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RETRACKING PROJECT

Verso l'economia circolare: tracciabilità dei manufatti in Compositi Fibro Rinforzati
Krožni ekonomiji naproti: sledljivost izdelkov iz kompozitov, ojačanih s steklenimi vlakni
Towards the Circular Economy: The Traceability of Fibre Reinforced Composite Products

Proposta di un modello di economia circolare per la raccolta ed il recupero dei rifiuti contenenti CFR, insieme alla definizione del criterio di cessazione della qualifica di rifiuto per i rifiuti di CFR / Predlog modela krožnega gospodarstva za zbiranje in recikliranje odpadkov, ki vsebujejo KOV, vključno s protokolom "end-of-waste"

.Proposal for Circular Economy Model for collection and recovery of FRC containing waste

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1. Introduction

The main objective of this deliverable is to develop a business model based on production of secondary raw materials (SRM)-based products, i.e. polymer slabs with filler from a recycled FRC waste. This products are in the shape of slabs and cut-to-size products and can be potentially used for different end-products, e.g. panels for internal and external cladding, flooring and stairs, vanity and kitchen tops. Compliance with the potential uses will be tested in laboratory tests and reported in R10.WP3.2 (Report on SRM-based products characterization).

As previously demonstrated in R2.WP3.1 (FRC waste stakeholders database) and R3.WP3.1 (Report on conclusions as regard to quantities and quality of FRC waste streams) there is potentially large stakeholders' base in the programme area and currently no circular business model exist in management of FRC-based products and waste. As a major obstacle to the circular business model based on the recycling of FRC-based products and waste is lack of FRC waste sorting, especially in the case of waste from FRC products (e.g. obsolete sport equipment) used by individuals. A slightly better opportunity is in the case of industrial waste in the production of FRC-based products, where waste flows are more homogenous and therefore better for SRM production. This and other presumptions were tested in the development of the RETRACKING circular economy business model (CEBM).

1.1. Reading guide

This deliverables is based on information gathered from: (i) Gees Recycling, an industrial partner in the RETRACKING project; (ii) stakeholders and value chain actors participating the RETRACKING workshops; (iii) interviews of individual value chain actors; and (iv) desktop research.

The deliverable contains 2 parts:

- Part I: Circular Economy Business Model (CEBM) for production of the SRM-based products out of collected and recycled FRC-based waste;
- Part II: End-of-Waste (EoW) criteria for the production of aggregate/filler for polymer based slabs from the inert FRC waste.

PART I: Circular Economy Business Model based on recycled FRC waste

2. Methodology for development of the CEBM

CEBM for the production of slabs out of recycled (crushed and grinned) inert FRC waste was developed based on:

- Assessment of existing and new value chains;
- Assessment of socio-economic and environmental context of development of a new CEBM. The latter was done through Political, Economic, Social, Technological, Legal, Environmental (PESTLE) analysis;
- Business Model Canvas (BMC).

3. FRC based CEBM

3.1. Value chain assessment

A value chain is a physical representation of the various processes involved in producing goods (and services), starting with raw materials through the delivered product and in the case of circular economy mode also to End-of-Life scenarios. It is based on the notion of value-added at the system level. The sum total of individual value-added yields total value[1].

A value chain consists of information on different levels:

- Material flow: the material flow consists of several properties, which include the material, geolocation, amount, quality, composition and availability;
- Stakeholder: there could be multiple stakeholders active per each step of value chain (here in this deliverable we call them actors of the value chain which are directly involved in the activities). They are profitable (industries) or non-profitable organisations (e.g. municipalities, public utility services, etc). There are also indirect stakeholders involved in the activities of the value chain (for the need of this deliverable we called them stakeholders), which are not producing or adding

[1] https://en.wikipedia.org/wiki/Value_chain

value in the value chain but can significantly impact the value chain. These are for example: architects, NGOs, policy and decision makers. Many actors and stakeholders can have multiple roles in the value chain;

- Activities: are performed on material management at each step by individual actors. These are: production of raw materials, transport of raw materials to the factory gate, production of products, transport of product from gate to shop, use of products, end-of-life management of obsolete products or waste;
- Value creation: the whole theory of value chain is focused around looking at the value creation in the system and not only on the level of individual actors as in conventional production. The question here are for example: how is value created throughout the chain? How do the activities add value to the material and how does it compete in the specific (end-)market of the material/product;
- Interests/stakes: the interest of the different actors/stakeholders in the current and new value chain.

