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PROJECT MIDWOR Deliverable C3.1

Preliminary report on cost-efficiency methodology and system defined

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[1] **Nature of Deliverable**: **P**= Prototype, **R**= Report, **S**= Specification, **T**= Tool, **O**= Other.

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1. Introduction

MIDWOR project aims to mitigate the environmental, health and safety impacts of current Durable Water and Oil Repellents (DWOR) and future alternatives by analyzing their environmental impact and technical performances in order to assess the best available products to provide repellency to liquids on textiles.

During the last decades DWOR chemistries based on polymeric perandpolyfluoroalkyl substances (PFASs), more precisely “side-chain fluorinated polymers”, have been common since side-chain fluorinated polymer DWORs are highly durable and both water and oil resistant (1). Conventional finishing products made of long chain fluorocarbon polymers are persistent and bioaccumulative. Many perfluorochemicals have already been listed in different European regulations to put emphasis on their risk for humans and the environment. These products have been used in the textile industry since many years ago and tentative to replace them has been done since 2000. Alternative products are currently proposed by different chemical companies for textile applications, however, the toxicity, environmental and economic impact of these new alternatives is still unknown. The substitution of toxic and persistent perfluorochemicals is of high importance as they occupy a high place in the market and almost all alternatives are perfluorocarbons based products (fluorocarbons polymers with shorter chain length).

The present deliverable is aimed to present the methodology developed to determine the economic impact of the application of DWOR products (conventional and alternative substances) in textile finishing treatments. This methodology will allow quantifying the potential economic impacts and benefits of DWOR alternatives evaluated in MIDWOR project in order to evaluate the economic sustainability.

A Life Cycle Cost (LCC) of the conventional and alternative DWORs selected in action B3 (Life Cycle Assessment) will be conducted. LCC will analyze the direct and indirect cost and benefits of using these chemicals.

2. Conceptualization of Life Cycle Costing

Besides environmental Life Cycle Assessment (LCA) conducted under Action B3 of MIDWOR project, a cost-efficiency assessment based on Life Cycle Costing (LCC) principles will be performed.

LCC is a key management tool that takes into account the whole life cycle implications of planning, acquiring, operating, maintaining and disposing a product/process.

The EU Directive 2014/24 in the Article 68 gives a precise definition of LCC: "Life Cycle Costing shall to the extent relevant cover parts or all 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 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".

A typical LCC for a product could be represented in the following equation:

$$LCC = (AC – TD) + (OC + RC) –RV$$

Where:

LCC = Total Life Cycle Cost

AC = Initial asset acquisition /capital cost

TD = Tax depreciation entitlements

OC = Operating and maintenance costs

RC = Replacement / disposal / upgrade costs

RV = Residual / salvage value

3. LCC methodology

A methodology with a life cycle approach has been defined in order to assess the economic implications of applying conventional or alternative DWOR substances within the MIDWOR project. The methodology proposed is based on the SETAC code of practice which provides guidance that build on the four-stages structure of the ISO 14040 standard to facilitate definition and application of consistent system boundaries for complementary LCC studies of a given product system. The LCC will be carried out through the four interrelated stages shown in Figure 1.

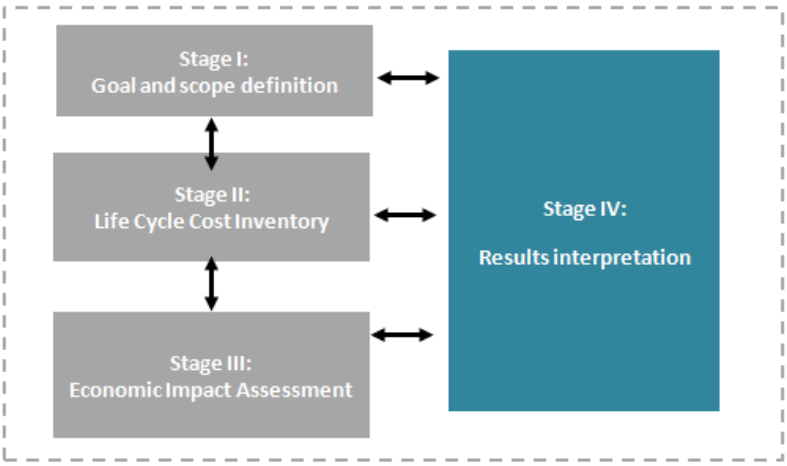

FIGURE 1. LIFE CYCLE COST STAGES.

