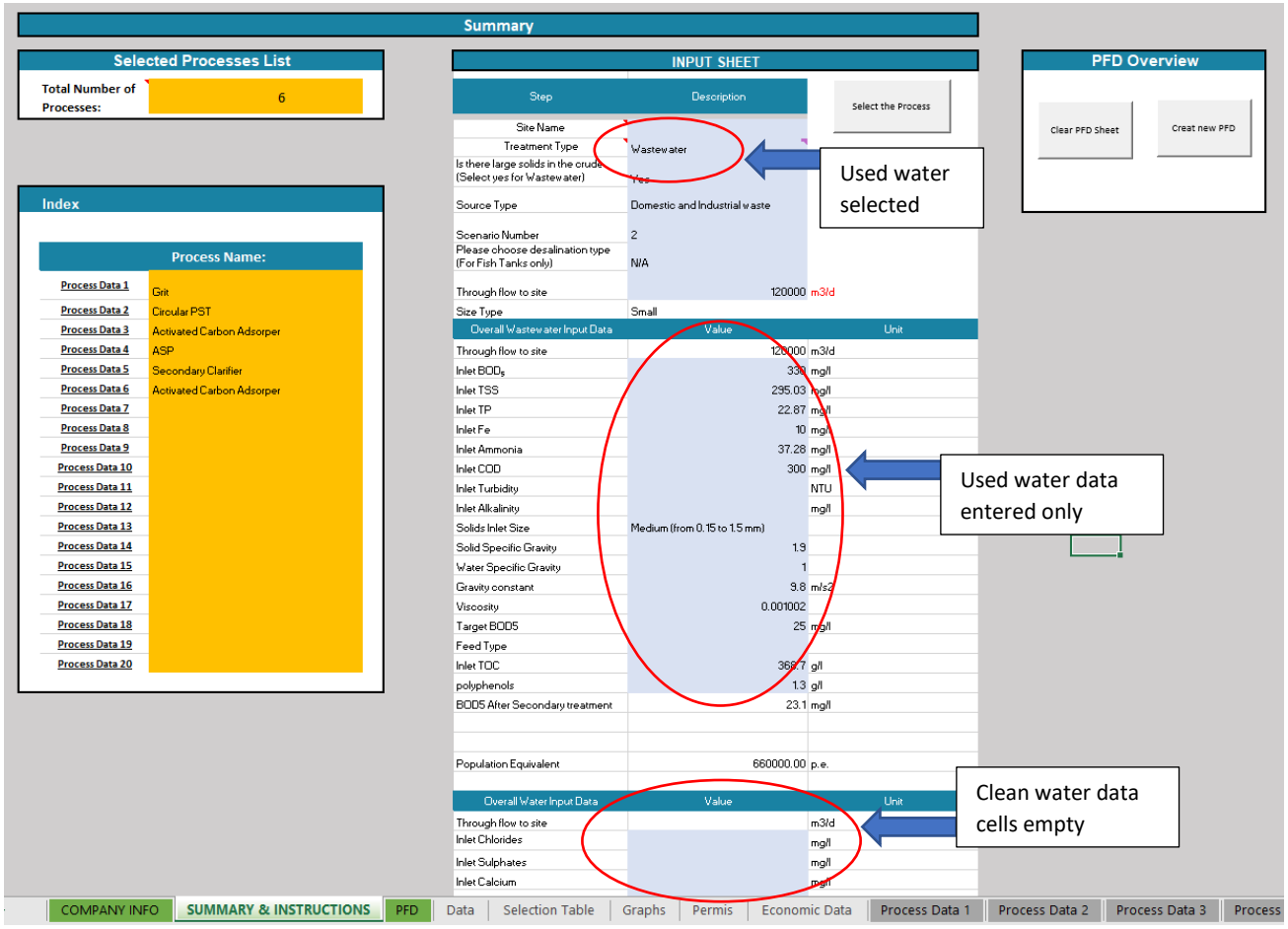

Figure 1: summary sheet to input data of only Used water contents.

Only cells in blue are to be filled and updated. Data in white cells are calculated and should not be manually updated.

2. The '**Process Data'** tabs provide the unit data for the Clean/Used water treatment. Input the required data in the Summary table and the stream table (light blue cells). For Used water selection please use Process Data 1 to 5 to input data. For water option use Process data 6 to 11 to input the relevant data.

