Project acronym: **LASH FIRE**

Project full title: **Legislative Assessment for Safety Hazard of Fire and Innovations in Ro-ro ship Environment**

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D5.2

Cost assessment tool

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Abstract

Alongside the evaluation of technical and operational solutions developed in the project, the economic feasibility of the solutions needs to be evaluated throughout the entire life span. Therefore, the Life Cycle Cost (LCC) methodology has been adapted to assess the characteristics, the pros, and cons of each solution for generic ro-ro ship types. Furthermore, the LCC assessment is required as input to calculate the cost-effectiveness in Formal Safety Assessment (FSA). In this deliverable, the evaluation process of the calculations of their parameters and results becomes clear. The following deliverable, on the other hand, deals with the development of the calculation system itself.

In order to measure the economic feasibility of the solution, CMT developed a basic LCC tool and data collector to calculate the LCC of each solution. The tool was supplemented by the user guide. The tool and data collector also completed with the cost categories to guide the user to input the economic value.

Furthermore, the tool takes into account varying fuel prices in the future, as the life span can reach beyond ten or twenty years. Besides that, the users are able to know the impact of the solutions on the environment from the external cost value. The calculation of the external cost is extracted from the Life Cycle Assessment (LCA). To understand the impact of the world economy and legislation situation on the LCC, a sensitivity analysis was made available in the tool so the users can understand the impact on the cost if a different scenario might happen in the future.

In the last chapter, the users are able to know all the LCC tool's features and finds a detailed guideline to navigate and use the tool correctly.

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1 Executive summary

Problem definition

One of the objectives of LASH FIRE is to evaluate and demonstrate ship integration feasibility and the costs of developed operational and design risk control measures for all types of ro-ro ships and all types of ro-ro spaces. Therefore, an LCC tool was developed to assess the financial parameter and to allow for sensitivity analysis.

In this deliverable, the evaluation process of the calculations of their parameters and results becomes clear. The following deliverable, on the other hand, deals with the development of the calculation system itself.

Technical approach

The economic feasibility study of risk control measures will be conducted by LCC methodology where all related costs are included, from investment/production to operation/maintenance and until the end of the life span. The required input parameters and KPIs in the tool were identified from discussion between WP04 and WP05. WP04 focuses on the formal safety assessment, while WP05 works on the integration of the components into the vessel. The tool considers varying fuel prices in the future and the external costs that comes from environmental impact. The required data for the LCC will be collected from ship operators as well as from the Development and Demonstration WPs in the project via a data collector formulated according to the methodology. The tool will be used to calculate the LCC of the selected Risk Control Options (RCO), as input to the cost-effective assessment in the Formal Safety Assessment (FSA).

Results and achievements

As a result of the internal meeting with WP04 and WP05, the LCC modelling approach was defined, including general key performance indicators and four different scenarios. Moreover, several individual KPIs were identified, which will be applied in specific demo-cases only. From this input, a data collector and a LCC tool are ready to be used by ship operators and the Development and Demonstration (D&D) WPs in the project. The LCA results will be useful for them to understand the economic impact on the developed solutions and for cost-effective assessment.

Contribution to LASH FIRE objectives

This report will contribute to LASH FIRE objective 2: “LASH FIRE will evaluate and demonstrate ship integration feasibility and cost of developed operational and design risk control measures for all types of ro-ro ships and all types of ro-ro spaces”, and LASH FIRE objective 3: “LASH FIRE will provide a technical basis for future revisions of regulations by assessing risk reduction and economic properties of solutions”.

Exploitation and implementation

The experiences made within the LASH FIRE project is used in the LCC assessments. These are directly related to the FSA and may also be used as basis for FSAs in the future, beyond the project. In addition, the LCC tool can be used by the end-users, such as ship operators, suppliers, or shipyard, to assess the economic feasibility of the proposed solutions.

2 List of symbols and abbreviations

CEU	Car Equivalent Unit
D&D	Development and Demonstration
FSA	Formal Safety Assessment
GT	Gross Tonnage
GWP	Global Warming Potential
HFO	Heavy Fuel Oil
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LCPA	Life Cycle Performance Assessment
LM	Lane-Meter/s (unit expressing ro-ro space capacity)
LPP	Length between perpendiculars
LSMGO	Low Sulphur Marine Gas Oil
MGO	Marine Gas Oil
KPI	Key Performance Indicator
PAX	Passengers
RCM	Risk Control Measure
RCO	Risk Control Option (one or several RCMs selected for assessment)
ULSFO	Ultra Low Sulphur Oil
VLSFO	Very Low Sulphur Fuel Oil
WP	Work package

3 Introduction

Main author of the chapter: Robert Julius Glade, Sri Lestari Maharani, CMT

When new solutions or services wish to be used, the assessment is not only limited to the technical and operational feasibility but also to the cost and even further to the environmental impact. For the cost assessment, the evaluation should not only rely on the purchasing cost, but also the supply, installation, operation, maintenance, and end of life costs. Based on the EU directive 2014/24/EU, "Life Cycle Cost (LCC) shall to the extent relevant cover parts or all of the following costs over the life cycle of a product, service or works:

a) costs, borne by the contracting authority or other users, such as:
    - costs relating to the acquisition,
    - costs of use, such as consumption of energy and other resources,
    - maintenance costs,
    - end of life costs, such as collection and recycling costs.
b) costs imputed to environmental externalities linked to the product, service or works during its life cycle, provided their monetary value can be determined and verified; such costs may include the cost of emissions of greenhouse gases and of other pollutant emissions and other climate change mitigation costs."

The use of the developed tool also has the advantage of calculating several different solutions. Here it is possible to determine a reference point by calculating the costs incurred and later running costs. It is therefore possible to determine which of the solutions will be the most cost effective. The developed tool offers, by a high range of parameters the possibility to calculate the environmental aspect in relation to the construction of the vessel, at the shipyard and at the end of the life cycle.

In order to measure the economic feasibility of the solution, CMT developed a basic LCC tool and data to calculate the LCC of the solutions. The tool completed with the guideline for the users. The tool and data collector also completed with the cost categories to guide the user to input the economic value.

Furthermore, the tool considers varying fuel prices in the future, as the life span can reach beyond ten or twenty years. Besides that, the users can know the impact of the solutions on the environment from the external cost value. The calculation of the external cost is extracted from the Life Cycle Assessment (LCA). To understand the impact of the world economy and legislation situation on the LCC, a sensitivity analysis was made available in the tool so the users can understand the impact on the cost if a different scenario might happen in the future.

The objective of the tool deals with the evaluation of all actions. Here, the cost factor of each individual action and its solutions become visible in combination and stand-alone.

A cost-benefit analysis can be used to assess whether the inclusion of the action in the operation of future newbuildings and existing ships will be advantageous.

