paperChain

Reference framework for the circular economy models

D3.2 November 2017 (M6)

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ACRONYMS:

CE	**Circular Economy**
CBMI	**Circular Business Model Innovation**
ESG	**Environmental, Societal and Governance**
BM	**Business Model**
QA/QC,	**Quality Assurance / Quality Certification**
BMfS	**Business Model for Sustainability**
SD	**System Dynamics**

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Executive summary

Within the PaperChain project, the task 3.2 "A reference framework for new circular economy models" represents the second stage of the WP3 which aims at designing the novel circular economy models of the five circular cases developed within the project.

The main goal of the present Deliverable 3.2 is to provide 'A reference framework for new economy models'. This report follows up the information provided in D3.1- Analysis of the existing and emerging approaches of circular economy models in PPI in order to design a reference framework for companies that are interested in operating and obtaining business benefits from circular economy in a resource recovery scenario (industrial symbiosis).

These first two tasks have been aligned with the consecution of the expected results of this WP3 in the PaperChain project: design of five novel circular economy models. It is therefore proposed in this second task, a streamlined approach to help companies to identify the strategic goals & elements in each dimension that are most critical to their long-term strategy and where they can have most impact in creating a circular economy model that results in the reference framework for the PaperChain project described in this deliverable.

More specifically, this project report (D3.2) first describes the complete set of critical elements (influencing on the success of the circular economy models) that has been identified following an exhaustive literature review and based on the characterisation of the circular cases. In this respect, the deliverable benefits from the efforts that all partners devoted during the working session organized at the same time of the 1st General Assembly meeting, the 15th and 16th June 2017. Their excellent collaboration, before and after the working session, has helped us to accomplish with one of this report's objectives: the completion of the characterisation of the five circular cases. After the complete identification process (theoretical and empirical) all critical elements are clustered by six dimensions: circular business innovation, technology, economic and finance, social, environmental and legal.

Secondly, the interactions of those elements following a systemic approach in order to discover the role of each critical element in the complex system that forms a circular economy model are described. A System Dynamics casual diagram is developed showing the connection between dimensions and variables and the circular economy model represented by PAPERCHAIN project. The analysis showed that most of the conclusions form the theory can be translated into a causal diagram that allow us to better understand how some of the critical elements interplay together.

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The conclusions derived from such analysis are translated to the design process of the reference framework which depict the third step. We provide a definition of the reference framework according to the project's objectives:

"The Reference Framework for creating and implementing a circular economy model of industrial symbiosis stands for a structure that supports firms (or systems) in producing innovative and value added solutions (waste valorisation-based products) under a collaborative perspective. It encloses a collection various elements that provide orientation, guidance, support and a basis for communication. These elements can be used to model, plan, operate and control corresponding innovation projects on a CE basis."

Based on the definition, the essential elements that constitute the Reference Framework are portrayed in the following figure:

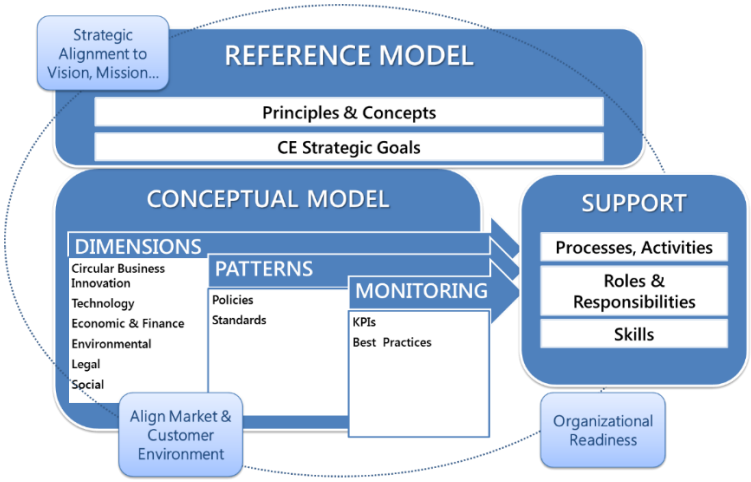

FIGURE 1: THEORETICAL PERSPECTIVE OF THE REFERENCE FRAMEWORK IN PAPERCHAIN PROJECT

The CE principles with regards to Industrial Symbiosis should enable firm/system to define the strategic goals of the circular economy model to be created form the reference model. Those strategic goals would be defined taking into account their alignment with the firm/system's vision, mission and objectives with regards to sustainability perspective. In the Conceptual Model, the dimensions, patterns and monitoring components necessary to fulfil the main objective of a circular economy model have been covered. Finally, since the appropriate configuration of processes, roles and responsibilities and skills or capabilities required to operationalize the circular economy model are quite relevant, it is required a third component that raises the support scheme.

The reference framework will be further improved through the testing process in the circular cases. A hands-on development of the reference framework for circular economy models in industrial symbiosis is needed. The conceptual approach has

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been overcome in this D3.2. Then, in the next task (T3.3) we are going beyond the conceptual recommendations and we will go a step forward throughout the adaptation of the reference framework to the five circular cases.

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1 Introduction

Research carried out through different perspectives enables an analysis of the existing and emerging approaches of circular economy models in the Paper and Pulp Industry. The results observed in the first deliverable of the PaperChain project (D3.1) pave the way for deeper analysis that would help to characterise the five circular models created in PaperChain. Such analysis, which starts in Task 3.2, should take into account those best practices for outlining the building blocks of the reference framework.

This deliverable represents the global result obtained as consequence of the activities performed in Task 3.2 which aims at developing 'A reference framework for new economy models'. Taking as a basis the work developed in the previous task 3.1 - Analysis of the existing and emerging approaches of circular economy models in PPI – this task has enabled creating a reference framework for companies that are interested in operating and obtaining business benefits from circular economy.

The main output of WP3 in the PaperChain project will be the novel circular economy models for the 5 circular cases. These first two tasks have been aligned to the consecution of the expected results of this WP3 as it is shown in the following figure (Figure 2).