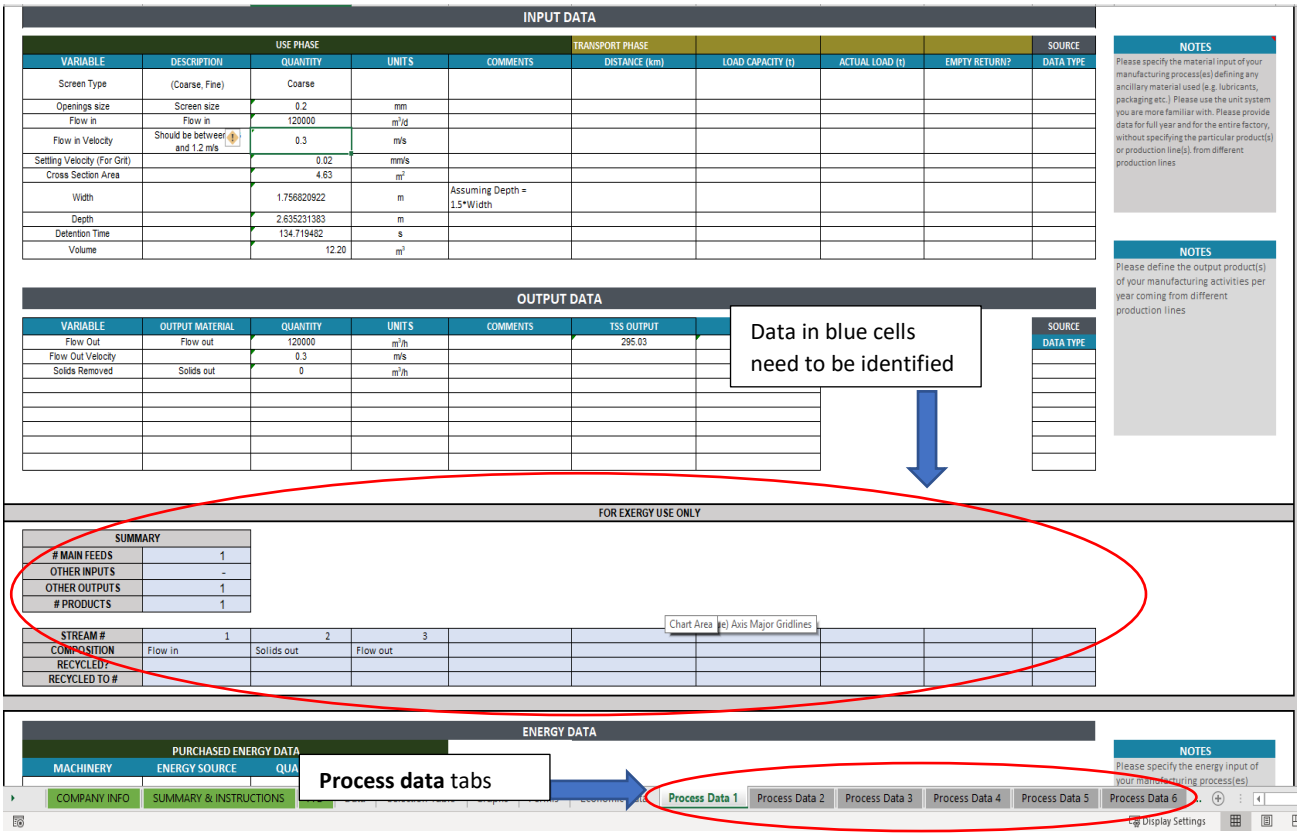

Figure 2: Process data sheet to input data streams number and names.

3. On the '**SUMMARY & INSTRUCTIONS'** tab, click on '**Select the Process**' button to display suggested technology / process needed; shown in column D (orange cells).

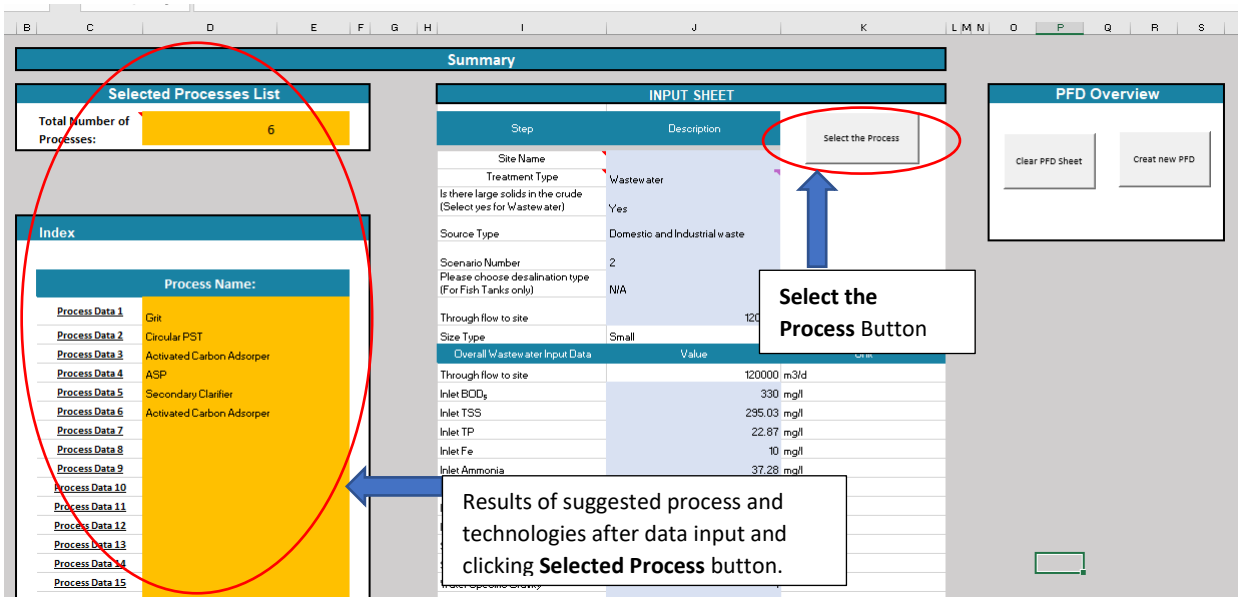

Figure 3: Suggested processes and technologies results

4. To reset the PFD in the '**PFD**' tab (which will display the resultant information as a diagram), on the '**SUMMARY & INSTRUCTIONS**' tab, click on the **'Clear PDF Sheet'** button, this will clear the old PDF. Then click the **'Create new PFD'** button to start a new PFD.

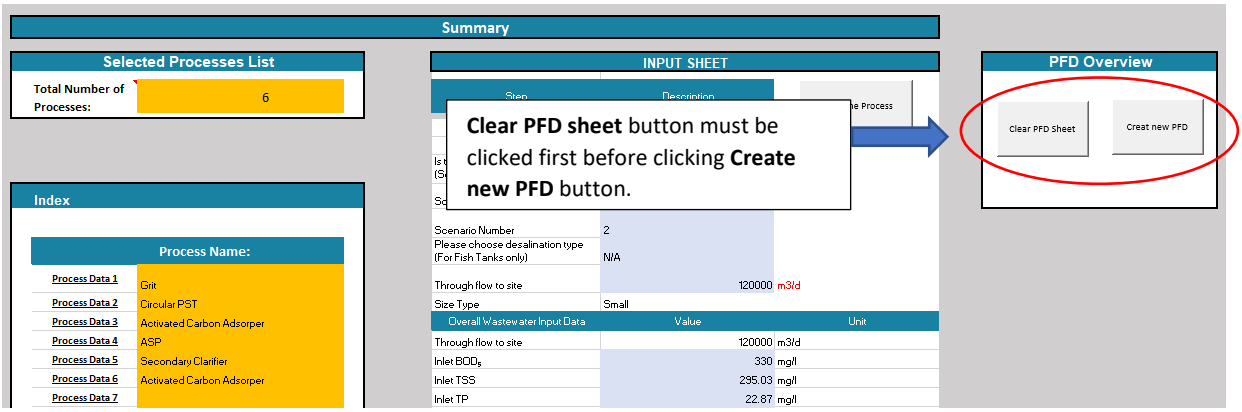

Figure 4: Process block diagram drawings procedure.

5. Once new information has been added and the user has clicked on **'Select the Process'** button', return to the **'PFD'** tab to build the diagram. Build by selecting the buttons to the right of the diagram window and under the **'Please click buttons below to draw PFD'** column. For each process, design parameters and results will be presented based on the input data.