3.1 Cost assessment tool workflow

The LCC assessment is an important study to understand the economic feasibility of the solutions proposed in LASH FIRE. All information related to equipment purchase, equipment energy consumption, and solution maintenance costs generally shall be provided by the D&D WP (WP06-WP11). The cost information related to the installation, the integration of the solution and the revenues during the operation generally shall be provided here by the WP05. For demonstration purposes, the following figure shows the workflow consisting of the input, the process, and the output. To provide the input, the Data Collector is available, which receives the input from the vessel operators, shipyards, and ship designer (WP05) and the D&Ds (WP06-WP11). This consists of the cost components of single and multiple systems and the cost of integration into the ship. After the data collector for newbuilding and existing ship is completed, the user can move the information to the tool.

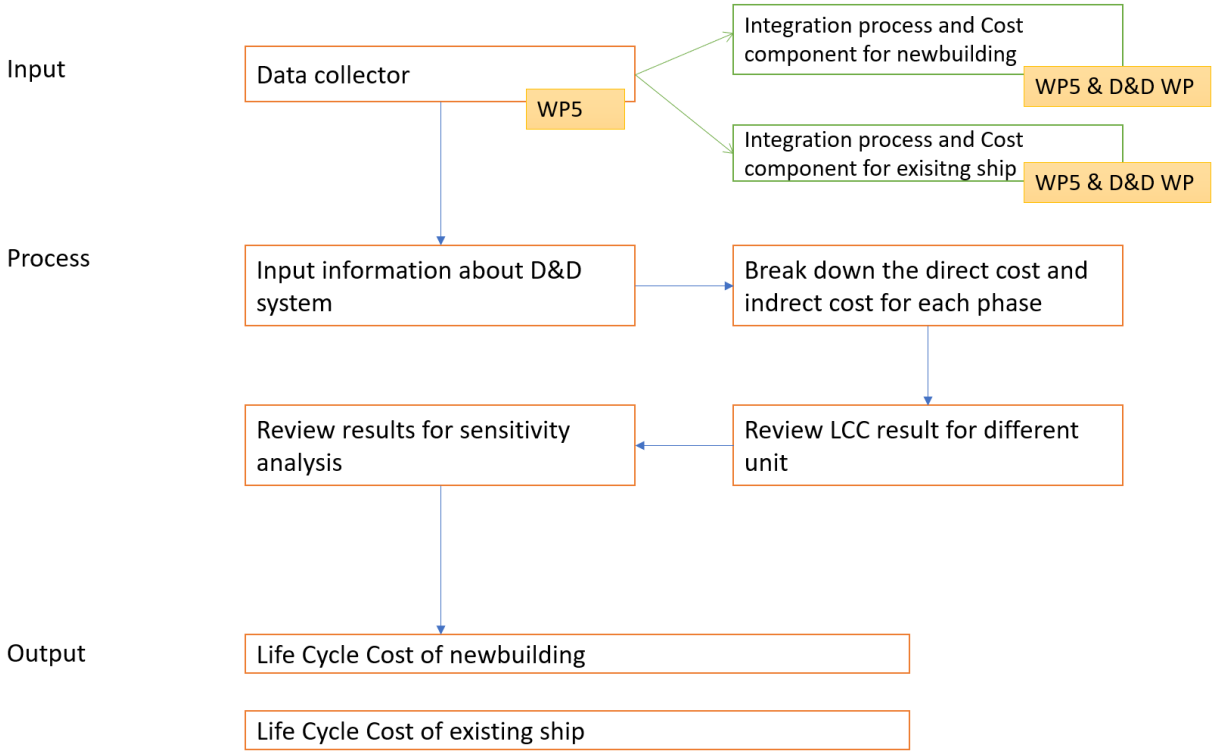


Figure 1: Cost assessment tool workflow

The first thing the users need to do in the LCC tools is to put the information about the D&D system. After that, the users need to provide detailed information about the cost during investment, operational, maintenance and end of life phase for each system or component. After that, the user can review the results for different KPIs. The users also need to look at the sensitivity analysis result to see how the cost changes according to the economic and regulatory situation. Besides Life Cycle Cost, External Cost, the users also can see the total cost for different RCO which are important inputs for the cost-benefit assessment in WP04.

4 Cost assessment tool overview

Main authors of the chapter: Sri Lestari Maharani, Robert Julius Glade, CMT

The data collector and LCC cost in the LASH FIRE is developed by CMT using Microsoft Excel. The purpose of the tool is to calculate the Life Cycle Costs (LCC) of the innovative solutions for safety hazards and fire in the Ro-Ro ship environment. The basic input comes from D&D WPs and ship operators are collected in the Data Collector. Furthermore, in the beginning of the project, CMT organized a recorded LCC workshop to guide the partners to do the assessment.

4.1 Data Collector

The Data Collector is used to collect information for the Life Cycle Cost and the Life Cycle Assessment on newbuilding's and retrofit of considered ro-ro ships. This information will be used to calculate different types of cost components for the integration of firefighting safety equipment. The inputs will come from the Development and Demonstrator (WP06 to WP11) and Ship Integration (WP05). All the cost information in the data collector are in the real cost values, not in the marginal cost.