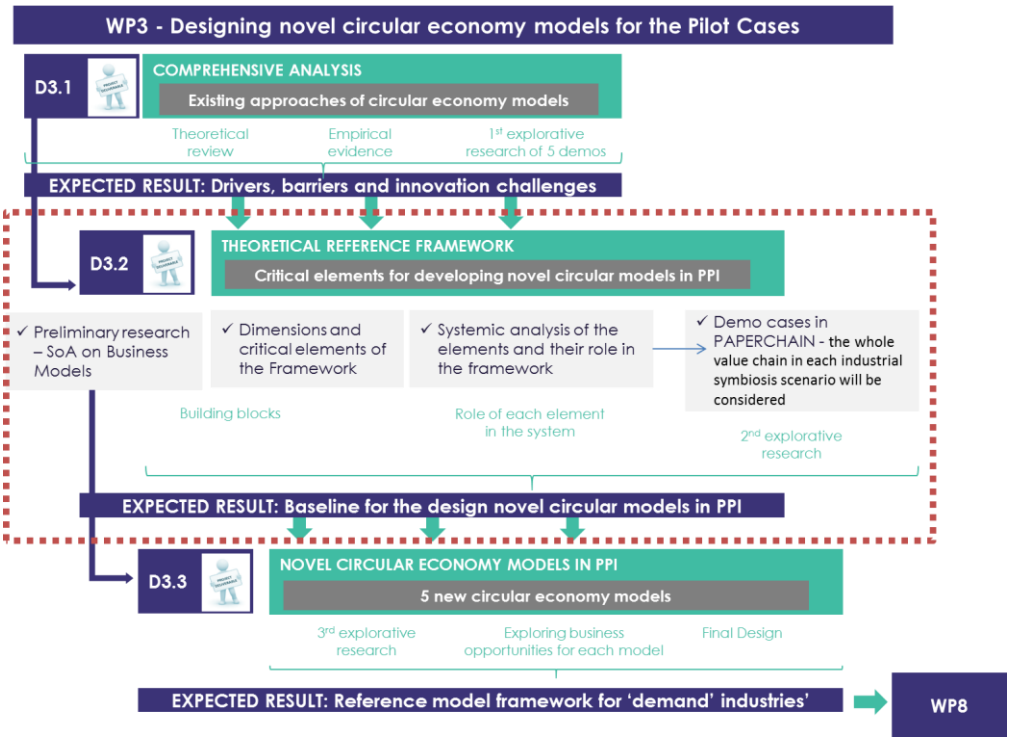

FIGURE 2: OVERVIEW OF WP3 TASKS AND THE POSITION OF DELIVERABLE 3.2

The activities of this task have been structured to address the following key challenges:

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- To obtain the second **characterisation of the five demo cases** - the whole value chain in each industrial symbiosis scenario will be considered in order to identify those critical elements that will take relevant influence on the success of the circular economy models. Those elements that have been empirically identified with the support of the key stakeholders involved in the demo cases will be translated to the framework.

- **To find in the literature other elements that will form the set of critical elements** that will be incorporated as components of the reference framework. A critical element concerns to being enough representative within the whole system, either enabling the success in the transition towards circular economy and constraining the operational and/or strategic processes of a circular economy model.

- To evaluate the **interactions** of those elements following **a systemic approach** in order to discover the role of each critical element in the **complex system that forms a circular economy model.**

- To develop a **reference framework with its components** that will allow designing the five circular economy models within PaperChain project.

Although circular economy has become a hallmark in the literature related to sustainability as an attractive alternative for businesses, the form in which its principles fit in the creation of new circular business models for companies is still incomplete. There are many case studies representing different circular business actions or models[1]. However, these models have limited transferability and they are not providing a comprehensive framework that enables companies the design of new circular business models in a practical way[2].

As described in D3.1, several case studies that represent successful examples of circular economy models can be found in literature and therefore, they should be explored and analysed for inspiring other players, other sectors or other geographical areas. We have also found in sustainability and business model innovation literature frameworks to assist companies in developing new circular business models[3]. Lewandowski (2016) develops an extended model of the popular Canvas Model and supplements it with additional components relevant to the circular economy: material loops and adaptation factors. Lewandowski's framework also includes the triple fit

[1] Ellen MacArthur Foundation. (2013). Towards the Circular Economy Vol. 1. *Journal of Industrial Ecology*, *1*(1), 4–8. http://doi.org/10.1162/108819806775545321

[2] E.g.: Lewandowski, M. (2016). Designing the business models for circular economy-towards the conceptual framework. *Sustainability (Switzerland)*, *8*(1), 1–28. http://doi.org/10.3390/su8010043

[3] Witjes, S., & Lozano, R. (2016). Towards a more Circular Economy : Proposing a framework linking sustainable public procurement and sustainable business models. *Resources, Conservation & Recycling*, *112*, 37–44. http://doi.org/10.1016/j.resconrec.2016.04.015

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challenge to implement a circular business model as a success factor. Witjes and Lozano (2016) proposed other relevant framework focused on the collaboration, which is a vital link between the public procurement process and the development of more sustainable business models. Their framework includes technical and non-technical specifications of product/service combinations that improve resource usage efficiency through recovery; socio-cultural specifications and physical and social proximity between the stakeholders in the procurement process.

Based on an exhaustive review of current advances in this field, this deliverable demonstrates that a comprehensive framework that allows companies to successfully design and implement new circular business models with the consideration of the entire value and supply chain is still needed including for instance: waste production (Paper and pulp) industry, waste treatment and recovery, product manufacturing and end-users of the products (industrial representatives of each sector).

The reference framework developed in PaperChain has been based on a streamlined approach to help companies identify the strategic goals & elements in each dimension that are most critical to their long-term strategy and where they can have most impact in creating a circular economy model.

Moving from the analysis of literature, we provide a conceptual structure depicting the current situation of literature dealing with the management of 'Circular Economy Model'. A Reference Framework for Circular Economy should provide a common baseline for delivering suboptimal business value in circular economy (Figure 3).

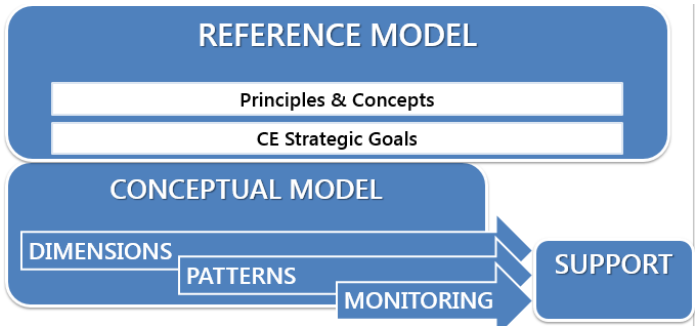

FIGURE 3: BASELINE OF THE REFERENCE FRAMEWORK FOR CIRCULAR ECONOMY MODELS (SOURCE: PAPERCHAIN RESEARCH TEAM)

An appropriate reference framework serves as a useful tool for the company's decision makers to operate optimally in circular economy where all stakeholders of the value chain will obtain their expected benefits. Moreover, it shall deliver a methodological structure, concerning guidelines, methods and tools as well as managerial recommendations according to the conceptual structure. Such a practical approach will be further developed in Task 3.3 through the adaptation to

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the PaperChain's sceneries (in Task 3.3). The main aims of the Reference Framework for circular economy models must be set up as follows:

- To identify the optimal circular economy model and its business strategies according to the sustainability strategies of the company;
- To define sustainable business models that provide value to stakeholders, society and environment;
- To establish (and define) the necessary key competences (internal & external) for operational and business perspectives cohesion in a circular economy model;
- To support managers in ensuring that all the stakeholders of the value chain are able to provide the key competences throughout the processes;
- To provide a reference tool to facilitate all stakeholders' efforts towards commonly agreed objectives.

2 Characterisation of the Demo Cases

As mentioned in the Introduction chapter (see Figure 2) the explorative process of circular cases initiated in the previous task (Task 3.1) continues in this step, in order to set up the basis for a generic characterisation of the circular economy models they represent.

This chapter describes the second iteration of such a process which takes a step forward regarding three key aspects that shape the characterisation of the circular cases: critical elements, global value chain and lean business canvas. That process has been developed in cooperation with the main partners involved in the circular cases to provide relevant information according to the objectives established for the current task. Throughout the following paragraphs each circular case is described providing firstly, the main critical elements identified; secondly, portraying a complete picture and description of the whole value chain that represents the circular case; and finally, showing a business model that the circular case characterises from a system perspective.

2.1 List of criteria specific for the 5 demo cases

In this subsection, a list of the main critical elements belonging to the five circular cases has been elaborated. A specific questionnaire was elaborated and used in each interview to gather the information from all partners involved in the circular cases (see Annex 1). The questionnaire encompasses a group of questions focused on identifying

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the critical elements of each of the following 7 dimensions: technical, organizational, business innovation, economic & finance, legal, social and environmental.