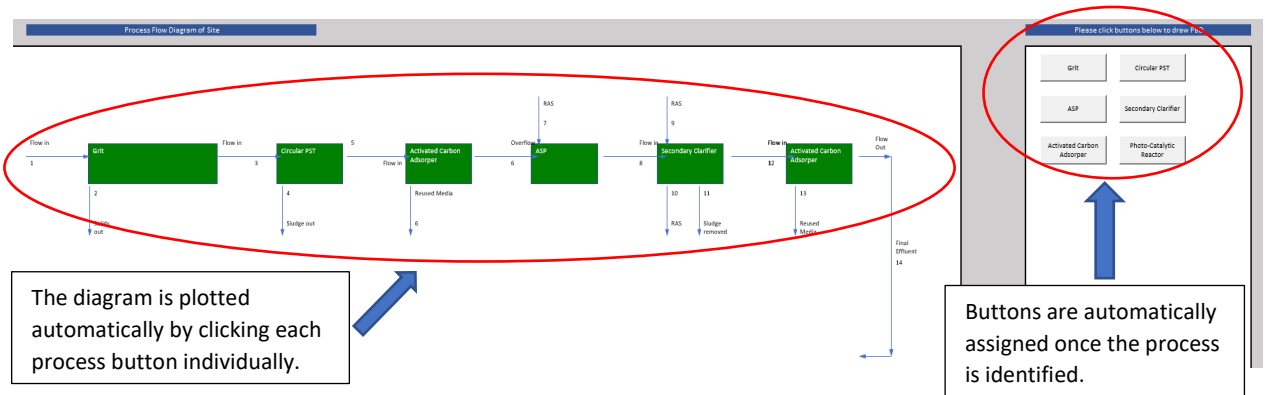

Figure 5: Process block diagram drawings results

6. Column K in the **'SUMMARY & INSTRUCTIONS'** tab displays auto-warnings for incorrect inputs, correct by following the warning(s) instructions. Ensure all warnings are cleared before clicking on the **'Select the Process'** button as errors could occur.

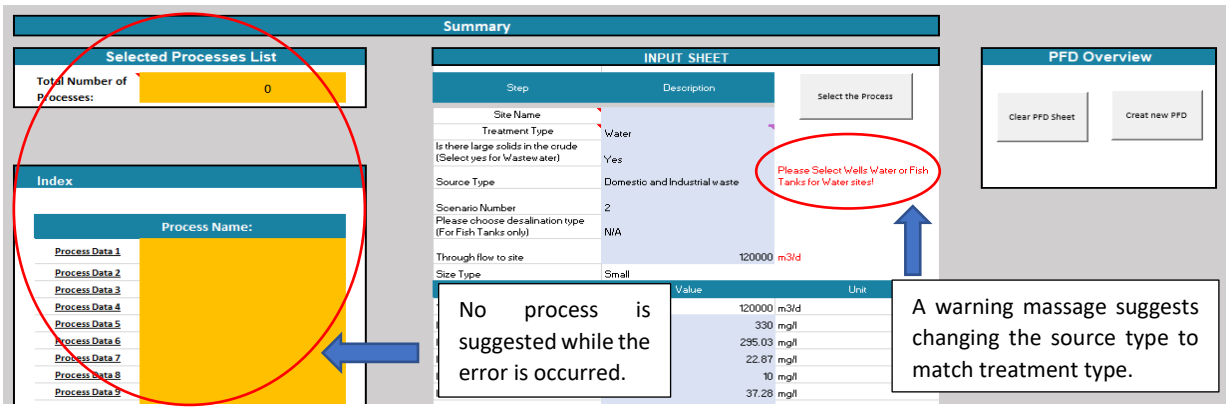

Figure 6: A warning massage example

7. Update data in sheets **'Permits'**, **'Data'** and **'Economic Data'** as shown in the following figures.

Wastewater		
KPI	**Permit**	**Unit**
Biological Oxygen Demand (BOD5)	25	mg/l
Chemical Oxygen Demand (COD)	125	mg/l
Total Suspended Solids (TSS)	25	mg/l
Total Phosphorus (TP)	1	mg/l
Ammonia	4	mg/l
Iron	4	mg/l
TOC	30	mg/l

Wastewater		
KPI	**Permit**	**Unit**
Chlorides	250	mg/l
Sulphates	250	mg/l
Calcium	100	mg/l
Magnesium	50	mg/l
Sodium	150	mg/l
Potassium	12	mg/l
Aluminium	0.2	mg/l
Nitrates	50	mg/l
Nitrites	0.1	mg/l
Ammonia	0.5	mg/l
Iron	200	µg/l
Manganese	50	µg/l
Copper	100	µg/l
Zinc	100	µg/l
Total Phosphorus (TP)	5	mg/l
Total Suspended Solids (TSS)	0	µg/l
Nickel	50	µg/l
Lead	50	µg/l
E. coli	10	UFC/ 100 ml

Figure 7: All data in Permits sheet can be checked and updated

Please update the cost in this table:

Tech	Prices k€/Unit			Operating Cost k€/yr		
	Micro	Mini	Small	Micro	Mini	Small
Membrane Distillation Unit MD	50	100	500	3.27	2.69	0.73
Solar Photo Fenton	35	336	1785	1.54	0.66	0.23
Photo-Catalytic Reactor	50	480	2550	2.28	1.81	0.73
HiNaPEF Disinfection	22	110	204	2.03	1.34	0.27
Activated Carbon Adsorper	85	660	1570	3.27	1.87	0.57
CDI Desalination	102	770	1710	2.4	2.13	0.33
Microwave enhanced catalytic degradation	175	847	1880	2.23	1.49	0.42
ASP Denitrification Reactor	27	30	33	2.23	1.4	0.52
Algea Separator	25	100	200	2.03	1.2	0.32
Advanced control unit						
Nanofiltration	80	145	325	1.21	1.03	0.28
Secondary Clarifier	13	50	79	3.5	2	1.2
Screenings	1	2	3	4	5	6
Grit	1	2	3	4	5	6
Flotation	1	2	3	4	5	6
Mixing	1	2	3	4	5	6
Rectangular PST	3	5	10	1.6	1	0.6
Circular PST	13	50	79	3.5	2	1.2
Percolating Filter	27	30	33	2.23	1.4	0.52
ASP Oxidation Ditch						
ASP Plug Flow						
ASP Complete Mix						
Granular Media Filter	1	2	3	4	5	6
Ultrafiltration (UF)	80	145	325	1.21	1.03	0.28
Microfiltration (MF)	80	145	325	1.21	1.03	0.28
Reverse Osmosis (RO)	80	145	325	1.21	1.03	0.28
Electrodialysis (ED)						

Figure 8: All data in Economic Data *sheet can be checked and updated*

In **'Data'** sheet (See figure 9), the removal percent shown in column F can be updated. This value is used to estimate the KPI value remining at the output flow of each technology. Therefore, data in columns O to AL must also be updated.