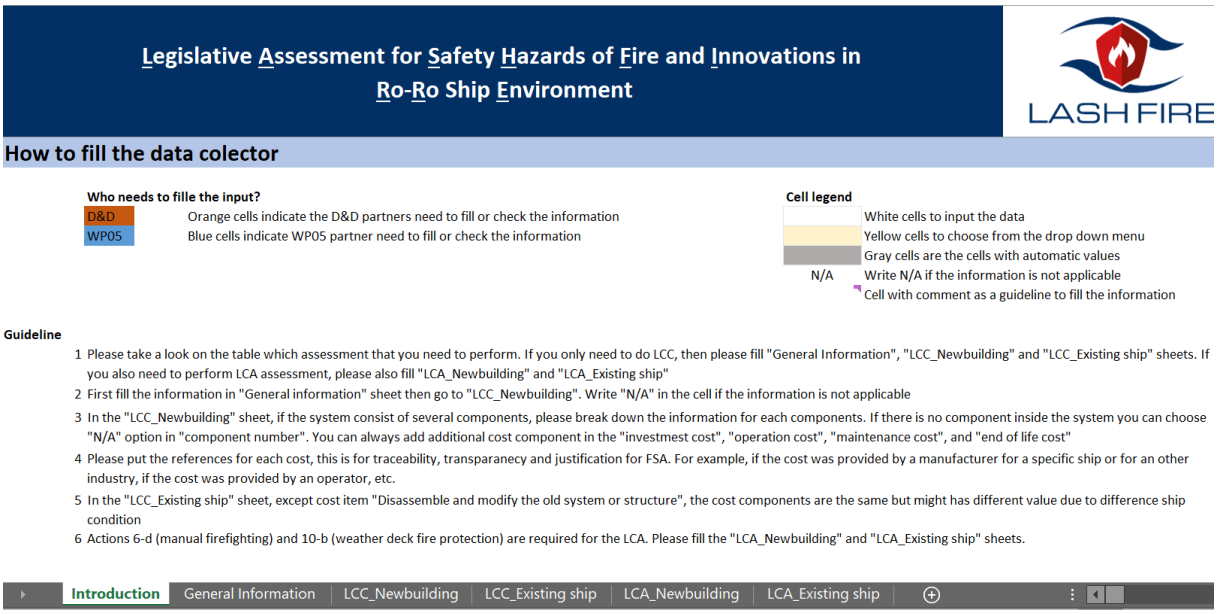


Figure 2. Data collector interface

The data collector consists of several worksheets. The first worksheet is the "introduction". In this worksheet a table shows the actions name, the responsible partners, and related internal report. Besides that, there is also the guideline to fill the data collector. For guidance purposes, the user needs to fill the information in the data collector, like the color index and different types of cells explain as follow:

- Orange cells require input from the D&D's
- Blue cells require input from WP05
- White cells are for the data input
- Yellow cells contain a drop-down menu
- Grey cells contain automatic values
- White cells with comments - which contains extra information for the user

The second worksheet is called “General Information”. Here general information about the vessel and the system(s) need to be filled. The information about the vessel should include the vessels engine, source of energy, and specific fuel oil consumption (SFOC) information to calculate the fuel cost. For general information about the system, the users are allowed to put the information about the new system and reference system. Moreover, the information about the D&D system should include the number of units, the expected lifetime, the source of energy, and to which RCM and RCO the system belongs. For the expected lifetime of the system, there may be a possibility that it has a longer or shorter lifetime than the ship.

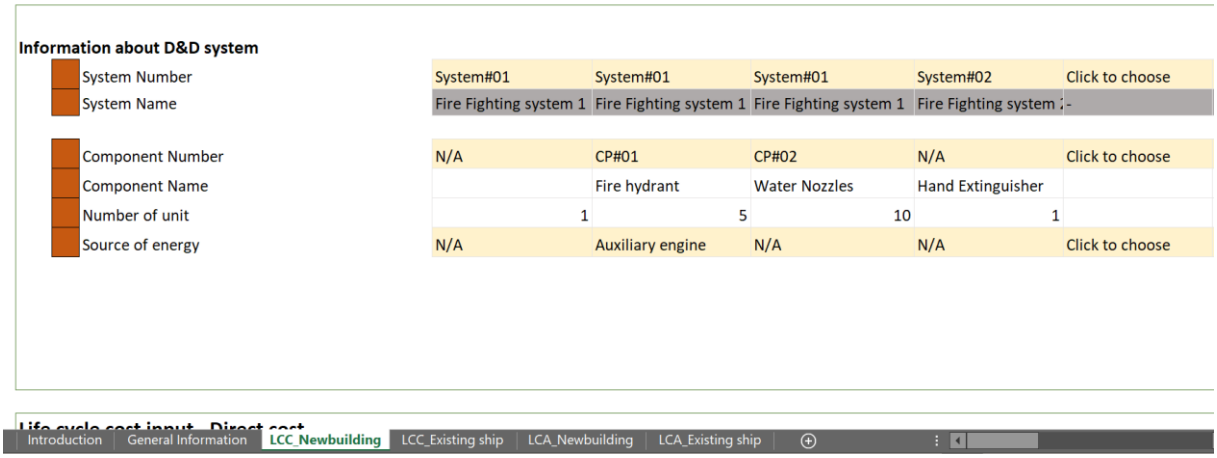


Figure 3. Example of the system detail breakdown.

The third worksheet is called “LCC_Newbuilding”. The worksheet is dedicated to fill the cost input for the newbuilding case. Here, the D&D can breakdown the system in more detail into components. Figure 3 shows an example of how the user able to fill in the information. There are two systems in the example, System#01 and System#02. System#01 has two components, CP#01 and CP#02. System#02 does not have any detail on the components, therefore the component number is “N/A”. However, System#01 also has “N/A” titled as the component number. This component number is to accommodate if the user is not able to breakdown all the costs for different components. For instance, in the investment cost, the user needs to provide information about the operator training cost. However, that training cost is for the whole System#01 and no detail available about the cost for each component, therefore that training cost can be written under “N/A” component of System#01.

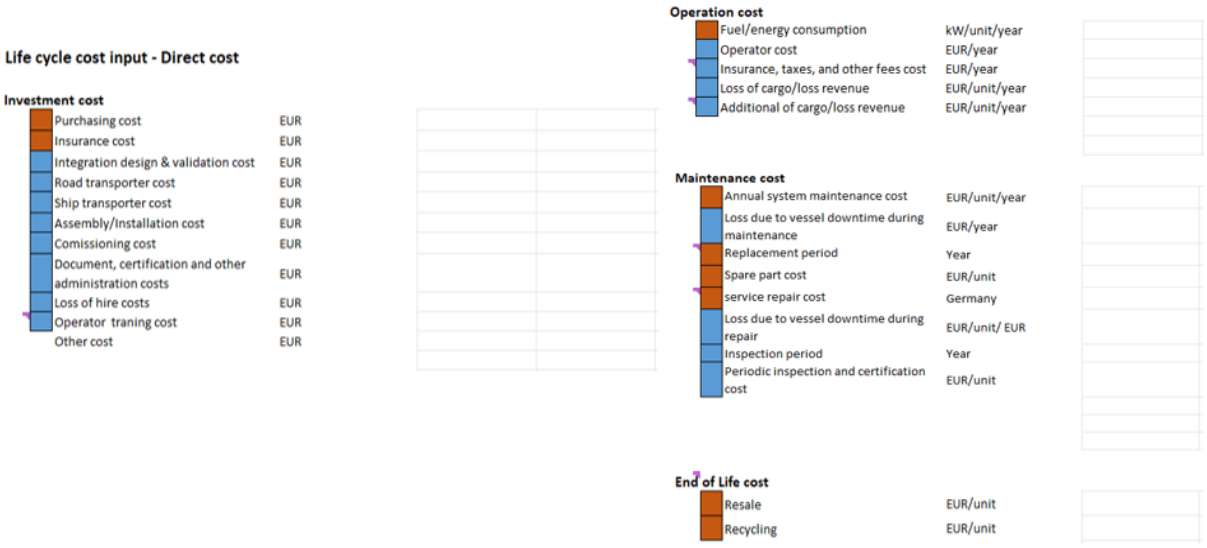


Figure 4. The cost component for different phases

In the same worksheet, the user needs to provide (if applicable) all the costs in the investment phase, operational phase, maintenance phase, and end of life. If users want to put additional cost component it can be put in the "other cost" or the new available column. It's important to put the **real cost** of the system or component of new solutions and reference solutions. A detail explanation for each cost component in different phases can be read in the next subchapter. If the solution doesn't require cost, still the D&D and WP05 need to check if the changes will impact the operation or maintenance cost.