3.1.1. Existing FRC value chain in the programme area

As previously identified in the R2.WP3.1 and R3.WP3.1 the current value chain in the FRC production and management in the programme area is mostly linear. The main actors of the value chain are listed in Figure 1.

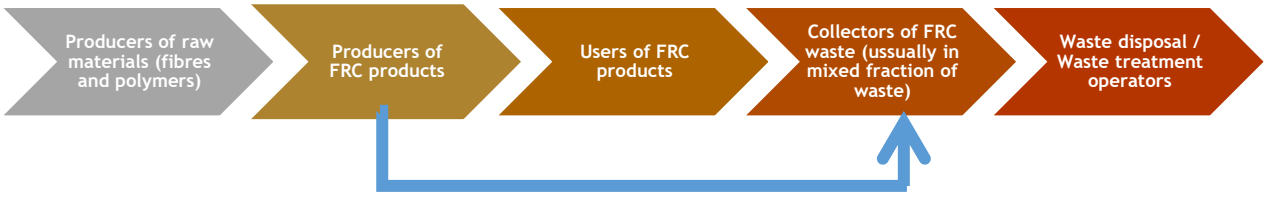

Figure 1: Conventional Value Chain of FRC production and waste management.

These are:

- Producers of the raw materials for FRC production (producers of fibers and polymers), which can be located in the programme area of outside the programme area;
- Producers of FRC-based products for different intended uses (e.g. sport equipment, vehicles, construction products,…), which can be located in the programme area or outside the programme area;

- Users of FRC-based products, which can be individuals or industries using these products;
- Collectors of FRC-based waste in different waste groups;
- Waste disposal operators (landfill and incineration operators) or waste treatment operators (mostly production of fuel).

FRC waste can be produced in two steps of FRC value chain:

- During production of FRC-based products – such waste streams are more homogenous by their composition and more uniform – or;
- After use of FRC-products – these waste streams are very heterogeneous by their composition and difficult to trace because they can be found in different waste groups.

Due to the relative ease of the production and long life span of the FRC based products it is assumed that most value is created in the phase of selling of products. Never the less due to plastic waste import ban instated in many countries in Asia in past years, the prices of plastic waste, including FRC waste, collection and management is increasing. This also creates momentum for new waste management options, such as recycling.

For further study two major groups of waste streams were considered:

- FRC waste from the production of FRC-based products;
- FRC waste from vehicles and vessels.

3.1.2. Potential new circular value chain

As already presented in the R3.WP3.1 (FRC waste stakeholders database) different FRC waste recycling option are possible (Figure 2). Some of the already existing processes such as pyrolysis and solvolysis enable recycling of fibres, but are less preferable option due to high costs, energy consumption and decrease of strength of recycled fibres. In the case of the RETRACKING project the mechanical recycling was consider which results in grinded powder/aggregate used in production of polymeric slabs.

The new more circular FRC value chain based on the RETRACKING project is presented in Figure 3.

