D3.1

Circular Model

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PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Modification Control

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WOOL2LOOP

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D3.1 Circular Economic Model

The objective of this deliverable is to develop a Circular Economic (CE) model of the WOOL2LOOP project. The project itself is "circular" by definition, fostering the use of mineral wool waste (MWW) as a precursor for different Alkali Activated materials. We examined in this report the overall scope of the project, the barriers and opportunities arising from its development and the interventions carried out at each step of the novel value chain.

The CE principle generates from the necessity of reducing human consumption of natural resources driven from the conventional Linear Model of "Make-Use-Dispose". The Circular Economy not only aims to foster resource circularity, but also aims to decrease the environmental impact from production, consumption and end-of-life (EoL) of different products and services. The WOOL2LOOP project offers an ideal case of decreasing natural resource depletion and reduced environmental impact, thus coupling the concepts of circularity and sustainability.

1. Methodology Considerations

The main objectives in developing our framework and model have been to pragmatically analyse the different phases of the project and the arising opportunities and barriers, so as to provide valuable considerations to the partners involved in the WOOL2LOOP project and external stakeholders.

The development of our framework and model has taken inspiration from state-of-the-art frameworks, such as Ellen MacArthur Foundation. Though, given that most frameworks propose strictly narrative approaches, we expanded the scope to include the economical facets of the case, since we believe that the future implementation of the technology is highly dependent on its economic feasibility.

The intent of this document and its following developments is not only the economic feasibility analysis (which is the focus in this report), but also assessing the level of "circularity" and quantifying the environmental cost burden based on LCA results (Task 3.3). Taking a holistic view of the project, we identified four drivers whose fulfilment could ensure the market uptake of the WOOL2LOOP products:

1. Technical feasibility, the developed W2L products have at least equal to or better performance than conventional products. The technical feasibility is evaluated in WP1 and WP2 of the project at an on-going basis.
2. Economic competitiveness against standard products (e.g.: OPC products). The economic competitiveness is analysed in the short-run perspective.
3. Sustainability performance, i.e.: if the products carry lower environmental impact against competing options. In order to measure sustainability performance of LCA results (Task 3.2, end in M36). Here the competing options is landfilling mineral wool, nevertheless we shall take into consideration that the product will substitute existing OPC product. Therefore, taking into consideration only CO2 emissions the circumstance can be expressed as:

   $$CO_2\ emission\ of\ new\ product < CO_2 emissions\ conventional\ product$$

   The formula can be expressed as:

   $$CO_2\ emission\ of\ new\ product - CO_2 emissions\ conventional\ product < 0$$

   This formula, if supported by necessary analysis, could be expressed with LCA values instead of CO2 emissions. Environmental impact from transportation to landfill is not considered, given the transportation will occur in the case of recycling as well.
4. Circularity performance, i.e.: the new products will have higher circularity level

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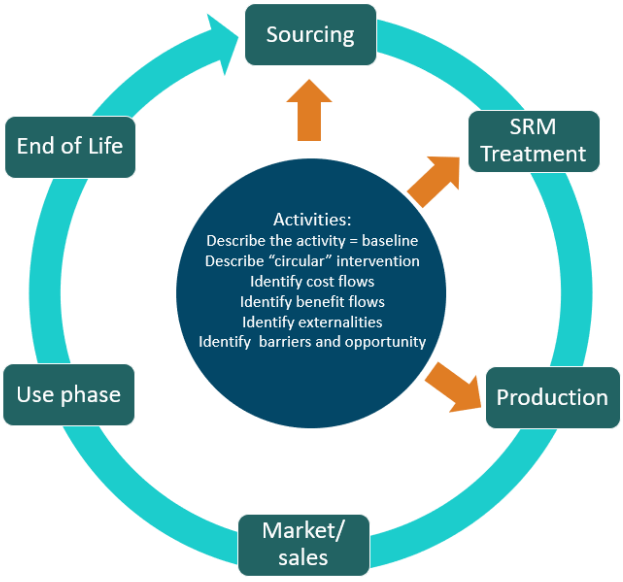
compared to conventional products, measured through Material Circularity Indicators[1].

Data collection has been performed within the consortium (through questionnaires and interviews) and from external sources when available.

We expect this report to shed some light on the different implications of implementing the WOOL2LOOP project at different stages, and through the construction of a simple model (focused on the production side and environmental impact) we aim to identify the key parameters that could ensure economic and environmental feasibility against competing products (e.g.: OPC or composite cements).

2. CE Model Approach Framework

The aim of the Circular Economic Model (CEM) is to understand the business case at every level of the WOOL2LOOP project and estimate the benefit and cost flows from the "circular intervention", as well as assessing the market value of the recovered secondary raw materials. Finally, externalities, barriers and opportunities will be identified. Given the novelty of the approach, a new methodology has been defined in order to reach the WP objectives.