The data gathering process was completed with two additional information sources:

- Data concerning technical, legal and environmental dimensions from the information available in 'D2.1-Baseline Report: PPI waste streams valorisation potential'.
- Complementary information was received from partners during the working session that was held in November 2017 taking advantage of the General Assembly meeting (17th November 2017) (see Annex II). In that working session, all partners were grouped by circular case. The time for discussion was devoted to the data concerning organisational, financial and economic and business innovation elements. They were requested to provide feedback in three ways: (1) describing in a more qualitative way the barriers or drivers per each dimension; (2) providing practical feedback from his own experience in previous / on-going projects; (3) identifying tools or methods or capabilities missing that would support the transition to CE

All the answers from the interviewed partners have been processed and grouped in the following tables which show the global list of critical elements identified amongst the five circular cases. It is worthy to mention that in some cases, the critical elements affect the system as a whole, not individually to the stakeholders involved.

TABLE 1: LIST OF CRITICAL ELEMENTS IDENTIFIED IN CIRCULAR CASE 1- PORTUGAL

Dimensions	Critical Elements	Previous experience & Methods or tools that will facilitate the CE transition
Technical	The implementation of new process to meet the required quality standard	
Environmental	The radius under which the solution is environmentally advantageous compared to classic solutions Tons of landfill avoid per year: considering 1 mill site, and considering the application of all the dregs/grits produced, about 4500 tons/year	
Social	No local opposition identified so far Creation of job (transport and processing raw materials)	

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Dimensions	Critical Elements	Previous experience & Methods or tools that will facilitate the CE transition
Legal	Authorisation license delivered by a certification body to enable the use of the products created The status over the utilisation of waste as a new raw material	
Economic & Finance	The radius under which the solution is economically advantageous compared to classic solutions No subsidies from local government	
Organisational	Availability of wastes all in good time Capacity of stocking wastes The strong relation among the stakeholders The geographical proximity of the stakeholders The potential involvement of a waste manager which take care of the transformation process	Experience from previous circular economy project
Business Innovation	Other circular economy projects based on other process streams and products are ongoing	

TABLE 2: LIST OF CRITICAL ELEMENTS IDENTIFIED IN CIRCULAR CASE 2 – SPAIN

Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
Technical	Too large testing process at demo site - iterative process until the optimum solution is achieved Diverse availability of waste (WPA) and quality of recycling material Supply of waste is limited by nearness of the waste manager to PPI Availability of special equipment for ash mixing and metering	Experience of ACCIONA Construction in road and highway construction Detailed economic studied needed to see the economic viability of having WPA warehouses at different strategic locations.

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Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
Environmental	There could be some potential risks which needs to be studied in detail and analysed, for e.g.: (i) contamination of soil by rain water after getting mixed with the chlorides present in the new product, (ii) the dry particle of the new material being very light in weight can float in air during transportation or handling and settle down over the plants and crops, which would later have a detrimental effect on them.	Prior experience and expertise with road binder formulations. Transporting as per respective environmental regulations Ground and superficial water monitoring campaign. Best practice document needs to be developed by the Waste manager for the logistics and construction company.
Social	Initial resistance is expected because Construction has always been a conservative industry in terms of new materials, methodology and technology implementation.	Appropriate dissemination of the positive impact resulting from this innovation will help gain target stakeholders attention and acceptance,
Legal	We are not allowed for the production and commercialisation of WPA as a "by-product" generated after recycling of a waste product,	Permissions could be obtained after modification of the WPA by addition of some performance enhancing additive and demonstrating the social, economic and environmental benefits to the respective legal authorities.
Economic & Finance	Major up-front investment costs (for the waste manager) Considerable amount of cost involved for on-site machine modifications.	More financial and economic incentives at national, regional and local level could motivate the stakeholders for its usage.
Organisational	In this case, the waste manager coincides with the seller of the end product -it is an advantage Existing departments that facilitate the stakeholders search strategy Strong relationship with stakeholders Lack of awareness or impulse from PPI side	Experience from on-going Circular economy projects.

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Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
Business Innovation	Limited initial awareness of the positive impact of the CE model in road and highway construction	Preference should be given by the client to companies (potential vendors) using CE model.

TABLE 3: LIST OF CRITICAL ELEMENTS IDENTIFIED IN CIRCULAR CASE 3-SLOVENIA

Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
Technical	Homogenisation of the new recycled material (composite MUDIPEL) at the construction site could find some difficulties. **Climate conditions** will affect the Thaw/freezing resistance of components **at the construction site**. In the laboratory special care was put on these tests.	Paper ash is difficult to mix with the water at the construction site without **special equipment.**
Environmental	Recycled material will replace the natural aggregate which will contribute to the lower CO2 emission for the whole construction	
Social	The use of new geotechnical structure for landslide support could increase the number of employees in the Slovenian railway (SZ) company, which produces gabions.	
Legal	**Absence of specific norms -** Legal approval before implementation is needed **Delay**	**Guarantee previous expertise from stakeholders** - The supplier already has one Slovenian Technical Approval (STS) for similar product.
Economic & Finance	**Major up-front investment costs** (for the construction phase; the cost of homogenisation and mixing of material at the construction site). Until now we have a plan to use a small mixing machine at the construction site or at the VIPAP facility.	**Large mixing** at the construction site increases the cost of the structure, however it speeds up the process itself.

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Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
Organisational	**Processes engineering** at waste manager is needed.	
Business Innovation	**Consciously awareness** of the advantages in terms of competitive advantage the CE model will provide to the stakeholders.	Best practise case has a positive influence on the stakeholders' decision about using the recycling material for the geotechnical structures.

TABLE 4: LIST OF CRITICAL ELEMENTS IDENTIFIED IN CIRCULAR CASE 4 – CHEMICAL (SWEDEN)

Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
Technical	Technical challenges are mainly linked to the **scale-up of the technology** Hydrolysis of fibre sludge for fermentation to ethanol Production of NaOH and HCl (a supplier of NaOH and electrolysis technology is required)	Experience of Sekab and Processum as a research institute for the scaling of technologies Production of ethanol from hemicellulose by Domsjö already at industrial scale 3 suppliers of both NaCl and electrolysis technology identified so far
Environmental	The circular model will replace another product imported by train → less environmental impact due to less transport Final product Bermocoll will be produced using EtCl from renewables and not from fossil-fuel-based chemicals	All the stakeholders are neighbours → no transport required Reduction of carbon footprint
Social	If the circular model reaches the industrial scale, Sekab may create numerous jobs Sekab employees are pretty used to shift their business so no difficulties regarding change management is foreseen.	