3.1. Goal and scope definition

The first stage of the LCC study is the **goal and scope definition** in order to define the general context of the study. **Goal definition** is aimed to describe and state the key objective of the LCC analysis. Since it lays the foundations for the rest of the work, its precise definition is of fundamental importance for avoiding erroneous methodological steps and misinterpretation of the results.

The main goal of the present LCC study is to assess and compare the economic impacts of using conventional and alternative DWOR substances in textile finishing processes, taking into account the whole life cycle of the finishing products.

Defining the **scope** of the LCC study refers to describing in detail the system to be evaluated along with the associated analytical specifications, indicating the functional unit and the system boundaries. The unit of analysis, also called the "functional unit", describes qualitatively and quantitatively the function(s) or the service(s) provided by the product, as well as its duration. The economic data obtained will be expressed in relation to this functional unit.

The system boundaries define which parts of the product life cycle and which associated processes belong to the analysed system (i.e. are required for providing its function as defined by the functional unit). The system boundary should be defined following general supply-chain logic, including all phases from raw material extraction through processing, distribution, the use phase and end-of-life treatment of the product, as appropriate to the intended application of the study.

- Functional Unit:

The functional unit considered for this study is the same that the one selected for conducting the LCA:

100 m^2 finished fabric treated with DWOR

- System boundaries:

The present LCC study has a **gate-to-gate approach**, focusing on textile finishing processes such as softener padding, drying, curing and winding. The whole life cycle of DWOR products will be considered.

Finishing involves a number of processes such as softener padding to impact softness, voluminous handle and hydrophilic character to the fabric, drying to remove moisture and compacting to impact dimensional stability. Figure 2 presents the system boundaries of the LCC assessment.

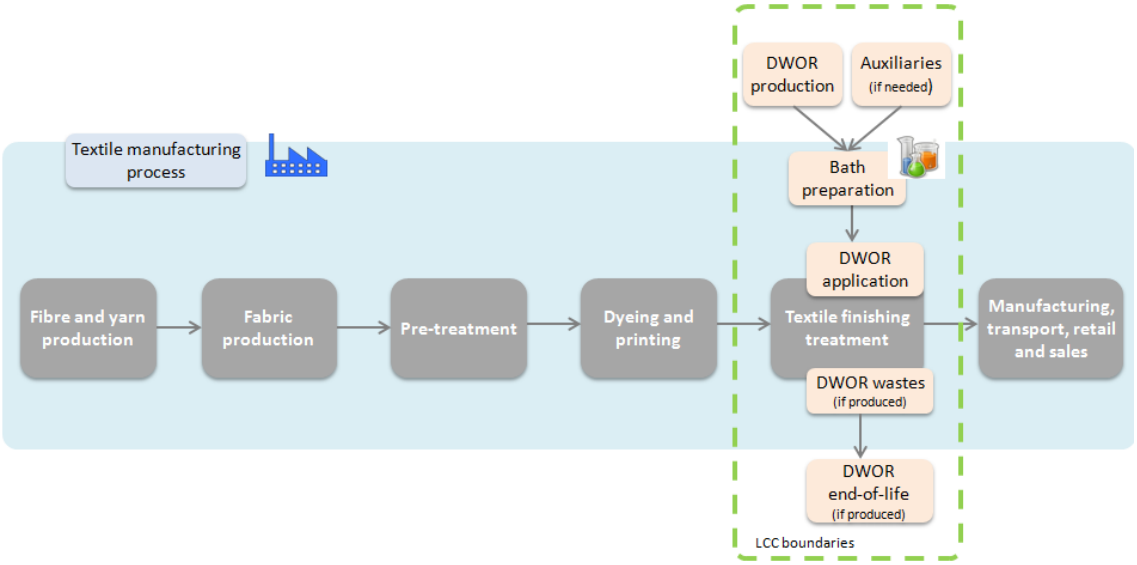

FIGURE 2. TEXTILE MANUFACTURING PROCESS AND THE SYSTEM BOUNDARIES CONSIDERED IN THE LCC ASSESSMENT.