The fourth worksheet is called "LCC_Existing ship". The worksheet is dedicated to fill the cost input for the existing ship case. The cost components are the same as in the "LCC_Newbuilding", however, the value of the cost might be different. Here the users do not need to fill in the information about the component, as it will automatically fill from the previous worksheet.

For the action 6-D and 10-B, the D&D WPs and WP05 also need to fill the data in "LCA_Newbuilding" and "LCA_Existing ship".

4.2 LCC Tool

The LCC tool's purpose is to calculate the Life Cycle Costs (LCC), external cost, and LCC/RCO. Moreover, the tool also has capability to perform the sensitivity analysis. The cost data can be found in the data collector.

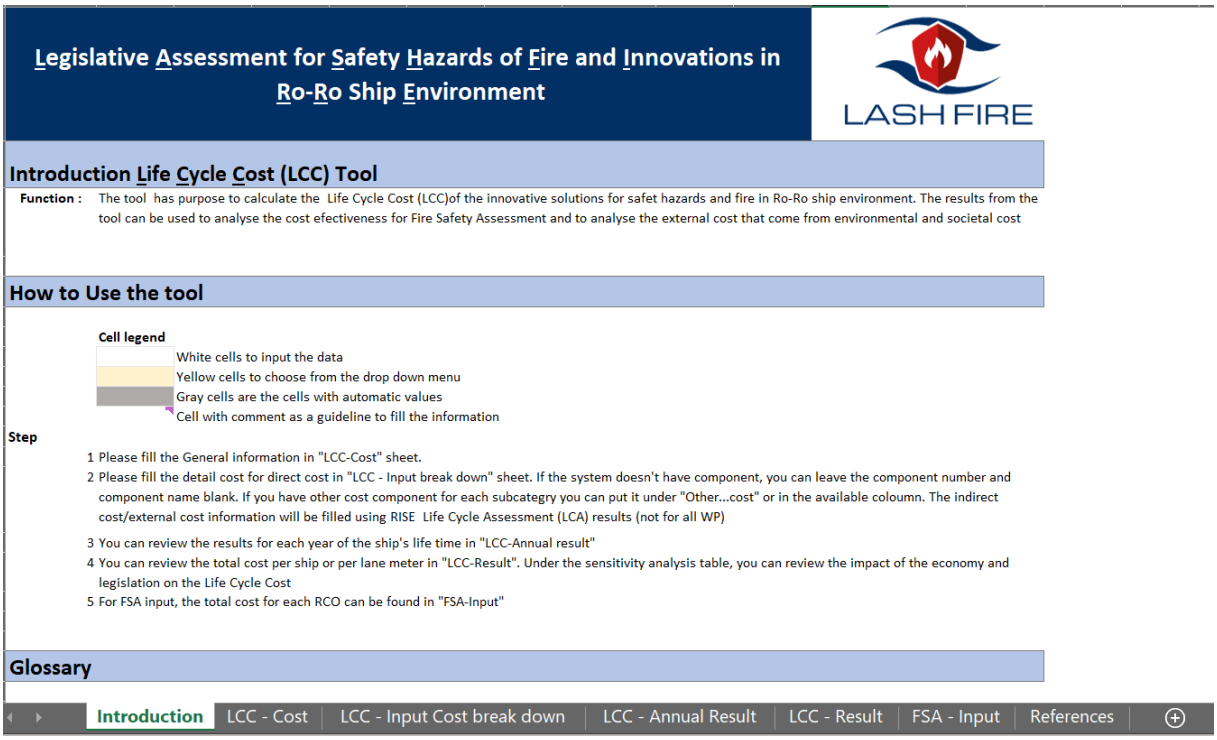


Figure 5. LCC tool interface.

The tool consists of several worksheets:

- Introduction: Provide basic information about the tool and guideline to use the tool
- LCC – Cost: The worksheet to provide the ship information, D&D system, and information for FSA
- LCC – Input cost break down: The worksheet to put the cost information for different phases

- LCC – Annual result: The worksheet provides the result for each year of the ship's lifetime
- LCC – Result: Showing the total cost for different KPIs
- FSA – Input: Showing the total cost result/RCO
- References: Showing the reference for fuel costs and externalities

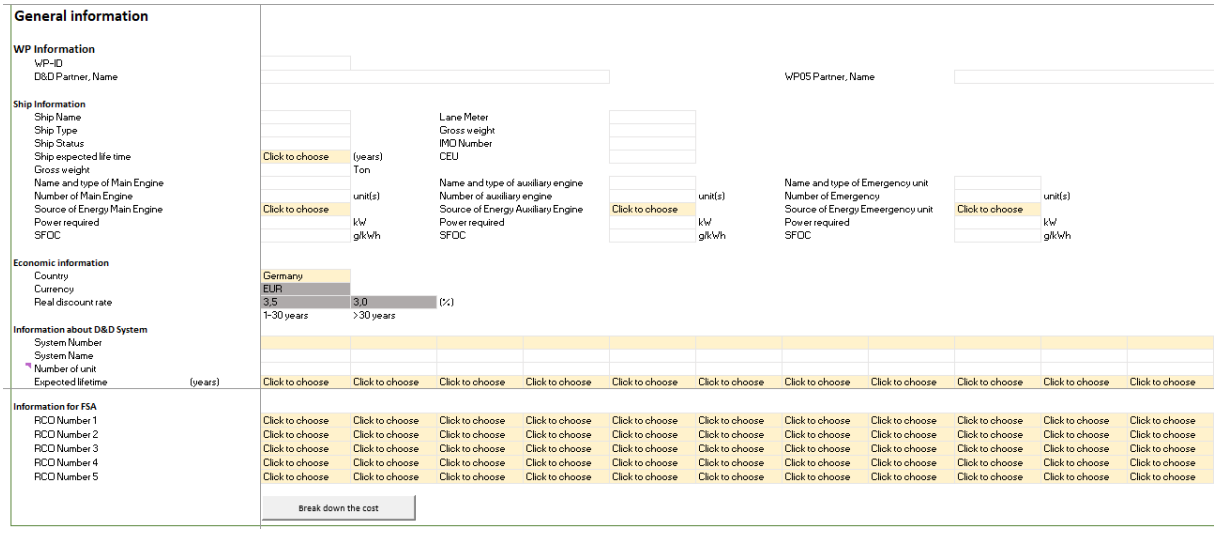


Figure 6. LCC - Cost interface.