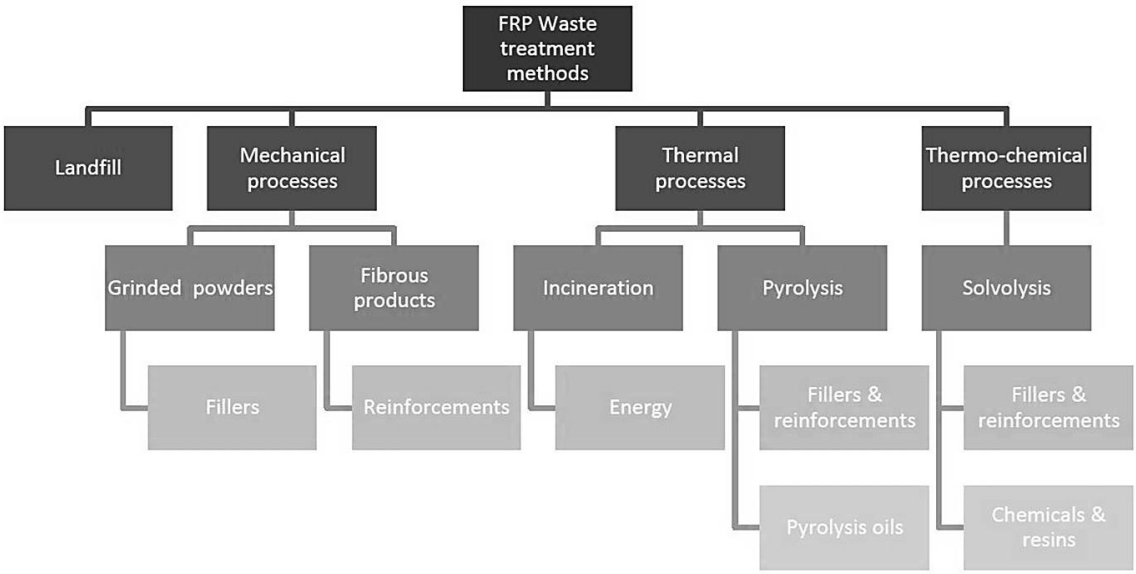

Figure 2: Schematic presentation of different FRC waste recycling technologies and processes (adopted from http://www.windfarmbop.com)

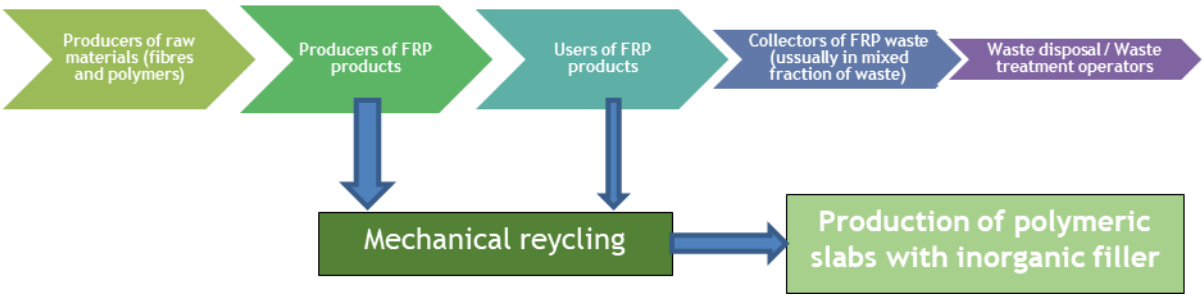

Figure 3: New more circular value chain developed in the RETRACKIGN project

3.2. Socio-economic and environmental analysis - PESTLE

Knowledge on socio-economic, environmental, political and legal context in which the value chain exists or new value chain could be created is highly relevant to understand, especially in terms of risks or to explain how certain players might behave or choose to interact.

Key considerations in assessment of socio-economic and environmental context are:

- Countries and geographies involved;
- Cultural differences;
- Prevailing political and economic climates;
- Environmental considerations.

The analysis of the socio-economic and environmental context were accomplished by using the PESTLE analysis (Figure 4).