In the textile finishing treatment, most DWORs are applied by padding process and then dried and cured (see Figure 4). Padding is a conventional technique in which the fabric is submerged in a textile auxiliary bath and then squeezed between two squeeze rollers by setting a certain pressure and speed. After the application of the DWOR substance, the fabric is dried to eliminate the water and cured to fix the finishing on the fibre surface.

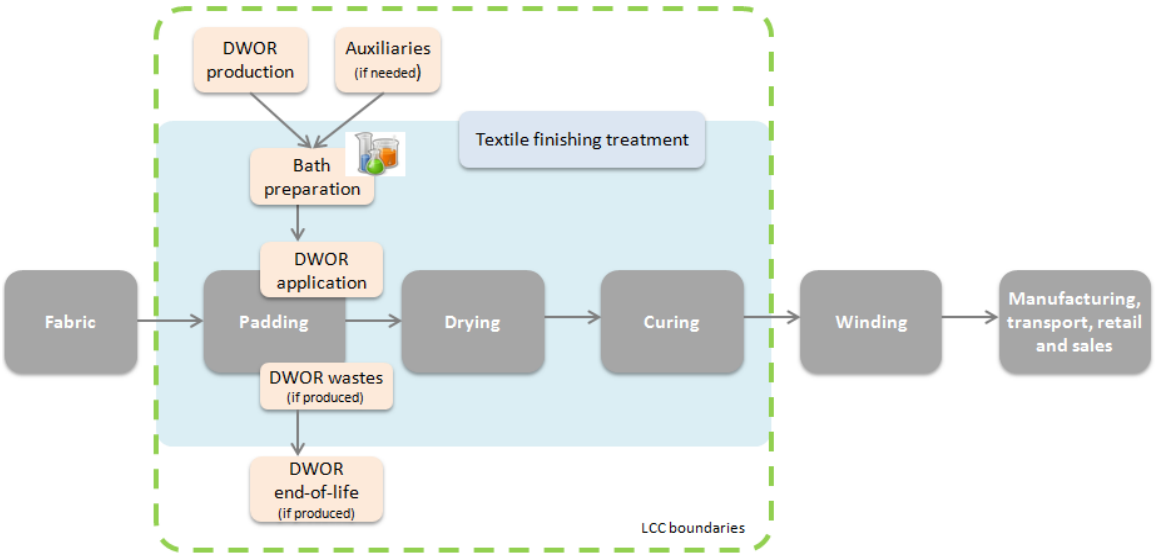

FIGURE 3. FINISHING PROCESSES AND SYSTEM BOUNDARIES CONSIDERED IN THE LCC ASSESSMENT.

3.2. Life Cycle Cost Inventory

The LCC inventory consists in collecting economic data of the different stages and processes of the system previously defined. Thus, the costs of each stage will be identified and quantified.

Both direct and indirect costs will be collected to perform the LCC assessment:

1) Direct costs: represents the costs directly paid along the life cycle phases. The direct costs indicated as follows will be considered:
   - Costs related to acquisition of DWORs (purchasing costs) for the treatment of textiles.
   - Costs of use: refers to the operation costs, such as:
     - energy costs related to finishing processes (padding, drying and curing);
     - water consumption costs;
     - amount of DWOR chemicals and auxiliaries (i.e. fixing agents, wetting agents) used for textile treatment;
     - time required for treatment of textiles.
   - Maintenance costs will be excluded from the LCC analysis due to limited duration of the trials demonstration in MIDWOR project to monitor the impact of the application of DWOR products in the finishing treatment equipments.

- Disposal costs associated to waste generated during finishing treatment process will be considered.

2) Indirect costs: are the costs imputed to environmental externalities linked to the DWOR chemicals during its life cycle. The environmental impacts determined by CETIM in Action B3 (Life Cycle Assessment) will be converted to monetary terms by applying monetization factors. Figure 4 shows the pathway to evaluate indirect costs.