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Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
Legal	Legal authorisation required to be allowed to use or produce in large amounts some new chemicals (HCl, H2, Cl2) in the industrial site	Companies are used to handle chemicals
Economic & Finance	Large investment cost to produce at an industrial scale EtCl to be used in the production of Bermocoll EtCl produced by Sekab should be less expensive or in the same range as the product sold by the German supplier Improved security of supply of sustainable EtCl for AkzoNobel (currently only one producer of EtCl in Europe) Opportunity for Sekab to commercialise a new product	Economic analysis to be discussed in WP8 Relying on another technique as other advantages than only economic (Cf organisational)
Organisational	Domsjö needs to get rid of the fibre sludge → not allowed to use as landfill Find a supplier of NaCl and arrange with transportation and storage	All the main stakeholders are neighbours and have a long history of collaboration Domsjö has a production plant of EtOH that uses hemi cellulose as a raw material
Business Innovation	It can be interested to transfer the technology producing EtCl from EtOH The coproduction of NaOH when producing HCl is a potential business opportunity, Akzo and Domsjö already use NaOH in their production	Other alcohols can be used in the chlorination step, thus producing alternative derivatives, which would increase the market

TABLE 5: LIST OF CRITICAL ELEMENTS IDENTIFIED IN CIRCULAR CASE 5 – MINING (SWEDEN)

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Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
Technical	The waste' (GLDs) properties variation (especially its water content and its water absorption capacity) for each mill influences the packing properties of the sealing layer. Also different mills have different chemicals used in the process as well as different de-watering processes. These factors influence the properties of the produced GLS and also the properties (e.g. Permeability) of the final product (sealing layer) There is not yet a standard "GLD product", thus there is not a product specification, data sheet, etc. Each mill generates different GLDs qualities due to different the pulp processes. Mining waste Capping layer is composed of a mix of Till (natural material) and GLDs (10% approx.). For the capping layer construction there is a window for application (drive by Till substitution % vs. Fines content), that must be considered. Other components dependency: Till material can be heterogeneous itself, and must be well known and controlled.	GLD characteristics and critical parameters are well known due to previous research and experiences. Upgraded procedures (GLD treatment-de-watering, storage), and **optimum Quality Control (testing), will be implemented.** Standardization of GLDs as product may suppose the acceptation of a "range" of specific qualities instead a fixed close quality. Most of the paper mills produce GLD within this "range" during normal production. Previous research developed procedure to determine the optimum application window for the mix. On-site mixing control procedures are necessary to guarantee quality. Till is a well-known material used in construction in Sweden (it requires an optimum grainulometry and moisture control) Other materials with similar properties (silt and sandy soils) are available A good knowledge of the available resources (soils) around the mine is necessary.

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Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
	Till is only available in previous glaciar sites, so there is a geographical limitation in EU. Supply of waste and till is limited by nearness of the waste manager to PPI. Application cannot be deployed for slopes steeper than 1/3, due to landslide risk. Layer hydraulic conductivity< 10-08 m/s. Raw materials transportation, mixing and layer compaction needs specific machinery and specialised company.	Max. slope must be specified through several tests. Failure experiences will be taken in account. Technical requirement by local legislation. Permeability tests will be stablished. Previous research experiences demonstrated achieving low conductivity values. Specific machines for this DEMO are available on the market, as these are used by the mining companies. Though, some modification will be necessary. There are solid previous experiences with handling, mixing and compacting this GLDs+Till mixture.
Environmental	Green liquor dregs (GLD) are classified as non-hazardous waste. No unacceptable Risks for humans and environment must be granted, during construction works and for long-time application use.	Waste / raw material" condition will be obtained when employed in this application. Quality and best practices guides can be shared among implied construction partners, based on previous experiences. Waste characterization, and groundwater and Superficial water monitoring campaigns and Risk Assessment for humans and ecosystems. Common in EU Standard Risk Assessment methodologies will suggested.
Social	No social critical elements are foreseen for this demo case.	A correct dissemination of the benefits of this application (waste reduction) and obtained results (performance) will help on a better

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Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
		acceptance by public and may avoid opposition against using waste origin materials in construction.
Legal	Specific Authorization is needed when GLDs are used. There is not a specific regulation for the use of GLDs in construction works. Constructive requirements defined in local regulations for capping. For example, hydraulic conductivity <10-08 m/s. Legal barriers can be of very different nature depending on the selected country in EU.	Specific Authorization will be requested, by submitting a Case project. Mine site reclamation as general framework. No issues are expected according to previous experiences. Implementation and following-up of the technical requirements for capping layer construction, by implementation of the QA/QC for the construction and verification of the Layer suitability and performance (strength, permeability, deposits leachate control, etc.). For Case 5 reproducibility a specific analysis should be done for each country of interest.
Economic & Finance	Major up-front investment costs (for the waste manager and layer construction). Landfilling is still "cheap", since there is not of application any landfilling tax to GLDs. But this scenario may change in the future. GLD transportation may increase the costs due to its lower density comparing to till material. It may risk the competitiveness of GLD use comparing to till transport.	There is a need to have specialised skill and adapted machinery for GLDs handling and compaction. New tax on GLD landfilling could drive a more intense GLDs research, use and acceptance as construction material in mine deposits capping, and push PPI/mining sector to apply for a more intense CE marking. Loss of competitiveness of the GLD transport can be compensated by a constant GLD availability and considering the overall cost/benefit

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Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
		balance analysis (layer better performance, and potential future landfilling taxes).
	GLD and GLD+Till mix Effective Quality Control. Increase of costs and time. These costs summarized have to be lower than commercially available bentonite till mixtures.	It will be implemented an efficient QA/QC in order to assure the optimal GLD and GLD mix qualities, and minimize the control costs, so, the valorisation process will not economically uncompetitive respect to standard materials.
	Long term Environmental Monitoring costs.	As long as new application long-term impact monitoring results are gathered and better knowledge is obtained, monitoring campaigns can be more safely and effectively designed and therefore, save costs. Monitoring costs Layer design may be improved based on such data, and thus, application acceptance.
Organisational	Waste manager is the unique specialised company in handling and compaction of GLDs. It may suppose a risk and a high dependence on this company (Ragnsells), since its role in this Demo Case is crucial.	Alternatives to be searched to minimize risks for contract/company failures. Dissemination of the experiences and good practices handling GLDs for increasing providers in EU.
	Communication issues between parties. Need to identify clearly responsibilities, objectives and activities.	Previous experiences in this type of applications involving the same parties will facilitate the communication. Implementation of a Communication Plan.
	Existing departments that facilitate the stakeholders search strategy Strong relationship with stakeholders	

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Dimensions	Critical elements	Previous experience & Methods or tools that will facilitate the CE transition
	Lack of awareness or impulse by PPI side	
Business Innovation	Limited initial awareness of the positive impact of the CE model to the company	

2.2 Value Chain specific for the 5 demo cases

In this second deliverable of WP3, we would like to go further in the **understanding of the ecosystem of each circular case**. For this purpose, partners were requested to provide a complete picture of the value chain. Value chain, as the names implies and in a simple way, is a set of activities that focuses on creating or adding value to the product. Supply chain, is the integration of all the activities involved in the procurement, conversion and logistics of the product. Even tough, Value chain and Supply chain are complementing and supplementing each other, and sometime juxtaposed, we would here use the term "Value chain", covering both the Value and Supply chain, for explaining the flux between the key-stakeholders. The value chain will be described based on:

- **Identifying the stakeholders** that could be involved at any moment of the development of the project: site approval, suppliers, transport company, quality insurance, legal representatives, etc. as well as explaining their role.

  Stakeholders, depending upon their importance, role and actions, could be classified under two categories: a) direct or key-stakeholders; and, 2) indirect stakeholders.