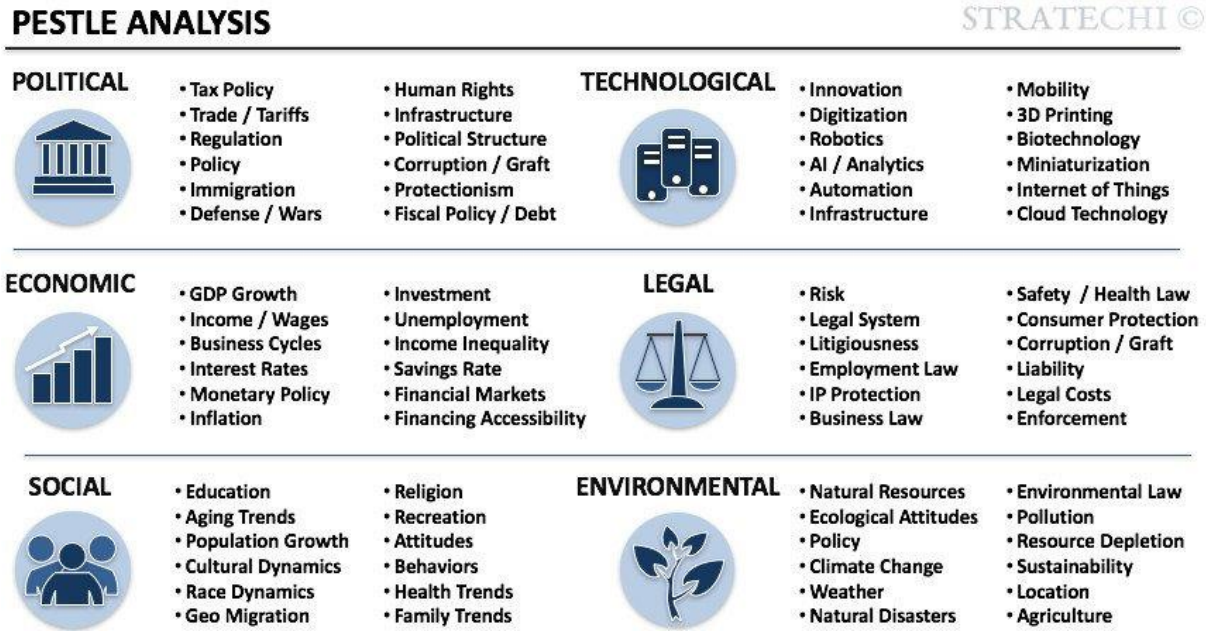

Figure 4: PESTLE analysis (source: https://www.stratechi.com/pestle-analysis/)

The main results of PESTLE analysis in the programme area are given in Table 1.

Table 1: Results of PESTLE analysis of FPR waste management in the programme area.

PESTLE	Slovenian part of the programme area	Italian part of the programme area
Political	CE is high on political agenda – existence of CE policies (national strategies). Relatively low taxes on primary resource production. No or little demand-side measures for producing and using SRM-based products. Lack of clear regulation on using recycled products (e.g. lack of EoW criteria).	CE is high on political agenda – CE policies (strategic documents) exists Long history in recycling Change of regulation on End of Waste Criteria (national versus regional) Less demand-side measures for producing and using SRM-based products
Economic	Low prices of primary resources. Increasing prices of landfilling and incineration, especially due to Asian ban of plastic waste import. Push by waste producers for new	Low prices of primary resources. Increasing prices of landfilling and incineration, especially due to Asian ban of plastic waste import. Push by waste producers for new

PESTLE	Slovenian part of the programme area	Italian part of the programme area
	solutions in waste recycling. Plastic based fuel is mostly exported. No waste-based thermal plants in area.	solutions in waste recycling. Cross-border waste transport also exists.
Social	Distrusts in recycled products and their quality by consumers. Low social licencing for recycling of industrial products (NIMBY effect). High awareness about environmental issues. Active NGOs.	High recycling awareness.
Technological	No recycling technology for FRC waste. No separate collection of FRC waste.	Some recycling technology exists. Little separate collection of FRC waste.
Legal	Waste legislation adopted. End-of-waste status is assessed individually by ministry/environmental agency. Lack of clear procedures and criteria for End-of-Waste.	Waste legislation adopted. Authorisation for assessment of end-of-waste status from regional governments to national governments and back to regional (most recently).
Environmental	No separate collection of FRC waste, heterogeneous waste flows. The most homogenous waste flows are in the case of industrial waste from production of FRC.	Little separate collection of FRC waste (in the case of industry).The most homogenous waste flows are in the case of industrial waste from production of FRC.

3.3. Business Model Canvas (BMS) for structuring and developing a FRC-based circular business model

The RETRACKING project is using the commonly adapted Business Model Canvas (BMC) method for mapping circular business models (Figure 5). By filling in the BMC, the unique business propositions and the lacking parts of business models can become visible. The BMC consists of four parts and nine elements in total. Below the different parts of the BMC are explained and results of the RETRACKING circular business model exercise is given in Figure 6.