To use the tool, the first step is to read the guideline in the "introduction" worksheet, see Figure 5. The whole tool contains four kinds of different colored cells:

- White cells are for the data input
- Yellow cells contain a drop-down menu
- Grey cells contain automatic values and do not need to be filled
- White cells with comments - which contains extra information for the user

4.2.1 Cost assessment tool input

4.2.1.1 General information

After the user read the guideline, the next step is inserting the input into the tool by filling all general information about the vessel, D&D system and RCO number in the "LCC – Cost" worksheet (see Figure 6). The information is available in the data collector. A fundamental input variable is the specification of the fuel type and the associated SFOC. This is to accommodate fuel consumption changes during the application of new innovative solutions. The life cycle costs are presented as present values, therefore an actual discount rate is needed. Following the FIRESAFE II study, in LASH FIRE the LCC will use a 3.5 % rate as the discount rate for years 1-30 and 3.0 % starting from year 31 [1].

After that, information is needed about the D&D systems with the number of units and expected lifetime. The expected lifetime is a useful information to know the frequency of investment cost that will appear in the overall lifetime of the ship. It is possible the solutions lifetime is shorter or longer than the ship itself.

Then, the information about the RCO number(s) needs to be filled in for the Formal Safety Assessment. After that, the users need to click the "Break down the cost" button. The information in the table underneath, which is titled *Life cycle costing input - Direct Cost*, is automatically calculated. The button will lead to "LCC – Input cost break down" worksheet. The next step is to fill in the information about

the systems and the components, see Figure 7. Here, the type, the number, and the fuel required for the system are important to be filled in order to calculate the total fuel cost.

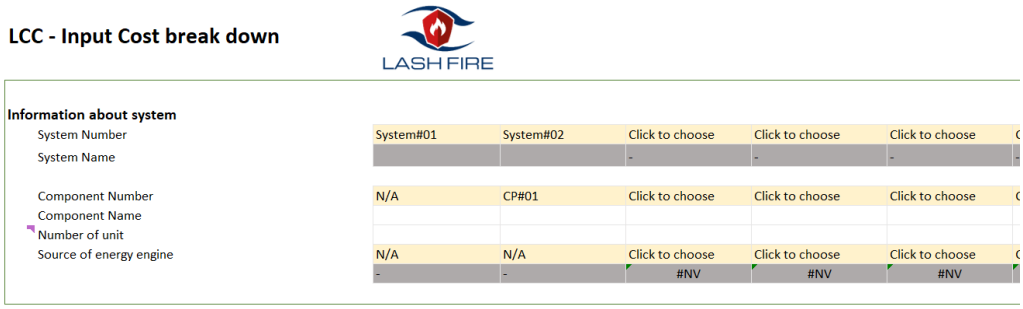


Figure 7. LCC – Input cost breakdown interface.

4.2.1.2 Investment phase

The information about investment cost can be filled in page "LCC – Input cost break down" worksheet. Users need to provide (if applicable) all the cost in the investment phase. If users want to put additional cost component, it can be fill in the "other cost" or the new available column. Basically, user can put any type of costs in the tool. However, it's important to put the **marginal cost** of the system or component of new solutions and reference solutions because it is the requirement for FSA study.

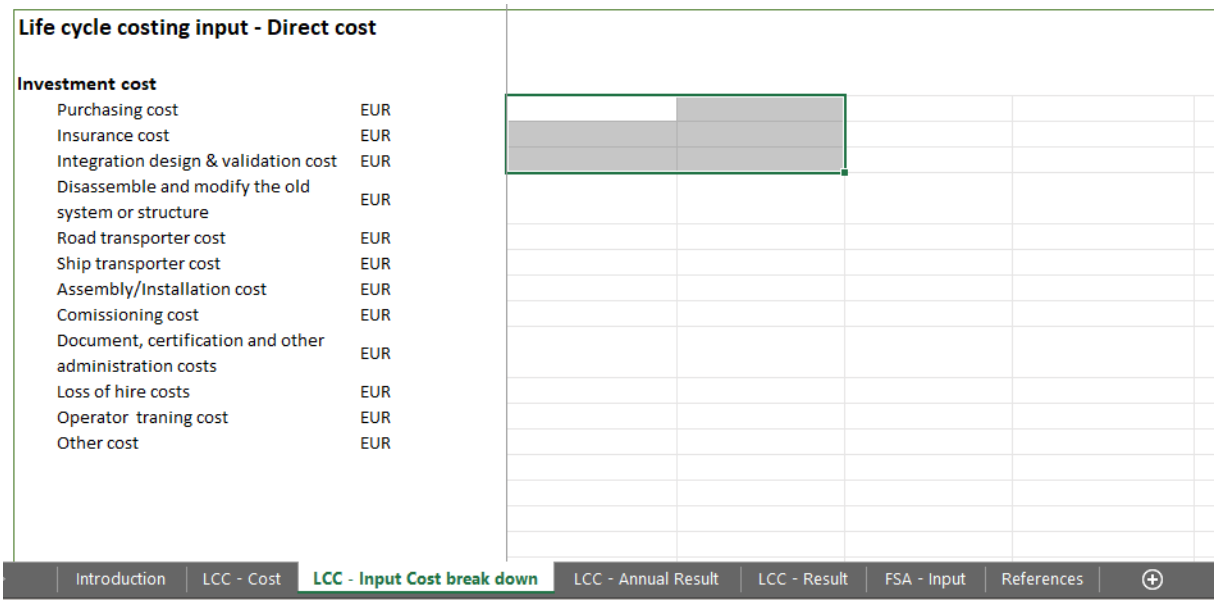


Figure 8. Investment phase in LCC tool

The general investment phase model in LASH FIRE contains the following investment cost breakdown:

- Purchasing cost: The equipment or software cost
- Insurance cost: The insurance for the purchased equipment or software
- Integration design & validation cost: The cost to integrate and validate the solution into newbuilding or existing ship design
- Road transporter cost: The cost to transport the equipment until the port
- Ship transporter cost: The cost to transport the equipment to the sea
- Assembly/Installation cost: The cost to assemble the solution to the ship, including the equipment and system assembly or installation.