- **Defining the flux between the stakeholders.** The flux between stakeholders could be classified as:

A) Depending upon the type:

- **Information flux** (movement of product data sheet, transmitting orders, production schedules, quality reports, inventory reports, dispatch schedules, financial reports etc.)
- **Material flux** (or product flow, is the movement of a product from a supplier to the customer)
- **Financial flux** (movement of revenues from the customer to supplier)

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- **Value flux** (movement of a material from one point to another as it gains value before reaching the final customer) &
- Risk flux

B) Depending upon stakeholders involved:

- **Internal flux** (flow of material/information/finance/value/risk etc. within the organization or with inside-stakeholders)
- **External flux** (flow of material/information/finance/value/risk etc. outside the organization or with outside-stakeholders)
- Adding **external actors** that will be involved in the circular cases

The following pictures and paragraphs describe the complete value chain of the five circular cases.

Value Chain of Circular Case 1

Key stakeholders:

Key stakeholders for circular case 1 are:

- Paper Company

  The Navigator Company: produces dregs/grits and lime mud as wastes for the production of paper

- Waste manager

  To be determined during the project: responsible for the transformation of the wastes into new raw material and the logistic among the stakeholders

- Road construction company

  Megavia: construction SME responsible for execution of asphalt pavements. The company incorporates grits and transformed dregs as replacements of classic aggregates in bituminous mixes road construction

- Construction company

  Spral: concrete products manufacturing SME. The company intends to use lime mud present in paper wastes as a mineral aggregate in cement-based-mortars for the building industry

- Research & Development centre

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University of Aveiro: responsible for the technical development of the solutions (characterisation, calculation, modelling, testing) and the coordination of the demo cases.

- Certification bodies

  Commission of Coordination and Regional Development and **ANR (Wastes National Authority)**: responsible for the standard procedure for simplified licensing of waste management operations in Portugal

- **Infrastructures of Portugal (Portuguese road authority)**: approved the utilisation of grits and transformed dregs as replacements of classic aggregates in bituminous mixes road construction

- Technical centres

  National Civil Engineering Laboratories: provide technical support to specify the features of the solutions produced and authorizes its utilisation in the building sector

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Flux between key-stakeholders

The following figure shows the stakeholders involved in circular case 1 of PaperChain project including the main fluxes between them:

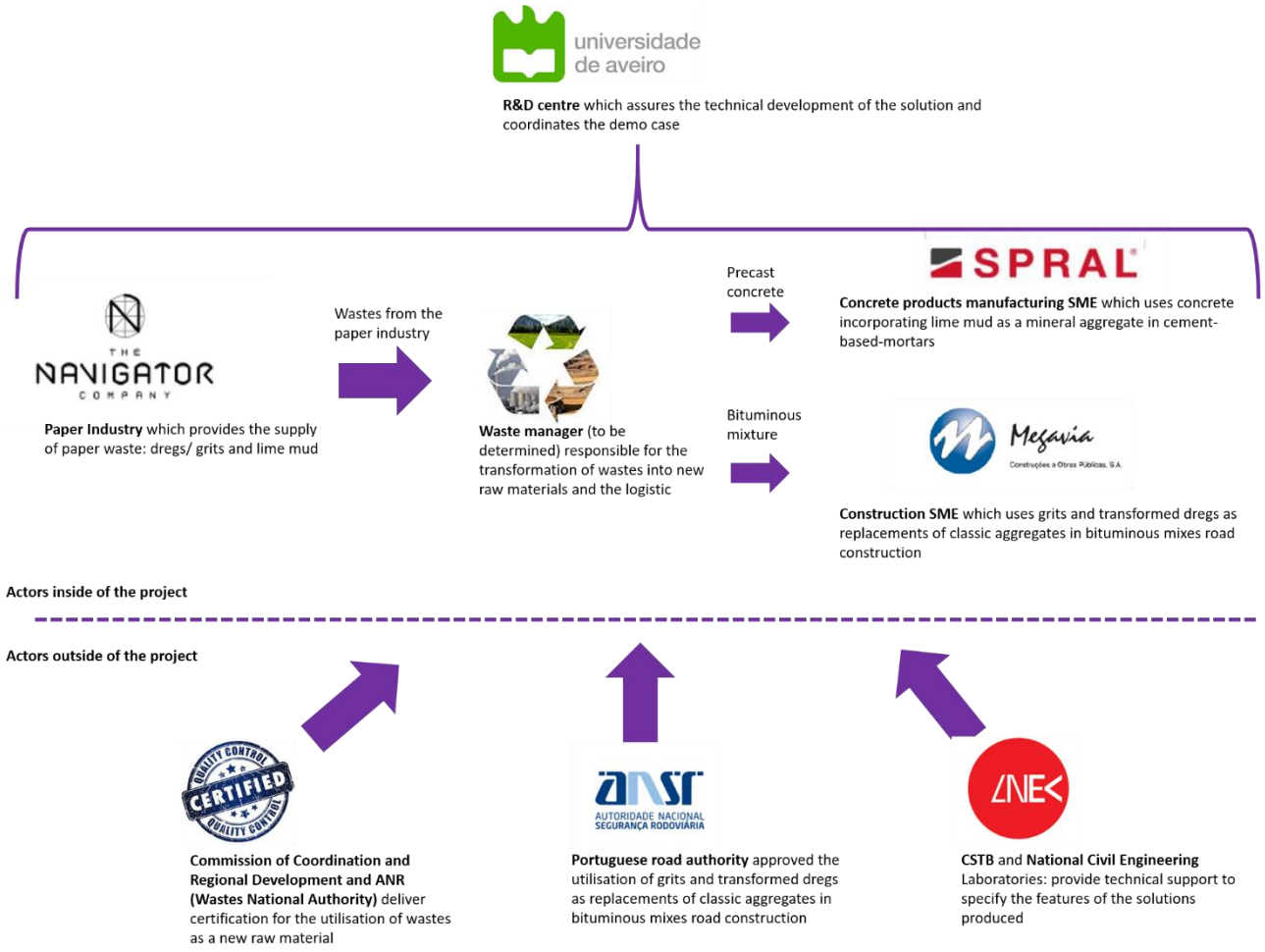

FIGURE 4: VALUE CHAIN OF CIRCULAR CASE 1

The next section details the "Material & Value" and "Information" flows among the stakeholders.

Material and Value flows:

The Navigator Company

The different wastes – dregs/grits and lime mud – resulting from paper fabrication have the potential to be valorised on condition of being proceeded and eventually transformed by a waste manager.

The wastes are sent to a waste manager on conditions to be determined and negotiated.

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Waste manager

After collecting the wastes, the waste manager carries out the different pre-treatment processes, if required, for the transformation of dregs/grits and lime mud in new raw materials. Once processed, these raw materials are delivered to Megavia and Spral respectively, on conditions to be negotiated.

Spral

The lime mud is used as a mineral aggregate in cement-based-mortars for the construction production activity of the company.

Megavia

The grits and transformed dregs are used as replacements of classic aggregates in bituminous mixes for road construction.