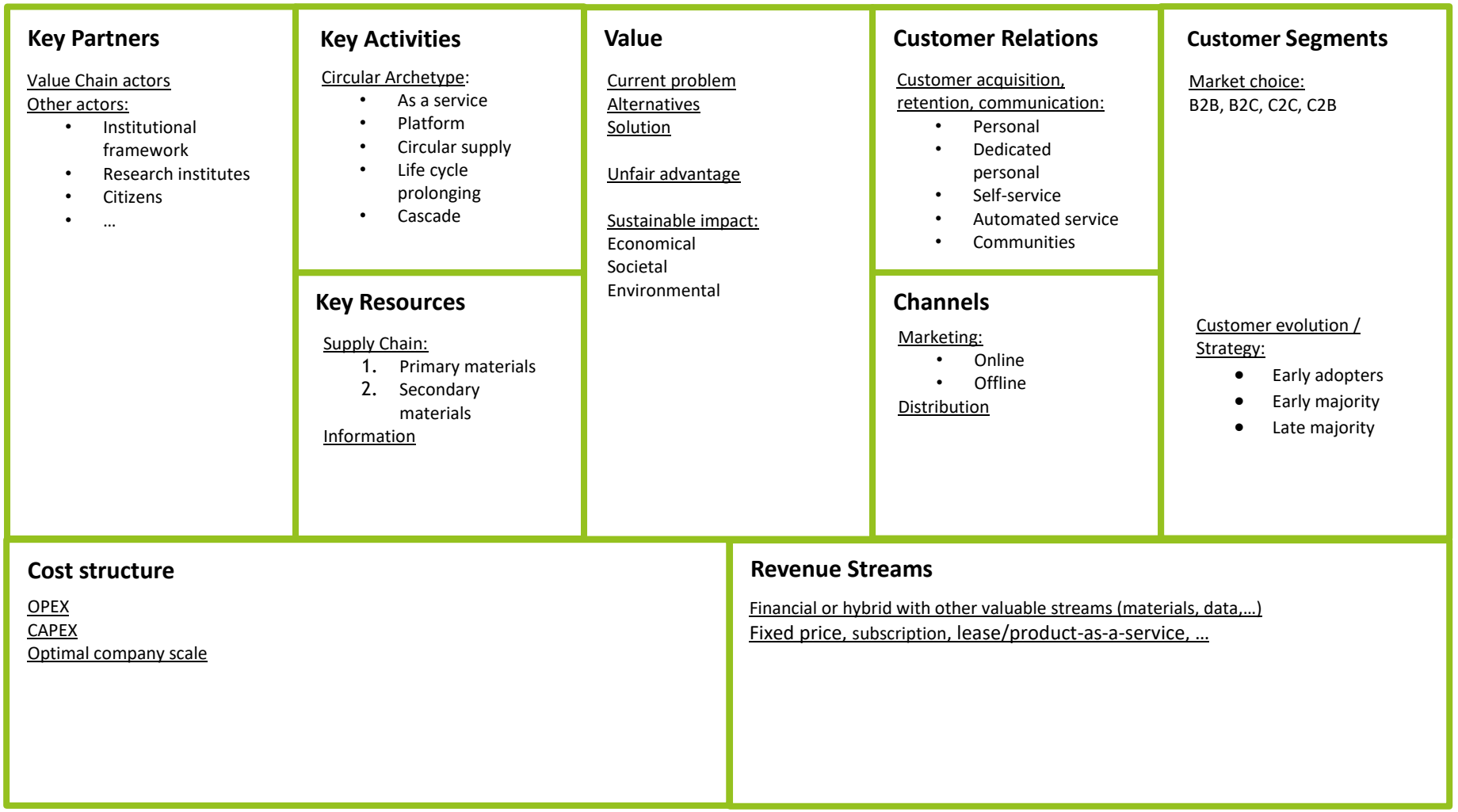

Figure 5: Business model canvas.

3.3.1. Value

The starting point for creation of a BMC is the value proposition element. A company's value proposition is what distinguishes the company from its competitors. With regard to circular and sustainable business models, other factors besides financials such as environmental and social value are of key importance. A circular business model is a specific type of sustainable business model, as it focuses on adding environmental value through improving the usage of SRM and reducing the usage of virgin materials.

3.3.2. Customers

The right side of BMC is dedicated to customers and contains three elements:

- Customer Segments: describes what are the most important customers and what are their needs;
- Customer Relations: describes how customer relations are made and maintained;
- Channels: describes how customers are reached, such as by a physical store, online webpage or trough partner channels.

3.3.3. Infrastructure

The left side of BMC consists of elements that describe the infrastructure necessary for value creation.

- Key Activities: describes the activities that are needed to perform in order to create the specific product or service (or combination) that delivers the expected value.
- Key Partners: the partners necessary for a successful business model. An extensive network of business relationships helps optimize business activities and reduce certain business risks such as material availability, unstable price points and a fluctuating product demand. Besides direct business partners, other collaborations can include governmental organisations, research institutions and citizens.
- Key Resources: the tangible and intangible resources necessary for business activities. These include materials, products, energy, employees, intellectual property and financial resources.