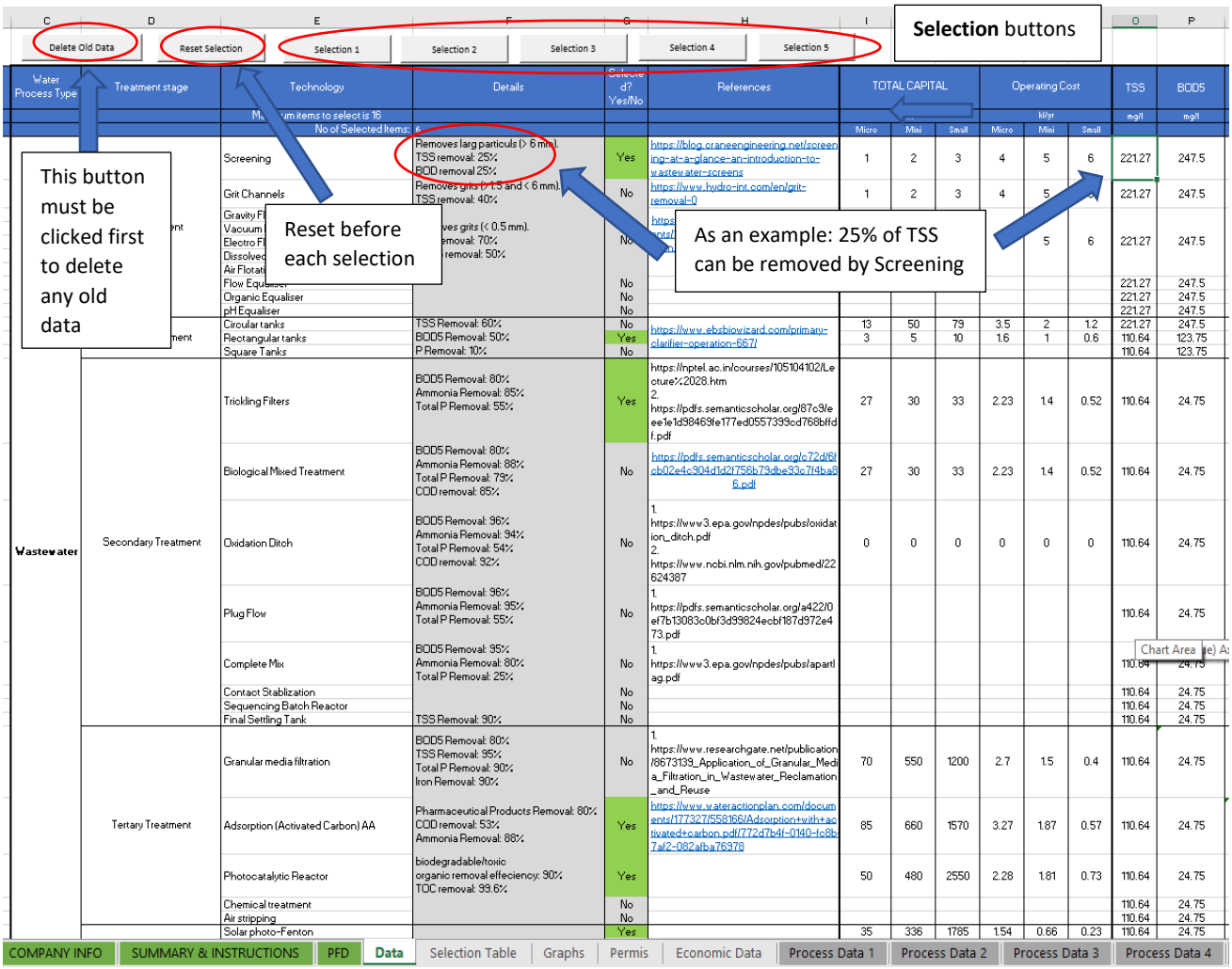

Figure 9: Data sheet to select relevant process

Data in columns J to N are linked to in the **'Economic Data'** sheet and must not be manually updated.

The old data must be cleared by clicking '**Delete Old Data**' button before selection. This is done only once, at the beginning of the selection process. After that, the **'Reset Selection'** button must be clicked to reset column G for the new selection. If the other selections are required the button must be clicked before each selection button (Selection 2, 3, 4 or 5) are clicked.

The technology can be selected by choosing **'Yes'** in column G. This will be highlighted in green once selected. The KPI values will be updated automatically.

To help the technology selection process, the cost per unit of KPI removal is shown in the "**CPI**" tab or Cost Performance Index. This value gives a good reference of how well a technology treats the water pollutants compared to its price. The CPI values are calculated for each technology individually and for the selected train of technologies as a whole.

Cost Performance Index (CPI) Small

Water Process Type	Treatment stage	Technology	KPI	Removal (mg/L)	Cost (€)	CPI (€/(ml/L removal)
Wastewater	Pre-treatment	Screening	TSS	73.8	3000	40.7
			BOD	82.5		36.4
		Grit Channels	TSS	88.5	3000	33.9
		Gravity Flotation/Vacuum Flotation/Electro	TSS	92.9	3000	32.3
			BOD	59.4	3000	50.5
	Primary Treatment	Circular tanks	TSS	79.7	79000	991.7
			BOD	44.6		1773.3
			P	2.3		34543.1
		Rectangular tanks	TSS	26.6	10000	376.6
			BOD	22.3		448.9
			P	2.1		4858.4
	Secondary Treatment	Trickling Filters	BOD5	17.8	33000	1851.9
			Ammonia	31.7		1041.4
			P	10.2		3238.9
		Biological Mixed Treatment	BOD5	3.6	33000	9259.3
			Ammonia	4.9		0.0
			P	6.6		0.0
			COD	255.0		0.0
	Tertary Treatment	Granular media filtration	BOD5	0.4	3000	6734.0
			TSS	25.2		118.9
			P	1.6		1904.1
			Iron	9.0		333.3
		Adsorption (Activated Carbon) AA	Pharmaceutical Products	50.0	1570000	31400.0
			COD	23.9		65828.1
			Ammonia	0.6		2658695.3
		Photocatalytic Reactor	biodegradable/ toxic organic removal	60.0	2550000	42500.0
			TOC	73.4		34719.8
		Chemical treatment				

COMPANY INFO | SUMMARY & INSTRUCTIONS | PFD | Data | CPI | Selection Table | Gra

Figure 10: Cost Performance Index table for individual technologies

	KPI Removal								CPI (cost/removal rate)					
	TSS	BOD5	Ammonia	Total Phosphorous	COD	TOC	Iron	Cost (€)	TSS	BOD5	Ammonia	Total Phosphorous	COD	TOC
S1	184	305	37	14	159	295	0	3,401,000	18444	11142	92901	249933	21390	11530
S2	229	326	36	7	159	295	0	3,371,000	14743	10331	92647	453533	21201	11429
S3	242	326	36	7	159	295	0	3,440,000	14219	10543	94544	462817	21635	11663
S4	242	328	37	13	289	368	0	5,990,000	24760	18275	161841	446954	20747	16259
S5	295	330	37	23	298	368	9	13,374,000	45386	40527	358745	585410	44833	36302

Figure 11: Cost Performance Index table for train of technologies

8. Each selection will be automatically inserted in individual tables in **'Selection Table'** sheet as shown in the figure below. These tables will also present all the relevant KPI for each technology.