Information flows:

Some of the information which flow in (IN) and out (OUT) from each stakeholder are:

The Navigator Company (NC)

- (OUT) Dregs/grits delivery status
- (OUT) Lime mud delivery status
- (IN) Wastes quality status from (WM)
- (IN) Quantity of wastes needed by (WM)
- (IN) Status of payment made by (WM)

Waste manager (WM)

- (IN) Dregs/grits delivery status from (NC)
- (IN) Lime mud delivery status from (NC)
- (OUT) Quantity of wastes needed to (NC)
- (OUT) Wastes quality status delivered to (NC)
- (OUT) Payment of wastes delivered (NC)
- (OUT) Quality status of the processed wastes to (UA), (CCDR) and (ANR)
- (IN) Technical adjustment delivered by (UA)
- (IN) Authorization to use the wastes as new material from (CCDR) and (ANR)
- (OUT) Transformed dregs/grits delivery status to (SP)

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- (OUT) Lime mud delivery status to (MG)
- (IN) Status of payment made by (SP)
- (IN) Status of payment made by (MG)
- (IN) Product quality status from (SP)
- (IN) Product quality status from (MG)

Spral (SP)

- (IN) Lime mud delivery status by (WM)
- (OUT) Quantity of lime mud needed to (WM)
- (OUT) Payment of lime mud delivered (WM)
- (OUT) Final product quality status to (WM), (UA) and (Infraestructuras de Portugal)
- (IN) Technical adjustment delivered by (UA)
- (IN) Authorisation to use the final product delivered by (Infraestructuras de Portugal)

Megavia

- (IN) Dregs/grits delivery status by (WM)
- (OUT) Quantity of dregs/grits needed to (WM)
- (OUT) Payment of dregs/grits delivered (WM)
- (OUT) Final product quality status to (WM), (UA), (LNEC or ITECONS)
- (IN) Technical adjustment delivered by (UA)
- (IN) Authorisation to use the final product delivered by (LNEC or ITECONS)

University of Aveiro (UA)

- (IN) Waste quality status from (WM)
- (IN) Final products quality status from (SP) and (MG)
- (OUT) Technical adjustment delivered to (WM) (SP) and (MG)
- (OUT) Technical status of the products delivered to (CCDR) and (ANR)
- (IN) Technical endorsement delivered by (CCDR) and (ANR)

Commission of Coordination and Regional Development (CCDR) and (ANR) (Wastes National Authority

- (IN) Quality status of the processed wastes delivered by (WM)

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- (OUT) Authorization to use the wastes as new material to (WM)
- (IN) Technical status of the products delivered by (UA)
- (OUT) Technical endorsement delivered to (UA)

IP, SA (Portuguese road authority)

- (IN) Final product quality status delivered by (SP)
- (OUT) Authorisation to use the final product delivered to (SP)

LNEC or ITECONS

- (IN) Final product quality status delivered by (MG)
- (OUT) Authorisation to use the final product delivered to (MG)

Value Chain of Circular Case 2

A Road construction project, due to its temporary and complex nature, has many challenges and restrictions inextricably tied to it. The entire road construction project involves management of several independent projects, which could mean a diverse set-of-portfolios of stake-holders, value & supply chain and business model.

Key stakeholders:

- Paper waste collector

SAICA Natur (SR): responsible for paper waste (PW) collection,

- WPA Supplier

SAICA recycling facility (SRF): responsible for, using PW for producing energy, collecting and supplying fly ash (WPA) that is being generated during the energy production process,

- Logistics Company

ACCIONA logistic services (ALS): responsible for transporting the PW, WPA & processed WPA (p-WPA),

- Waste Manager

ACCIONA facility services (AFS): responsible for valorization WPA by processing it into p-WPA,

- Construction Company

ACCIONA Construction (AC): responsible for usage of p-WPA for road construction,

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- Spanish Environmental Management Institute -SEMI

INAGA: approving/qualifying authorities for the usage of WPA (residues from PPI) for the infrastructure projects like Road and highway construction.

- Government authorities (GA):

National level: *Spanish Ministry of Public Works*: Spanish public authority that will support the Spanish demonstrator activities at national level

Regional level: *General Roads Directorate of Aragón province-Aragon Director General of Transport & Mobility*: Spanish public authority, responsible for supporting the Circular case 2 at regional level.

Local level: *Morata de Jalon, Villamayor & Burgo de Ebro municipalities*: Spanish public authority, responsible for providing the site (1km long country road) to implement the demonstration activity.

- Non-governmental organizations (NGOs)

Ecologists, local people, farmers, etc. -as they could interfere in the usage of p-WPA as a HRB.

Flux between key-stakeholders

The following figure shows the stakeholders involved in circular case 2 of PaperChain project including the main fluxes between them:

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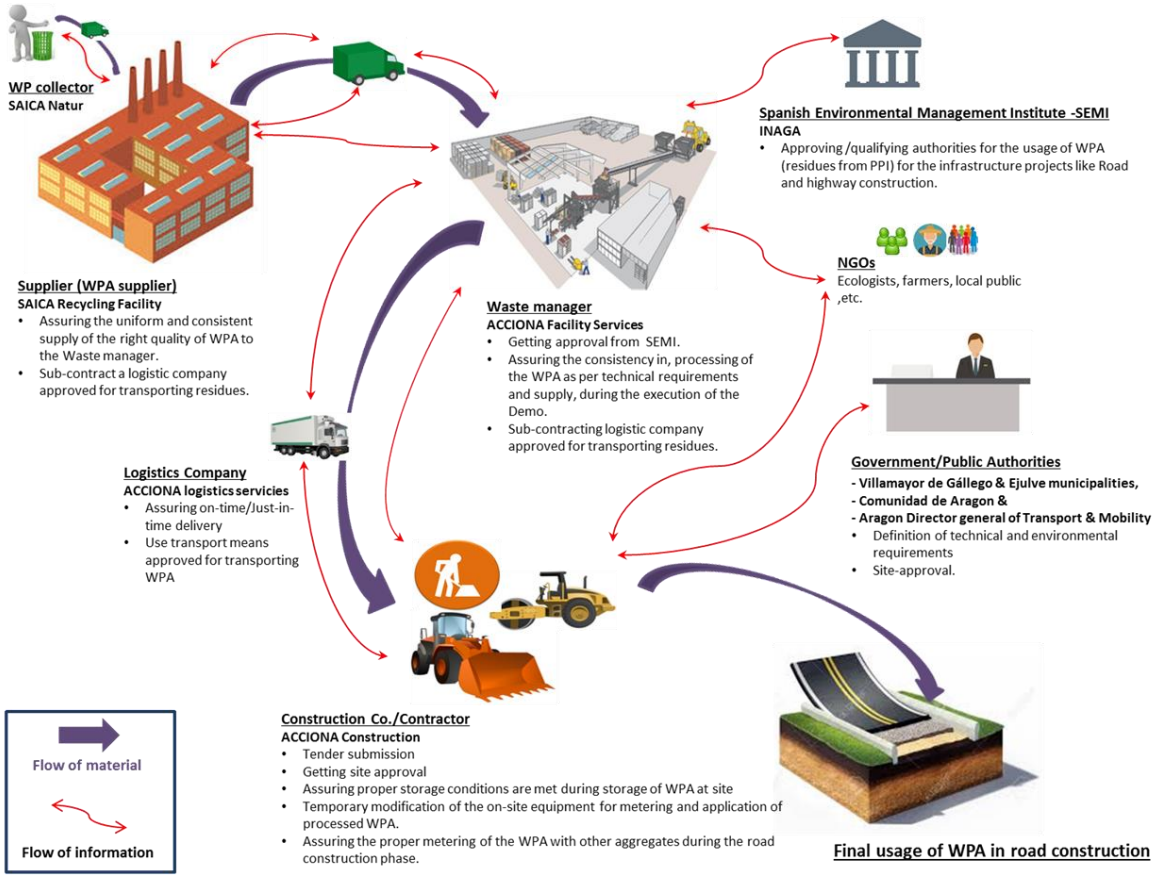

FIGURE 5: VALUE CHAIN OF CIRCULAR CASE 2

In current scenario, for circular case 2, we will see in detail, the following two types of flux/flow: Material & Value flow and Information flow (among external-stakeholders).