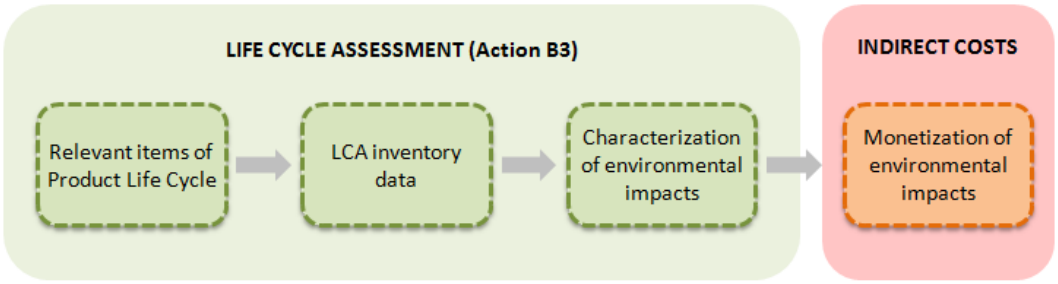

FIGURE 4. STEPS TO ESTIMATE THE MONETARY VALUE OFINDIRECT COSTS

In line with the recommendations of the EU's 7th Environment Action Programme, four externalities will be assessed:

- Human health: expressed as the number of year life lost and the number of years lived disabled. These are combined as Disability Adjusted Life Years (DALYs), an index that is also used by the World Bank and WHO.
- Ecosystem: expressed as the loss of species over a certain area, during a certain time.
- Resource availability: are assessed by the marginal increase costs due to extraction of a resource
- Climate change: the characterization factor of climate change is the global warming potential.

Figure 5 shows the two types of costs that will be considered in the LCC assessment: direct costs and indirect costs (those related to environmental externalities).

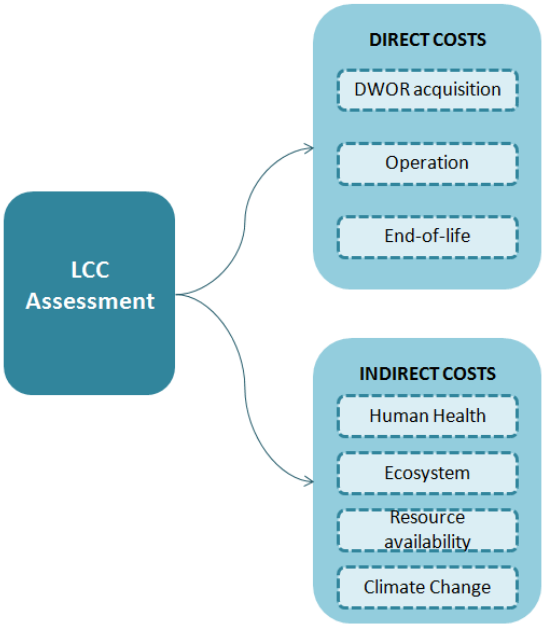

FIGURE 5. LIFE CYCLE COSTING STRUCTURE.

The related expenditures associated with MIDWOR project (i.e. personnel costs, equipment, materials and travel expenses) will also be gathered to assess the economic indicator included in the LIFE platform.

3.3. Economic impact assessment

The economic impact assessment is the stage in which the set of results from the Life Cycle Cost Inventory are processed in terms of potential economic impacts.

The four environmental externalities (Human Health, Ecosystem, Resource availability and Climate Change) are considered in the EU's 7th Environment Action Programme as key priorities to be addressed in EU and Member States policies.

There are several Life Cycle Impact Assessment (LCIA) methods (i.e. ILCD, ReCiPe, USEtox, etc) that can be used to assess the environmental impacts associated to products. The method selected to perform the LCC analysis is ReCiPe, since it allows calculating potential environmental impacts for the four externalities indicated: human health, ecosystem, resource availability and climate change. According to the Joint Research Center (European Commission), ReCiPe is considered as a consistent and reliable method (1).

The methodology proposed to quantify indirect costs is based on monetary valuation, which allows converting human health and environmental impacts into monetary units. Each endpoint category used in ReCiPe has an indicator to assess damages to Human health (Disability-adjusted loss of life years), Ecosystem (Loss of species during a year) and Resource availability ($). As it is shown in Figure 6, Climate Change is considered as a midpoint category. Midpoint indicators (i.e. climate change) focus on specific

environmental aspects, whereas endpoint indicators (i.e. Human Health, Ecosystems and Resources) provide a broader overview of the effects on key areas of interest.