Selection 1

Technology	TOTAL CAPITAL	Operating Cost	TSS	BOD5	Ammonia	Total Phosphorous	COD	TOC	Iron
	k€	k€/yr	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Screening	3.00	6.00	221.273	247.5	37.28	22.87	300	368.7	10
Rectangular tanks	10.00	0.60	110.636	123.75	37.28	20.583	300	368.7	10
Trickling Filters	33.00	0.52	110.636	24.75	5.592	9.26235	300	368.7	10
Adsorption (Activated Carbo	1570.00	0.57	110.636	24.75	0.67104	9.26235	141	73.74	10
Solar photo-Fenton	1785.00	0.23	110.636	24.75	0.67104	9.26235	141	73.74	10
Overall	3401	7.92	110.636	24.75	0.67104	9.26235	141	73.74	10

Selection 2

Technology	TOTAL CAPITAL	Operating Cost	TSS	BOD5	Ammonia	Total Phosphorous	COD	TOC	Iron
	k€	k€/yr	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Screening	3	6	221.273	247.5	37.28	22.87	300	368.7	10
Grit Channels	3	6	132.764	148.5	37.28	22.87	300	368.7	10
Rectangular tanks	10	0.6	66.3818	74.25	37.28	20.583	300	368.7	10
Complete Mix			66.3818	3.7125	7.456	15.43725	300	368.7	10
Adsorption (Activated Carbo	1570	0.57	66.3818	3.7125	0.89472	15.43725	141	73.74	10
Solar photo-Fenton	1785	0.23	66.3818	3.7125	0.89472	15.43725	141	73.74	10
Overall	3371	13.4	66.3818	3.7125	0.89472	15.43725	141	73.74	10

Selection 3

Technology	TOTAL CAPITAL	Operating Cost	TSS	BOD5	Ammonia	Total Phosphorous	COD	TOC	Iron
	k€	k€/yr	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Screening	3	6	221.273	247.5	37.28	22.87	300	368.7	10
Grit Channels	3	6	132.764	148.5	37.28	22.87	300	368.7	10
Circular tanks	79	1.2	53.1054	74.25	37.28	20.583	300	368.7	10
Complete Mix			53.1054	3.7125	7.456	15.43725	300	368.7	10
Adsorption (Activated Carbo	1570	0.57	53.1054	3.7125	0.89472	15.43725	141	73.74	10
Solar photo-Fenton	1785	0.23	53.1054	3.7125	0.89472	15.43725	141	73.74	10

COMPANY INFO | SUMMARY & INSTRUCTIONS | PFD | Data | **Selection Table** | Graphs | Pe

Figure 10: Selection Table sheet shown the results of the selection process.

The result of the performance of each selected process and technology will be presented in **'Graphs'** sheet for comparison of the performance of each selection. This sheet contains a table of the overall performance of the integrated selected technologies for each selected option. These values are then plotted in graphs of each KPI for each selection. This will help to decide the most cost-efficient technology for the most optimised and effective removal process.

The table in this sheet is automatically updated and must not be changed manually.

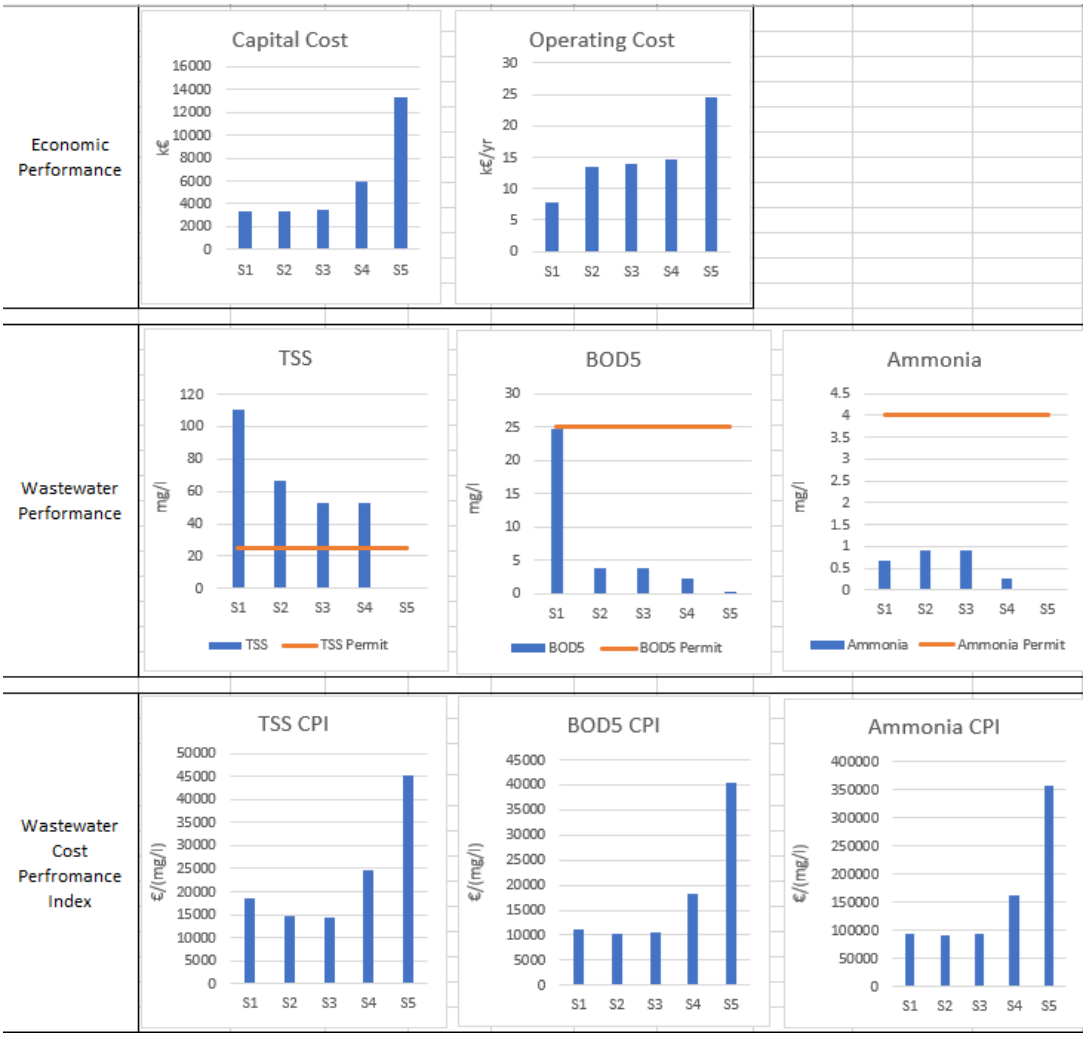

Figure 11A: Final selection options performance results sheet (A).