- Material & Value flow:

SAICA Natur (SR):

Through its network of waste paper collectors (distributed at predetermined locations at national level), collects the paper waste and delivers it to the SAICA Recycling facility. Before the delivery, SR ensures that the waste paper is free from plastics/steel or other unwanted materials (however, some traces of these unwanted materials in paper waste are unavoidable).

SAICA Recycling facility (SRF):

Receives this paper waste and use it as a fuel, by burning it, for heat generation. This heat is used for different internal production processes. The residues generated as a result of burning waste paper are Bottom and Fly ash (WPA). SRF on receiving a

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demand/purchase order for WPA from AFS arranges the transportation and delivers it to AFS facility. Before delivery, SRF ensures that this WPA is free from foreign materials.

ACCIONA Facility services:

AFS on receipt of WPA, allocates a specific batch number to it. Later, laboratory test on random samples taken from the respective batch are performed to know the chemical composition of the WPA received. Depending upon the customer requirements (AC in this case), AFS decides on next treatment processes to be performed on this WPA, so as to ensure that the treated/processed (p-WPA) meets AC specifications. Each time WPA passes through a treatment process, a quality test is performed and a respective lot number is allocated to this p-WPA. These batch and lot numbers are used as a reference for further communication and traceability.

The p-WPAs are later packed in plastic bags. The plastics bags are tagged with RFIDs (Radio-Frequency Identification devices) and stored in a conditioned warehouse.

ACCIONA logistics services (ALS) Construction:

AC or AFS contracts ALS for collecting the p-WPA from AFS facility and delivering it to the site where it will be used as a Hydraulic Road Binder (HRB), thereby substituting (partially or completely) cement or lime required for road construction.

ACCIONA Construction (AC):

AC on receipt of p-WPA, performs quality control/checks, on the in-coming/received p-WPA, as per the relevant standard and norms and ensures that it meets the acceptance criteria. Once, it is ensured that the received p-WPA is having the desired properties, it is then sent to the laboratory where additional tests are performed in order to obtain the optimum mix ratio (p-WPA with other site materials like sand etc.) which could meet the technical and environmental specifications of the client (Road authorities in this case). Since, this mix formulation could vary depending upon the local site condition and material availability, hence, a unique formulation number is assigned to this mix, in-case of future reference and traceability. After assignation of a unique identification number to the mix formulation, the formulation/mix is communicated to the site, so that the p-WPA could be used in road construction as a HRB.

We have seen the "Material and Value" flows downstream (from SAICA Natur—waste collector through SAICA Recycling--WPA producer till Road Constructor—ACCIONA construction for final usage)

- Information flow

Some of the information which flow in (IN) and out (OUT) from each stakeholder are:

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SAICA Natur (SR):

- (IN) WP demand receipt from SRF,
- (IN) WP delivery status from ALS (for e.g.), regarding the status of the WP delivery from SR to SRF,
- (IN) status of the payments made by SRF against the receipt of WP,
- (OUT) based on the information received from the logistics company, SR communicates the delivery status to SRF &
- (OUT) status of the payment made to the logistics company, against their transportation services (SR to SRF), etc.

SAICA Recycling facility (SRF):

- (IN) WPA demand receipt from AFS,
- (IN) WPA delivery status from ALS (for e.g.), regarding the status of the WPA delivery from SRF to AFS,
- (IN) status of payments made from AFS against the receipt of WPA,
- (OUT) WP demand request to SR
- (OUT) based on the information received from the logistics company, SRF communicates the delivery status to AFS
- (OUT) status of the payment made to the logistics company against their transportation services (SRF to AFS), etc.

ACCIONA Facility services (AFS):

- (IN) p-WPA demand receipt from AC,
- (IN) p-WPA delivery status from ALS (for e.g.), regarding the status of the p-WPA delivery from AFS to AC,
- (IN) status of payments made by AC against the receipt of p-WPA,
- (OUT) WPA demand request to SRF,
- (OUT) based on the information received from the logistics company, AFS communicates the delivery status to AC,
- (OUT) status of the payment made to the Logistics Company against their transportation services (AFS to AC),
- (OUT) chemical composition, quality control and process reports to SEMI (INAGA in this case) and AC &

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- (OUT) project proposal to SEMI (INAGA, in this case), explaining the usage of p-WPA as a by-product.
- (IN) letter of approval or certificate for use as a by-product, from SEMI (INAGA in this case)
- (OUT) benefits (like efficient natural resource utilization, reduction in GHG emissions, increase employment opportunities etc.) obtained through the value added to the WPA is communicated to various NGOs, etc.

ACCIONA Construction (AC):

- (IN) tender approval notice or road construction contract from GA.
- (IN) p-WPA delivery status from ALS (for e.g.), regarding the status of the p-WPA delivery from AFS,
- (IN) definition of technical and environmental requirements from GA
- (IN) approval of site from GA, for p-WPA usage.
- (OUT) status of road construction project to GA,
- (OUT) report on the usage of p-WPA to GA,
- (OUT) status of the payment made to AFS against the receipt of p-WPA,
- (IN) status of payment received from GA against the completion of the road project
- (OUT) benefits (like efficient natural resource utilization, reduction in GHG emissions, new employment opportunities for local people etc.) obtained through the value added to the p-WPA is communicated to various NGOs, etc.

We have seen that the "Information" flows both upstream and downstream, depending upon the individual need.

Value Chain of Circular Case 3

Key stakeholders:

- Paper waste collector and WPA Supplier

VIPAP Videm Krško: responsible for using paper waste (PW) for producing energy, collecting and supplying deinking paper ash (WPA) that is being generated during the energy production process and supplying deinking paper sludge.

- Construction Company

Dusan Holesek (DH): responsible for construction of retaining wall for slope stabilization. Transport material from VIPAP to construction site.

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- Notify body for Slovenian Technical Approval

ZAG; Service for Technical Assessment and Approvals: Approving the Technical Approval request (STS). The Ministry of the Economy, by Decision No. 3210-9 / 2002-23 of 20 December 2006 declared ZAG as the Body for Technical Approvals. In accordance with Article 22 of ZGPro-1 (the Slovenian Law on the Construction Products), ZAG continues to be nominated as the Slovenian Technical Approval Authority.

- Infrastructure operator

Slovenian railway (SŽ); Accepted a geotechnical design project with use of recycled material as a backfill material between the slope and gabions. Infrastructure operator will determine the location of the demo case in Slovenia.

- Non-governmental organizations (NGOs)

Ecologists, local community, etc. -as they could interfere in the usage of WPA and WPS.

- Laboratory

ZAG; Departmen of Geotehnics and Traffic Infrastructure: Department of Materials. As a research institute ZAG has accredited laboratories for testing the recycled material in a phase of the applying STS documents and performs a Third part control of the whole geotechnical structure at the construction site.