3.3.4. Finance

The bottom side of BMC is dedicated to the financial structure of a business model.

- Cost structure: the fixed and variable costs associated with daily operations and business development. Possibly plus a description on the benefits of company scale and scope;
- Revenue streams: the revenues earned by selling the product or service to customers, as determined by the Key Activities of the business.

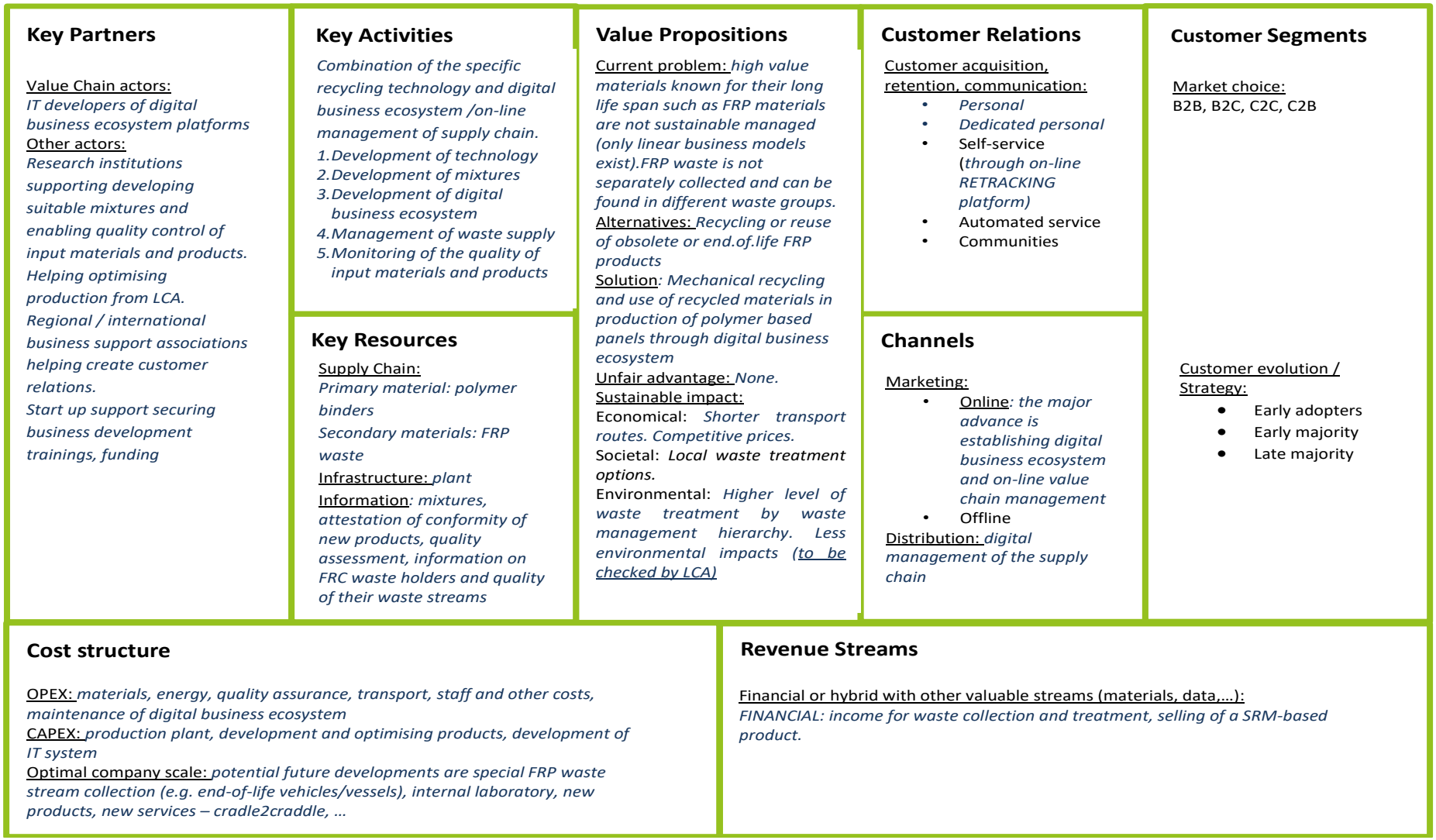

Figure 6: The RETRACKING BMC based on FRC waste recycling.