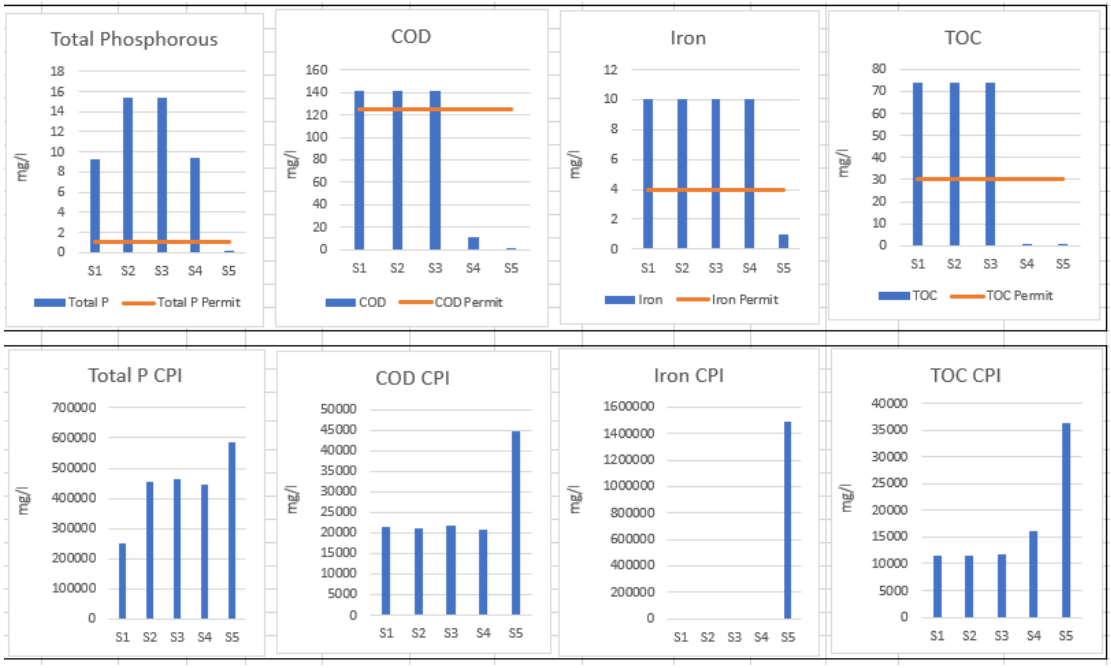

Figure 11B: Final selection options performance results sheet (B).

4 Conclusions

As the H2020 instruments, and specifically projects with high TRL such us Project Ô, aim to deliver tools and technologies closer to market, higher attention needs to be paid to the business opportunities and the plan to capture value through the innovations proposed. The Toolbox presented herein is built with that purpose: a tool for the water sector and its key stakeholders to find new or optimal ways of treating water streams, thus, creating new business opportunities with reusable water and resources.

This deliverable describes the main functionalities of the Technology Selection Toolbox and can be used as a user guide offering some guidance to use the outputs obtained with the tool properly.

The Technology Selection Toolbox developed in Project Ô is a decision support tool to help selecting the most suitable water treatment technology for specific water streams. It considers precise information input provided by the user regarding the water characteristics. Additionally, the tool gathers and estimates some other parameters automatically (e.g. process diagram and output KPIs content).

The designed decision support tool integrates different technologies and packages that allows it to be easily extended to consider additional analysis and information. The tool's catalogue gathers the water treatment technology specifications supplied by the tech providers in the project. The information that the Toolbox generates to support decision making relies mainly on the quality of the information on the database. The flexible architecture of the tool allows it to consider additional information in the database without intensive changes on the software. Moreover, a service model business can be generated around the tool by customizing the database for specific technology providers.

Additional developments, analysis and useful information can be generated from the tool's use history, which can serve for generating business rules or developing policies. Data mining and bigdata approaches could be applied on the database that the tool builds, based on the profiles' inputs so that trends and insights can be drawn with respect to variables such as user needs, technology adoption.

It is worth to remember that the tool is just a frame for the user to insert their data. The quality of the data inputted by the user is directly linked to the quality of the outputs generated by the tool: the hypothesis considered to reach the outputs needs as careful consideration as the outputs obtained.

5 Next steps

The Technology Selection Toolbox is ultimately meant to be a web-based platform, with added features such as databases for helping the users filling the forms and for collecting the information generated. The current version of the tool focuses on the treatment process selection depending on the input water source and type, with a high-level comparison of the different water treatment technologies performance and cost.

As the project develops, and specially the demonstration activities involving the technologies testing in a real environment, the tool will be updated with more accurate and realistic data. Furthermore, the new version of the platform will address more in detail the specifications and different variables affecting the technology selection, therefore, shifting towards a more tech-oriented approach for achieving optimal results. The web-based version of the tool will also include a user-friendly interface to facilitate the technology comparison and the decision making, for example with respect to the application of the water after treatment. Several captures are shown below representing how the Toolbox will potentially be presented.