The model has been developed using insights from three EU funded research projects on Alkali Activated materials, besides WOOL2LOOP, these are URBCON[2] and DurSAAM[3]. In the case of WOOL2LOOP the major intervention in the value circle (i.e.: the differences from a business as usual cement production) are identified at the initial stage, sourcing, and subsequent treatment of SRM and product manufacturing (indicated by the orange arrows).

The activities pursued at each identified step, in order to apply the framework, are in detail:

- Description of baseline activity, i.e.: in a business as usual configuration, how is the activity carried on.
- Description of "Wool2Loop intervention", what will be changed due to the Wool2Loop concept, e.g. what is needed in terms of additional manpower or routines in order to separate and collect the mineral waste at the level of the demolition site
- Identification of cost flows, capital investments or operational investments necessary to implement the new technology or to source the mineral wool waste.
- Identification of benefit flows, deriving from the implementation of the WOOL2LOOP technology.
- Identification of positive or negative externalities, the quantification of those will be performed in LCA, D3.2.
- Identification of barriers (regulatory and non-regulatory barriers) arising at the analysed

[1] The Material Circularity Indicator (MCI) is a circularity indicator developed by the Ellen Mac Arthur Foundation (EMC). https://www.ellenmacarthurfoundation.org/resources/apply/material-circularity-indicator.
[2] https://www.nweurope.eu/projects/project-search/urbcon-by-products-for-sustainable-concrete-in-the-urban-environment/
[3] http://www.dursaam.ugent.be

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steps of the value circle as well as arising opportunities.

Input to the analysis will come from different sources, such as:

1. Interviews with stakeholders involved in the activities (e.g.: demolition companies at "Sourcing" level), production companies.
2. Using Narratives to describe the interventions.
3. Data and statistics when available at local, regional and national level.

The development of the Circular Economic model is currently on-going and is performed in Excel, following the logic of the above-mentioned steps along the value circle. The analysis consists of both descriptive and modelling methods. The results from the descriptive analysis (e.g.: interview with partners, literature research) have been used as input for the modelling approach. Four different scenarios have been developed in the Circular Economic Tool (i.e.: modelling tool implemented in Excel):

- 2 scenarios representing the "true cost" of the actions performed during the value chain (nominally "Baseline" and "Efficient" scenarios).
- 2 scenarios representing business cases, therefore including cost/opportunity considerations of stakeholders involved in the value chain.

The scenarios have been applied to three different EU countries (Poland, Germany, Denmark).

3. Preliminary Results

From our preliminary analysis of the "Sourcing" phase, main results indicate that:

- the flow of waste material from demolition/renovation sites, assessed at 3.5 Mt/year, is likely to be underestimated, so more MWW is likely going to be available in Europe.
- The estimated cost of collection of MWW yields negative results (thus a revenue) when taking into consideration the cost opportunity of landfilling. Though comparing the estimated values with the overall cost of OPC production (estimated ex-factory production cost 60 €/ton), the preliminary cost estimation indicates that the sourcing of MWW needs to be carried out in a more cost-efficient way to make it competitive with OPC.
- Fragmented regulations of the utilization of waste could hinder the recyclability of MWW.
- The classification of mineral wool produced prior to 1997 could result in additional barriers given the classification as hazardous waste (thus requiring proper handling methods), specifically in Germany and Austria.

From the analysis of the "Treatment" phase it emerges that:

- From our preliminary estimation the operational capacity of the considered milling machines results in a high cost/price of mineral wool powder, that makes the precursor non-competitive with OPC. Furthermore, based on preliminary results from WP2 a second milling could be needed, thus increasing costs of processing. This issue will be further investigated once it will be properly addressed in the project.
- There is need of more detailed information, also regarding the scaling at industrial level, as reliable data are scarce.
- No additional significant barriers were detected.

The results from the application of the CE tool are illustrated in graph below. The results are to be interpreted as preliminary cost/price of MWW powder after treatment. Main factors affecting the results are : (1) cost of labors in different EU countries, (2) milling capacity of the

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machinery (here it's important to remark that the application at industrial level could result in low processing costs).

4. Future Development

The phases of manufacturing, marketing and distribution, use and EoL will be analysed following the proposed analytical framework. These will be modelled and included in the next months on an ongoing basis, following the partners time schedules of the project. We expect the tool to be finalised in M36, at the end of the project, or before if data are going to be available. The business cases for project partners will be evaluated in a separate deliverable (D3.4, M36).

The level of "circularity" of the WOOL2LOOP products will also be taken into consideration. In order to be consistent with the analytical framework for the development of the CE Model we selected the Material Circularity Indicator (MCI) from the Ellen MacArthur Foundation[4]. The intent is to include the indicator in the tool so to provide the companies in the consortium the possibility of evaluating the circularity of their own products once they are developed. Since the applied indicator covers the product-level (thus can only be applied to the final commercial products) it has not been possible to date to deploy the indicator, given the products of the WOOL2LOOP project have not yet been finalised at the time this deliverable is being written (M12).

[4] https://www.ellenmacarthurfoundation.org/our-work/activities/ce100/co-projects/material-circularity-indicator

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