Part II: End-of-Waste (EoW) criteria

4. Requirements for the EoW

4.1. Background

The European Waste Directive (EC 2008/98/EC) defines the following condition for a specified waste to cease to be a waste :

- the substance or object is commonly used for specific purposes;
- a market or demand exists for such a substance or object;
- the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
- the use of the substance or object will not lead to overall adverse environmental or human health impacts.

Where necessary the criteria should also include limit values for pollutants and shall take into account any possible adverse environmental effects of the substance or object.

The purpose of this part of deliverable is to assess the main conditions for the development of the Quality Protocol with End-of-Waste criteria for FRC-based waste which once cease its waste status can be used as a filler in polymer-based slabs for different intended uses. Currently, there is no such regional, national or European based document, which would address the FRC-based waste to be used as a filler. Due to the certain similarity to the aggregate this document is based on the WRAP document Aggregates from inert waste[2].

4.2. Pre-conditions

A pre-condition for use of FRC-waste in the production of polymer slabs is that such waste once ceased its status will not lead to adverse environmental or human health impacts. In the case of FRC-waste especially the following properties must be checked in order to exclude its hazardous properties:

- HP3 – highly flammable - flammable solid waste: solid waste which is readily combustible or may cause or contribute to fire through friction;

[2] https://www.gov.uk/government/publications/quality-protocol-production-of-aggregates-from-inert-waste

- HP4 - “Irritant — skin irritation and eye damage: waste which on application can cause skin irritation or damage to the eye;
- HP 13 “Sensitising:” waste which contains one or more substances known to cause sensitising effects to the skin or the respiratory organs.

Other waste properties which render it hazardous are also to be checked and reported before consider to be used as input material for the production of SRM-based products.

4.3. Producing filler from the inert FRC-waste

The process of turning inert waste material into a product is classified as a waste recovery operation and is subject to the waste management controls set out in the Waste Framework Directive and national / regional legislation. In order to ensure that only inert waste is accepted, producers must have acceptance criteria.

The producer must comply with all the requirements of a technical specification, such as national or EN standard (for example, EN 13242[3] or EN 12620[4]) or other technical specifications (e.g. National Technical Assessment Document).

Producers must set up and produce the filler under a system for Factory Production Control as set out in the relevant technical specification (see for example R9.WP3.2 Quality Control Manual).

4.3.1. Records management

To be able to demonstrate compliance with the Quality Protocol, producers must maintain delivery documentation for every load of FRC waste accepted and filler recycled from FRC waste to be used in the final product (i.e. polymer slab). Such documentation must include:

- date of supply;
- supplier’s name and contact details;
- waste description (its chemical composition, especially that waste doesn’t have any properties which could classify it as a hazardous waste) and customer specification;
- the name and contact details of the producer, including the address of the site of production;
- quantity supplied by weight/volume

[3] Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
[4] Aggregates for concrete

Where requested by the purchaser further documentation should also include (i) test results and procedures in accordance with the relevant standard or technical specification and for any further tests required to assess suitability for a particular end use; (ii) outline details of the Factory Production Control manual; and (iii) information on good practice relating to the storage, transportation and handling of aggregate.

Producer, must: (i) keep and retain specified records for a minimum of two years; and (ii) make them available for inspection by the regulator (if requested).

4.3.2. Storage of FRC waste and the filler recycled from FRC waste

Users of the waste and the filler from recycled FRC waste should take full account of any environmental impact resulting from its use. The filler which is regarded as having ceased to be waste, may need to be stored temporarily before its use in the production of polymer slabs. In the case that the material is being stored indefinitely with no certainty of use, the material will revert to being a waste and waste management controls will apply. Producers, distributors and users should follow good practice for the transportation, storage and handling of FRC waste and filler recycled from the waste.

4.3.3. Use of the filler recycled from FRC waste

The recycled filler must be destined for use in polymer based slabs. In the case of the other intended uses these must be assessed in the Quality Protocol.

4.3.4. Factory production control

Factory production control must be set up and needs to include:

- Quality control of waste acceptance;
- Other procedures covering evaluation of conformity requirements.