- Commissioning cost: The cost that occurs to test and review if the equipment or the system are working according to the standard
- Document, certification, and other administration costs: The cost related to the administration or certification
- Loss of hire costs: The loss that might occur if any activities related to the integration of the solution disturb the operation plan
- Operator training cost: The cost to train the ship crews to use the new solution
- Other costs: Other costs that occur during production or integration of the solution

4.2.1.3 Operational phase

The information about investment cost can be filled in page "LCC – Input cost break down" worksheet. Same as in the investment phase, the cost in the operational phase should be filled as a marginal cost. Beside the fuel costs, the other operating costs on the ship are:

- Operator cost: The cost that occurs if the solution needs to be operated by the crew, including the maintenance and repair process per year
- Insurance, taxes, and other fee costs: Insurance (P&I) cost, taxes and other administrative costs that occur by using the solution during operation per year
- Loss of cargo or loss of revenue: The loss that might occur if the solution reduces the cargo capacity per year
- Additional cargo or revenue: The revenue that might occur if the solution increases the cargo capacity per year
- Annual system maintenance cost: The cost that occurs for the solution's maintenance per year
- Loss due to vessel downtime during maintenance: The loss that might occur if any activities related to the maintenance activities disturb the operation plan
- Spare part cost: The cost that occurs to replace the part(s) of the solution
- Service repair cost: The service cost that occurs to replace the part(s) of the solution
- Loss due to vessel downtime during repair: The loss that might occur if any activities related to the repair activities disturb the operation plan
- Periodic inspection and certification cost: The cost that occurs to do period inspection and certification of the solution

The maintenance costs are divided into annual maintenance cost and periodic maintenance cost. Annual maintenance cost is for the item that should be maintained, replaced, or repaired every year. Other than that, users can put it in the periodic maintenance cost. For periodic maintenance cost, users need to put the maintenance period so the cost will not count as yearly operation cost.

Operation cost								
Additional Energy consumption	kWh/unit/year							
Additional Fuel Consumption	t/year							
Reduce Fuel Consumption	t/year							
Operator cost	EUR/unit/year							
Insurance, taxes, and other fees cost	EUR/unit/year							
Loss of cargo/loss revenue	EUR/unit/year							
Additional of cargo/profit revenue	EUR/unit/year							
Other operation cost	EUR/unit/year							
Maintenance cost								
Annual maintenance								
Annual system maintenance cost	EUR/unit/year							
Loss due to vessel downtime during maintenance	EUR/unit/year							
Other annual maintenance cost	EUR/unit/year							
Periodic maintenance								
Replacement period	Year	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
Spare part cost	EUR/unit							
Service repair cost	EUR							
Loss due to vessel downtime during repair	EUR/unit							
Other periodic maintenance cost	EUR/unit							
Inspection								
Inspection period	Year	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
Periodic inspection and certification cost	EUR/unit							
Other cost	EUR/unit							

Figure 9. Operational phase in LCC tool

4.2.1.4 End of life phase

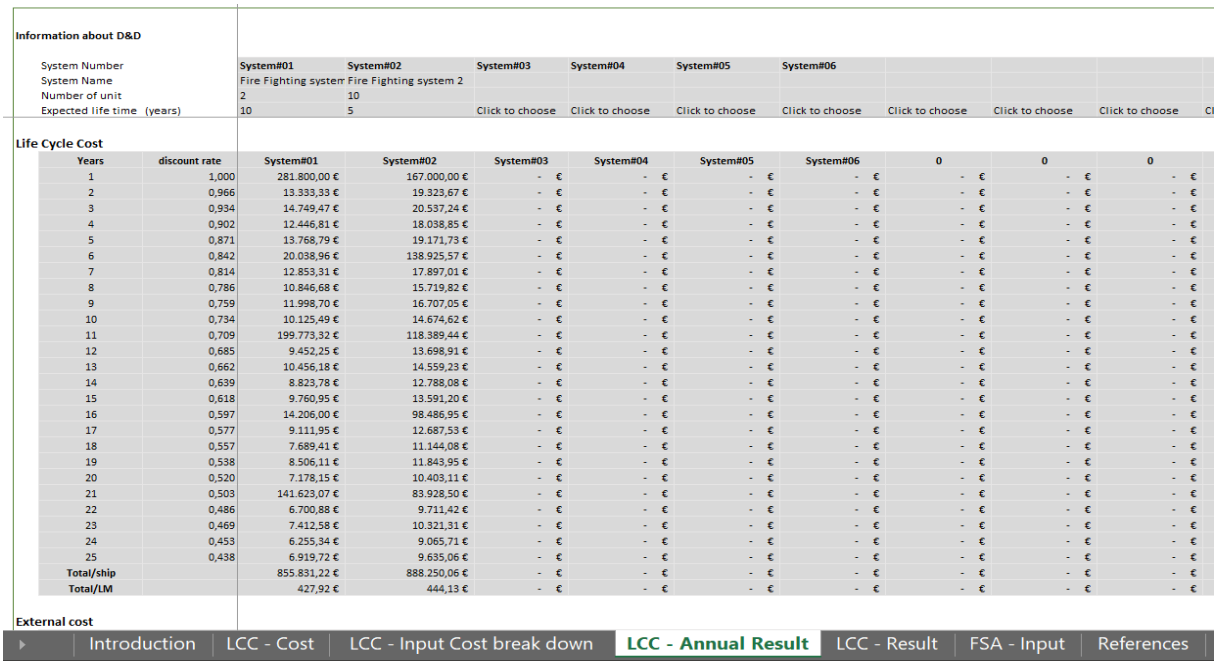
The information about investment cost can be filled in page “LCC – Input cost break down” worksheet. Same as previous phases, the cost in the end-of-life phase should be filled as a marginal cost. In the tool, the user has two choices how the solution ends up. The first choice is to resale it and the second one is to recycle it. The resale option will add revenue to the ship while the recycling option sometimes can decrease the revenue. However, knowing the information at the end of life is quite difficult, sometimes such information is not always available. Therefore, for the cost-effective assessment, the information about LCC will be excluded. However, for LCC assessment the user can put the end-of-life cost to analyse the cost from one solution to another.

LCC - Input Cost break down									
Information about system									
System Number		Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
System Name		-	-	-	-	-	-	-	-
Component Number		Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
Component Name									
Number of unit									
Source of energy engine		Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
		#NV	#NV	#NV	#NV	#NV	#NV	#NV	#NV
End of Life cost									
Resale	EUR/unit								
Recycling	EUR/unit								
Other cost									

Figure 10. End of life phase in LCC tool

4.2.2 Cost assessment tool results

To see the results, users can navigate through “LCC - Annual results” and “LCC – Result” worksheets. The present value of investment cost, operation cost, maintenance cost, end of life cost, life cycle cost, and external cost per ship year are available in “LCC - Annual results” worksheet, see Figure 11.