Figure 1 – Technology selection toolbox landing page

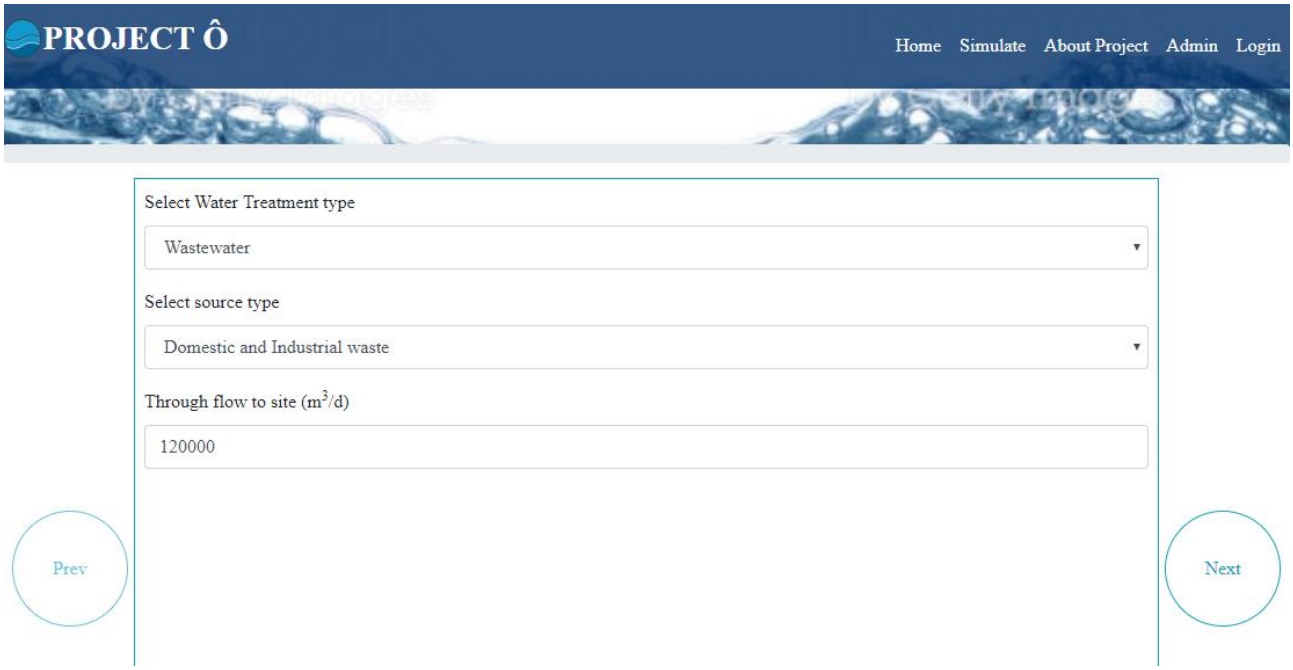

Figure 2 – Selection of water type, source and flow volume

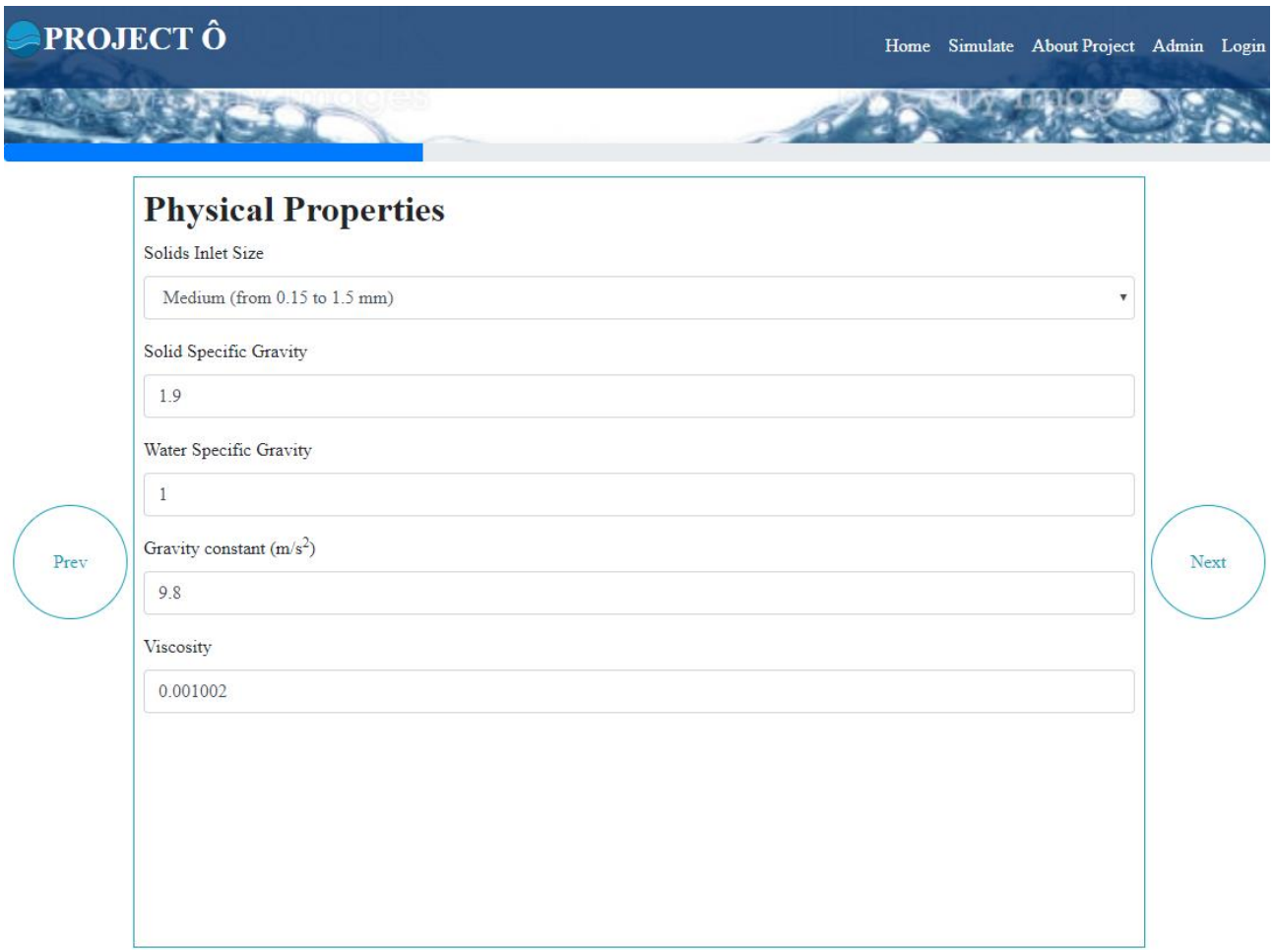

Figure 3 – Physical properties of water to be treated

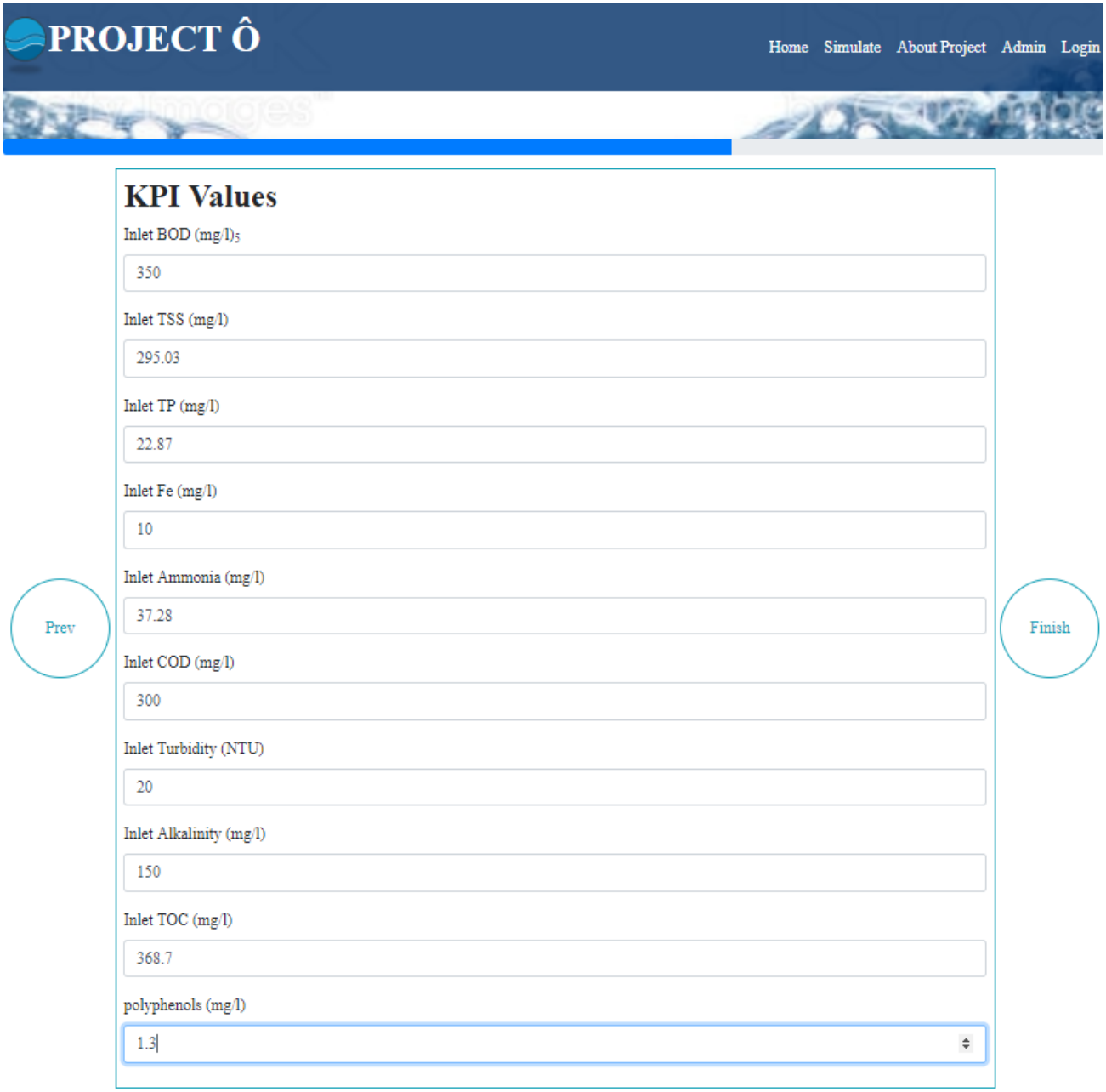

Figure 4 – KPI values of the water to be treated

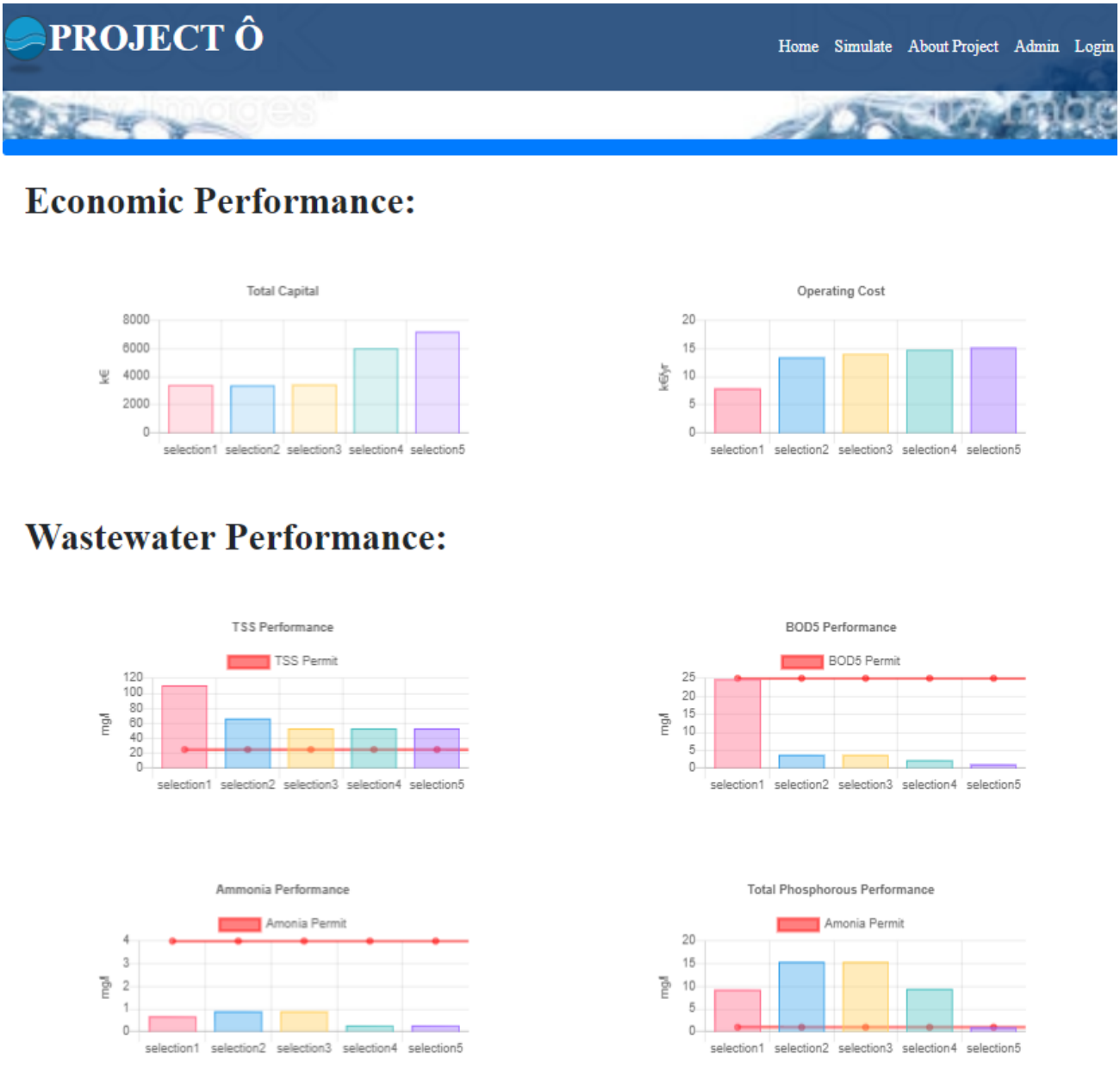

Figure 5 - Economic and performance values of the different selections

6 Annex

The Key Performance Indicators considered for the treatment technologies performance analysis are listed below. These parameters are based on the information displayed in Project Ô's Deliverable 6.1 – Key Performance Indicators, specifically the ones concerning technological and operational aspects, as well as, economic values. For the purpose of not overloading the software tool, the most relevant KPIs have been considered.

Technological and Operational KPIs

Total Suspended Solids (TSS)	Biological Oxygen Demand (BOD_5)	Total Organic Carbon (TOC)	Chemical Oxygen Demand (COD)
Ammonia	Iron	Sodium	Zinc
Sulphates	Chlorides	Potassium	Nickel
Total Phosphorous	Magnesium	Aluminium	Lead
Copper	Calcium	Manganese	E. coli

Economic KPIs

CAPEX	OPEX

7 References

1. Council Directive Concerning Urban Wastewater Treatment. 91/271/EEC. Official Journal of the European Communities, No L 135/40. 21 May 1991.
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