4.3.4.1. Waste acceptance criteria

To ensure only inert waste is accepted, the producer must develop ‘acceptance criteria’ specific to each site/location. The acceptance criteria must incorporate all statutory requirements relating to the receipt of incoming waste shall be observed and included in the Acceptance Criteria. These requirements include those arising from an environmental permit, waste management licence or a waste exemption, and the duty of care. The acceptance criteria must also include:

- a list of the types of waste that are accepted (including waste codes);
- source/place of origin of the waste;
- supplier and transporting agent; and
- method of acceptance.

Every load must be inspected visually, both on initial receipt and after tipping, to ensure compliance with the acceptance criteria. A procedure for dealing with non-conforming incoming waste must be set up, for example, rejection of loads, quarantine or disposal. Records must be kept of how the procedure has been implemented.

4.3.4.2. Production and testing

The manner in which processing equipment is maintained and adjusted during production must be defined. Input materials must be stocked in a controlled manner in clearly identified locations. Material taken from stock for processing must be checked for deterioration. Procedures must be in place and implemented to maintain the quality of the product during handling, storage, transport and delivery. Procedures for the use, control, calibration and maintenance of inspection, measuring and test equipment must be setup and followed. Equipment must be uniquely identified.

4.3.4.3. Training

All personnel must be trained on the FPC including:

- acceptance criteria;
- procedures for non-compliant input wastes and output products;
- sampling;
- testing; and
- inspection.

4.3.4.4. Records

Records of relevant controls and inspections, calibrations, changes and training must be maintained for a suitable period of time. This period must be defined. A Method Statement of Production (MSP) must be produced and maintained. The MSP represents the recovery process for the incoming waste and it is part of the factory production control. It must contain a description or representation of the production process for each product type including:

- input materials;
- equipment used; and
- actions undertaken at each stage from acceptance of waste to allocation to product stockpiles.

The filler must be produced to a recognised standard and/or specification. This specification will define the properties and characteristics of the product, as suitable for its application.

4.3.4.5. Documentation

Accompanying documentation inside the production line must:

- record the type of filler used in the production;
- state the batch in which the filler was produced.

Historical records of test results of the filler must be kept and/or made available as summary results (for example, a graph of test results over time).

4.3.4.6. Testing

Procedures for the use, control, calibration and maintenance of inspection, measuring and test equipment must be set up and followed. Equipment must be uniquely identified. A test plan for production of the filler must be defined that includes:

- the type of testing for each product; and
- sampling and testing frequency.

The test procedures must be appropriate to the end use of the filler, i.e. in the polymer-based slabs and testing frequencies must comply with the standards/specifications for the

slabs. Producers must have in place testing procedures to meet the testing requirements for each product. A summary of the frequencies required for the minimum testing requirements within the mainstream standards is provided in R9.WP3.2 (Quality Control Manual).

5. Conclusions

This deliverable specify the main building blocks of FRC-waste based circular business model developed and tested in the RETRACKING project complaining of mechanical recycling of FRC waste and production of polymer-based slabs with FRC-based filler and developed digital business ecosystem platform. The first part of the deliverable summarizes regional ecosystems for development of circular business models and main value chain characteristics (of existing linear and more sustainable circular one). It also includes main value proposition of new business model not only from the point of its economic value but also from social and environmental. One of the important advantage of such CEBM is its digital aspect and digital management of value chain, which enables more efficient and faster supply and value management. This is highly in line with the new concepts of digital economy.

The second part of the deliverable is focusing on End-of-Waste criteria and quality management of filler from recycled FRC waste to be used in production of polymer slabs.

What is important is to set appropriate technical specification according to which the filler can be tested and its waste status can be ceased. The filler in this case is only intermediate product for production of polymer-based slabs with its final intended use to be further developed in the RETRACKING project and beyond it. The following intended uses of the polymer slabs are currently assessed: cladding panels for internal and external use (e.g. according to EN 15286), panels for floors and stairs (e.g. EN 15285) and slabs for vanity and kitchen tops (e.g. EN 15388). This indicates that three out of four condition for a specified waste to cease to be a waste from European Waste Directive could be met. Much more important condition on the prevention of any adverse environmental or human health impacts must also be checked which should be specified by the regional or national legislation in the form of the limit values for pollutants.