Information about D&D

System Number	System#01	System#02	System#03	System#04	System#05	System#06				
System Name	Fire Fighting system	Fire Fighting system 2								
Number of unit	2	10								
Expected life time (years)	10	5	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Cl

Life Cycle Cost

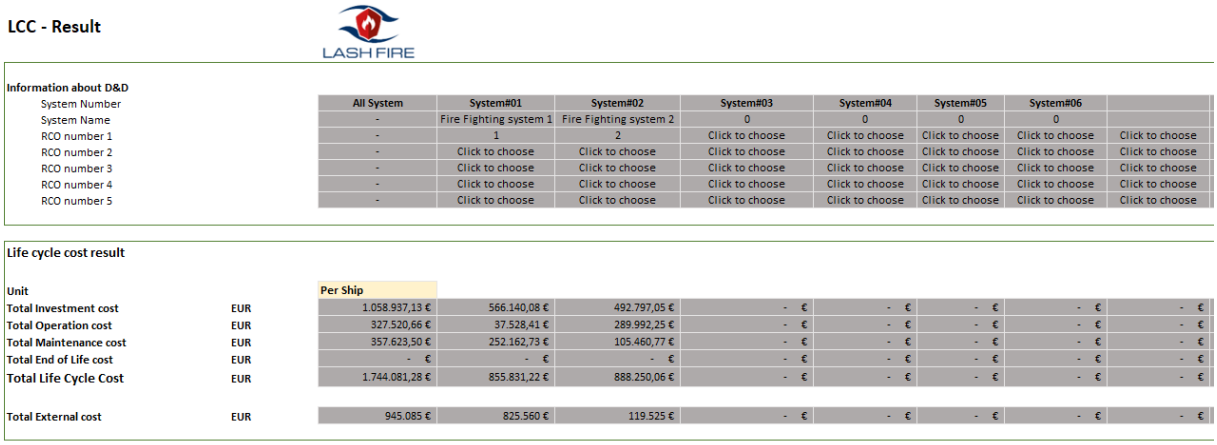
Years	discount rate	System#01	System#02	System#03	System#04	System#05	System#06	0	0	0
1	1,000	281.800,00 €	167.000,00 €	- €	- €	- €	- €	- €	- €	- €
2	0,966	13.333,33 €	19.323,67 €	- €	- €	- €	- €	- €	- €	- €
3	0,934	14.749,47 €	20.537,24 €	- €	- €	- €	- €	- €	- €	- €
4	0,902	12.446,81 €	18.038,85 €	- €	- €	- €	- €	- €	- €	- €
5	0,871	13.768,79 €	19.171,73 €	- €	- €	- €	- €	- €	- €	- €
6	0,842	20.038,96 €	138.925,57 €	- €	- €	- €	- €	- €	- €	- €
7	0,814	12.853,31 €	17.897,01 €	- €	- €	- €	- €	- €	- €	- €
8	0,786	10.846,68 €	15.719,82 €	- €	- €	- €	- €	- €	- €	- €
9	0,759	11.998,70 €	16.707,05 €	- €	- €	- €	- €	- €	- €	- €
10	0,734	10.125,49 €	14.674,62 €	- €	- €	- €	- €	- €	- €	- €
11	0,709	199.773,32 €	118.389,44 €	- €	- €	- €	- €	- €	- €	- €
12	0,685	9.452,25 €	13.698,91 €	- €	- €	- €	- €	- €	- €	- €
13	0,662	10.456,18 €	14.559,23 €	- €	- €	- €	- €	- €	- €	- €
14	0,639	8.823,78 €	12.788,08 €	- €	- €	- €	- €	- €	- €	- €
15	0,618	9.760,95 €	13.591,20 €	- €	- €	- €	- €	- €	- €	- €
16	0,597	14.206,00 €	98.486,95 €	- €	- €	- €	- €	- €	- €	- €
17	0,577	9.111,95 €	12.687,53 €	- €	- €	- €	- €	- €	- €	- €
18	0,557	7.689,41 €	11.144,08 €	- €	- €	- €	- €	- €	- €	- €
19	0,538	8.506,11 €	11.843,95 €	- €	- €	- €	- €	- €	- €	- €
20	0,520	7.178,15 €	10.403,11 €	- €	- €	- €	- €	- €	- €	- €
21	0,503	141.623,07 €	83.928,50 €	- €	- €	- €	- €	- €	- €	- €
22	0,486	6.700,88 €	9.711,42 €	- €	- €	- €	- €	- €	- €	- €
23	0,469	7.412,58 €	10.321,31 €	- €	- €	- €	- €	- €	- €	- €
24	0,453	6.255,34 €	9.065,71 €	- €	- €	- €	- €	- €	- €	- €
25	0,438	6.919,72 €	9.635,06 €	- €	- €	- €	- €	- €	- €	- €
Total/ship		855.831,22 €	888.250,06 €	- €	- €	- €	- €	- €	- €	- €
Total/LM		427,92 €	444,13 €	- €	- €	- €	- €	- €	- €	- €

External cost

Introduction | LCC - Cost | LCC - Input Cost break down | **LCC - Annual Result** | LCC - Result | FSA - Input | References

Figure 11. Example result in "LCC – Annual result" worksheet.

To see the total cost and the result in the diagram, the user can navigate through "LCC – Result" worksheet. Users are also able to change the unit into rational KPI, results/ship or results/Lane Meter (LM), results/CEU see Figure 13.



LCC - Result

Information about D&D

	All System	System#01	System#02	System#03	System#04	System#05	System#06	
System Name	-	Fire Fighting system 1	Fire Fighting system 2	0	0	0	0	
RCO number 1	-	1	2	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
RCO number 2	-	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
RCO number 3	-	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
RCO number 4	-	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
RCO number 5	-	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose

Life cycle cost result

Unit		Per Ship						
Total Investment cost	EUR	1.058.937,13 €	566.140,08 €	492.797,05 €	- €	- €	- €	- €
Total Operation cost	EUR	327.520,66 €	37.528,41 €	289.992,25 €	- €	- €	- €	- €
Total Maintenance cost	EUR	357.623,50 €	252.162,73 €	105.460,77 €	- €	- €	- €	- €
Total End of Life cost	EUR	- €	- €	- €	- €	- €	- €	- €
Total Life Cycle Cost	EUR	1.744.081,28 €	855.831,22 €	888.250,06 €	- €	- €	- €	- €
Total External cost	EUR	945.085 €	825.560 €	119.525 €	- €	- €	- €	- €