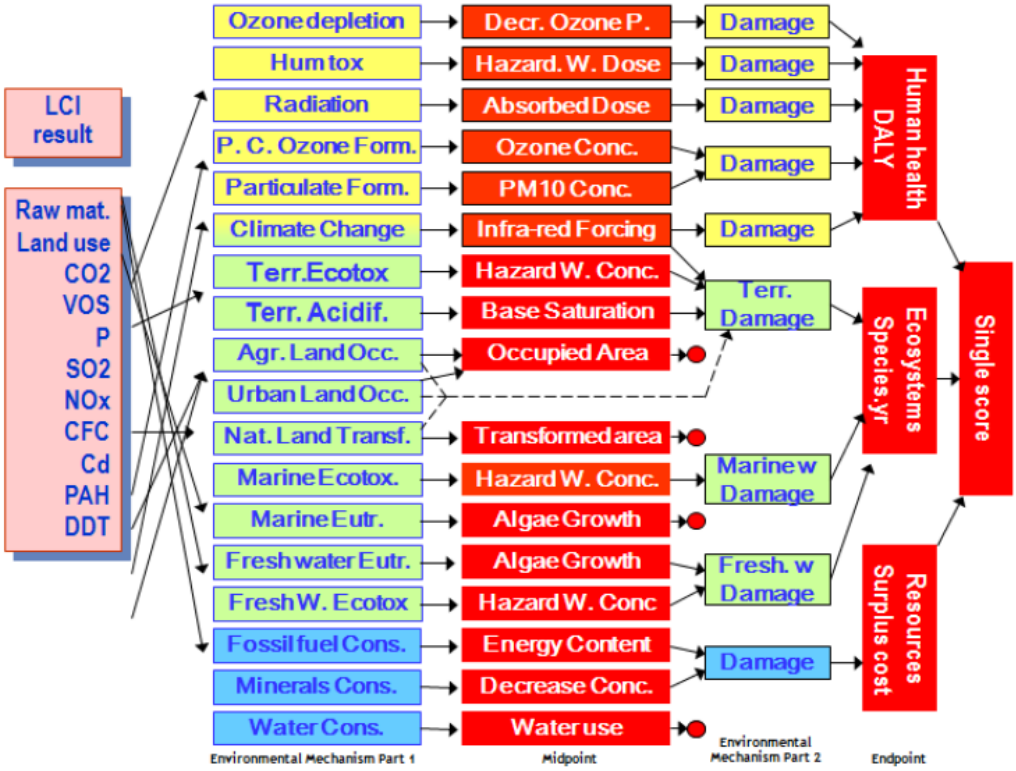

FIGURE 6. RELATIONSHIP BETWEEN MIDPOINT (LEFT) AND ENDPOINT (RIGHT) INDICATORS. SOURCE: SIMAPRO DATABASE MANUAL (2)

Human health and environmental externalities will be monetized by applying the following weighting factors obtained from literature (2):

Impact category	Weighting factors	Source
Human Health	60.000 $/DALY	Heijungs, 2008
Ecosystems	175.000.000.000 $/PDF·year	Heijungs, 2008
Resources	1 $/$	Heijungs, 2008
Climate Change	40 €/ton CO_2	Directive 2009/33 EC

TABLE 1. WEIGHTING FACTORS FOR ESTIMATING DAMAGE COSTS

DALY means Disability Adjusted Life Year and PDF means Potentially Disappeared Fraction of species.

3.4. Interpretation of results

In the final stage of the LCC, a critical interpretation of the results will be done in order to verify its reliability. In this step the completeness and consistency of data gathered and results obtained will be done. The interpretation of the results will help to define the most relevant economic impacts and the stages where attention has to be paid in order to minimize the impact.

4. Conclusions

The methodology presented in this report provides a LCC framework to estimate the economic impacts of the application of conventional and alternative DWORs in textile finishing processes will be aligned with the Life Cycle Assessment (LCA) conducted in Action B3. Thus, the same functional unit and the same system boundaries will be considered in both assessments (LCA and LCC). A comprehensive model for the assessment of the most relevant costs, both direct and indirect costs (externalities), is presented aligned with the requirements of an ISO 14040-compliant LCA. The present LCC adopts from ISO 14040 its structure, and the importance of the goal and scope and defined functional unit in structuring the analysis.

It is worth to mention that the aim of assessing life cycle costs is to generate a reasonable approximation of the costs (consistently derived over all feasible alternatives), but in any case LCC approach will be able to achieve a perfect answer due to uncertainties and assumptions associated.

References

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