Figure 12: LCC -Results

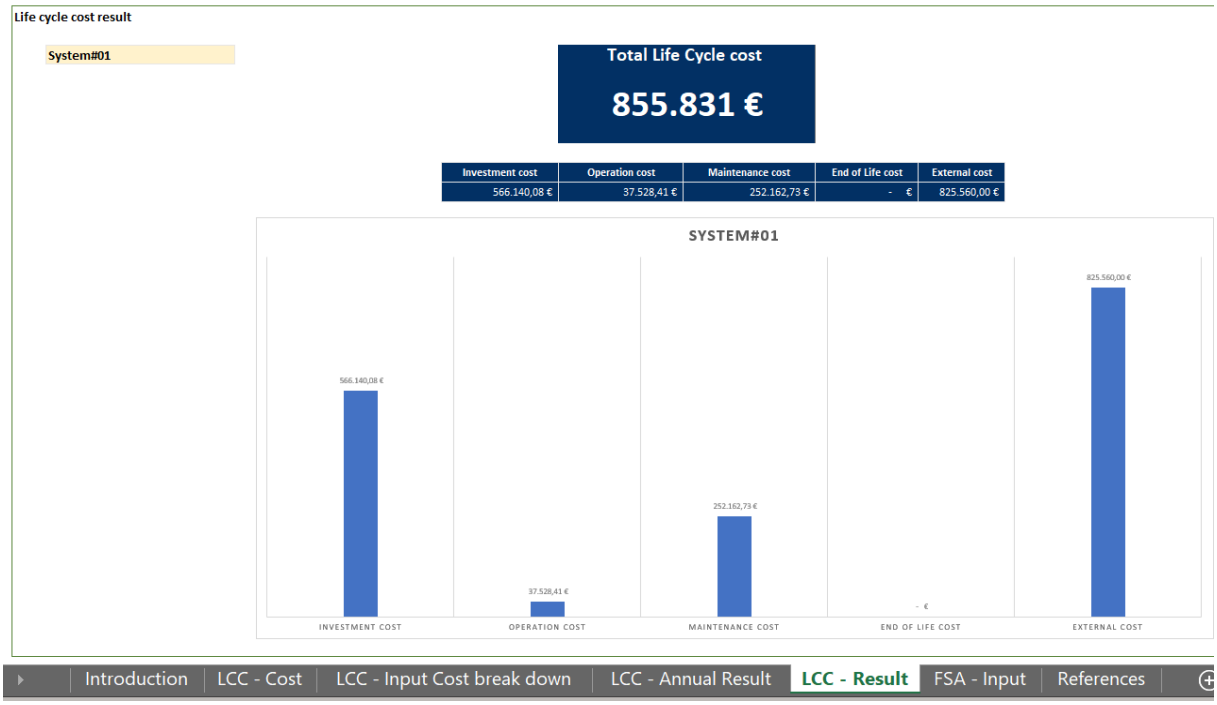


Figure 13. Example result in "LCC – Result" worksheet.

The last worksheet shows the result is the "FSA Input" worksheet. Here all the cost items for the formal safety assessment per RCO can be displayed: the total investment cost, operation cost, maintenance cost, end of life cost, life cycle cost, and external cost information. The users just need to change the RCO number and the unit to be shown in the table, see Figure 15. To understand the effect of the economic and legislation situation on the total life cycle cost, users can navigate through the result in the sensitivity analysis, see Figure 14. The result is useful to understand the true cost of the ownership of new solutions.

The last "References" worksheet shows information about the future cost of conventional fuel and the cost for externalities. D5.3 explains the background on how future fuel costs and external cost are being calculated.

LCC - Result

Information about D&D

	All System	System#01	System#02	System#03	System#04	System#05	System#06	
System Number	-	Fire Fighting system 1	Fire Fighting system 2	0	0	0	0	
System Name	-	1	2	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
RCO number 1	-	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
RCO number 2	-	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
RCO number 3	-	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
RCO number 4	-	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose
RCO number 5	-	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose	Click to choose

Life cycle cost result

Unit		Per Ship							
Total Investment cost	EUR	1.058.937,13 €	566.140,08 €	492.797,05 €	- €	- €	- €	- €	- €
Total Operation cost	EUR	327.520,66 €	37.528,41 €	289.992,25 €	- €	- €	- €	- €	- €
Total Maintenance cost	EUR	357.623,50 €	252.162,73 €	105.460,77 €	- €	- €	- €	- €	- €
Total End of Life cost	EUR	- €	- €	- €	- €	- €	- €	- €	- €
Total Life Cycle Cost	EUR	1.744.081,28 €	855.831,22 €	888.250,06 €	- €	- €	- €	- €	- €
Total External cost	EUR	945.085 €	825.560 €	119.525 €	- €	- €	- €	- €	- €

Sensitivity Analysis

Total life cycle cost	EUR								
Unit		Per Ship							
1. High GDP (inflation rate 2.6%) without restrictive legislation		1.789.427,39 €	878.082,83 €	911.344,56 €	- €	- €	- €	- €	- €
2. High GDP (inflation rate 2.6%) with restrictive legislation		2.734.512,39 €	1.703.642,83 €	1.030.869,56 €	- €	- €	- €	- €	- €
3. Low GDP ((inflation rate 0,87%) without restrictive legislation		1.728.907,77 €	848.385,49 €	880.522,29 €	- €	- €	- €	- €	- €
4. Low GDP ((inflation rate 0,87%) with restrictive legislation		2.673.992,77 €	1.673.945,49 €	1.000.047,29 €	- €	- €	- €	- €	- €

Introduction | LCC - Cost | LCC - Input Cost break down | LCC - Annual Result | **LCC - Result** | FSA - Input | References

Figure 14. Example result for different LCC results after sensitivity analysis.

Ship Information

Ship Name		Stena Flavia
Ship Type		RoPax
Ship Status		NEWBUILDING
Ship Lifespan	(years)	25

Information for FSA

RCO		2
Unit		Per Lane meter
Total Investment cost	**EUR**	246,40 €
Total Operation cost	**EUR**	145,00 €
Total Maintenance cost	**EUR**	52,73 €
Total End of Life cost	**EUR**	- €
Total Life Cycle Cost	**EUR**	444,13 €
Total External Cost	**EUR**	59,76 €

ntroduction | LCC - Cost | LCC - Input Cost break down | LCC - Annual Result | LCC - Result | **FSA - Input** | References

Figure 15. Example result in "FSA – Input" worksheet.

5 Conclusion

Main author of the chapter: Sri Lestari Maharani, CMT

One of the objectives of LASH FIRE is to evaluate and demonstrate ship integration feasibility and cost of developed operational and design risk control measures for all types of ro-ro ships and all types of ro-ro spaces. Alongside the evaluation of technical and operational solutions developed in the project, the economic feasibility of the solutions needs to be evaluated throughout the entire life span. Therefore, an LCC tool was developed to assess the financial parameter. Furthermore, to understand the impact of the world economy and legislation situation on the LCC, a sensitivity analysis feature was made available in the tool so the users can understand the impact on the cost if a different scenario might happen in the future.

The report provides explanations of the data collector and LCC tool developed in the LASH FIRE project. This report will be used as a guideline to carry out LCC assessments in the LASH FIRE project. A detailed report about the methodology to do the calculation is provided in D5.3 (Development of cost assessment tool).