Flux between key-stakeholders

The following figure shows the stakeholders involved in circular case 3 of PaperChain project including the main fluxes between them:

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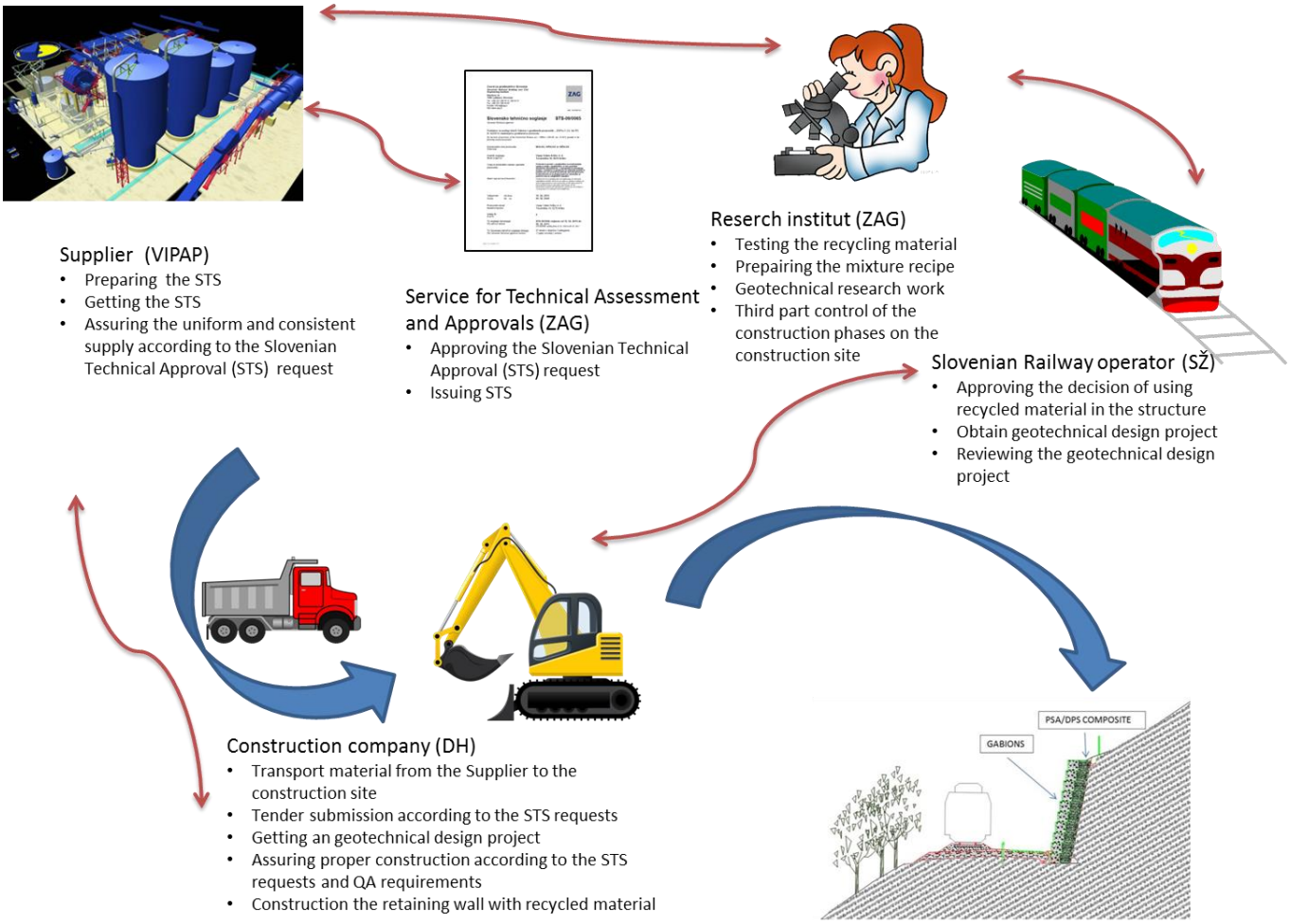

FIGURE 6: VALUE CHAIN OF CIRCULAR CASE 3

In current scenario, for circular case 3 we will see in detail, the following two types of flux/flow: Material & Value flow and Information flow (among external-stakeholders).

- Material & Value flow:

VIPAP Videm Krško (VIPAP):

Since 2003, the paper producer VIPAP has used DPS (deinking paper sludge) as a fuel for K5 and K4 combustion plants for which has the environmental protection permit (EPP) - OVD No. 35407-106/2006-3. For further waste treatment from combustion plans, the producer has another environmental protection permit OVD No. 35406-58/2012-23.

Through its network of waste paper collectors, VIPAP collects the paper waste (DPS and DPA), treated it according to the Slovenian Technical Approval (STS) and delivers it to the construction site.

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From VIPAP facility the recycled product MUDIPEL will be delivered to the construction site where it is used as a backfill material for retaining wall support system. The product MUDIPEL will be controlled according to the STS requirements and samples will be randomly taken and sent to the ZAG research laboratories.

DUŠAN HOLEŠEK (DH) – construction company:

DH as a construction company will install and compact recycled material between the gabions and soil slope. The technology will be determined with geotechnical project design which has to include all requirements from the STS for recycled material.

Slovenian National Building and Civil Engineering Institute (ZAG): ZAG will randomly take samples at VIPAP production plant and test the quality according to the STS requirements. At the construction site ZAG will perform a Third part control of the construction phases.

- Information flow

Some of the information which flow in (IN) and out (OUT) from each stakeholder are:

VIPAP:

- (OUT) apply to ZAG; Service for Technical Assessment and Approvals for Slovenian Technical Approval (STS) for product MUDIPEL
- (IN) get Slovenian Technical Approval (STS) for product MUDIPEL
- (OUT) send Slovenian Technical Approval (STS) for product MUDIPEL to construction company (DH)
- Slovenian railway (SŽ);
- (OUT) order the geotechnical research work of the landslide
- (IN) get the results of the geotechnical research work of the landslide from research institute (ZAG)
- (OUT) send geotechnical design project to the construction company (DH)
- (OUT) approving the decision of using recycled material in the structure (DH)
- (OUT) sending an order to the Third part control (ZAG)
- (IN) get results from the Third part control (ZAG)

Service for Technical Assessment and Approvals (ZAG):

- (IN) Getting a request for the Slovenian Technical Approval (STS) from VIPAP
- (OUT) Approving and issuing the Slovenian Technical Approval (STS)

Research Institut (ZAG):

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- (IN) getting an order for laboratory testing for recycled composite MUDIPEL from VIPAP
- (OUT) sending results of the laboratory testing of MUDIPEL
- (OUT) sending the results of the Third part control at the construction site
- (OUT) sending the results of the structure monitoring to railway operator (SŽ)

Value Chain of Circular Case 4

Key stakeholders:

Key stakeholders for circular case 4 are:

Pulp company

Domsjö Fabriker: produces cellulose for viscose application, while fibre sludges are generated as waste

Bio-ethanol producer

Domsjö Fabriker: produces bio-ethanol from wood based hemicellulose

NaCl and electrolysis technology supplier

Several actors that provide the electrolysis technique are identified and contacted. Suppliers of NaCl, that are required for production of HCl, are being investigated and will be contacted in the near future.

Ethyl chloride producer

Sekab: will use NaCl and the chosen electrolysis technology to produce HCl. Then, Sekab produces EtCl by using HCl and bio-ethanol in a catalytic process

End-user of Ethyl Chloride

Akzo-Nobel: uses ethyl chloride to produce their product Bermocoll, a cellulose ether

R&D institute

Processum: assists Sekab and Domsjö Fabriker in the development and the scale-up of the circular case

Public sector

The County Administrative Board: a part of the County Administrative Board called; Environmental Permit Office decide and delivers authorisation to store and use chemicals on an industrial site according to Swedish Environmental Code.

Flux between key-stakeholders

The following figure shows the stakeholders involved in circular case 4 of PaperChain project including the main fluxes between them:

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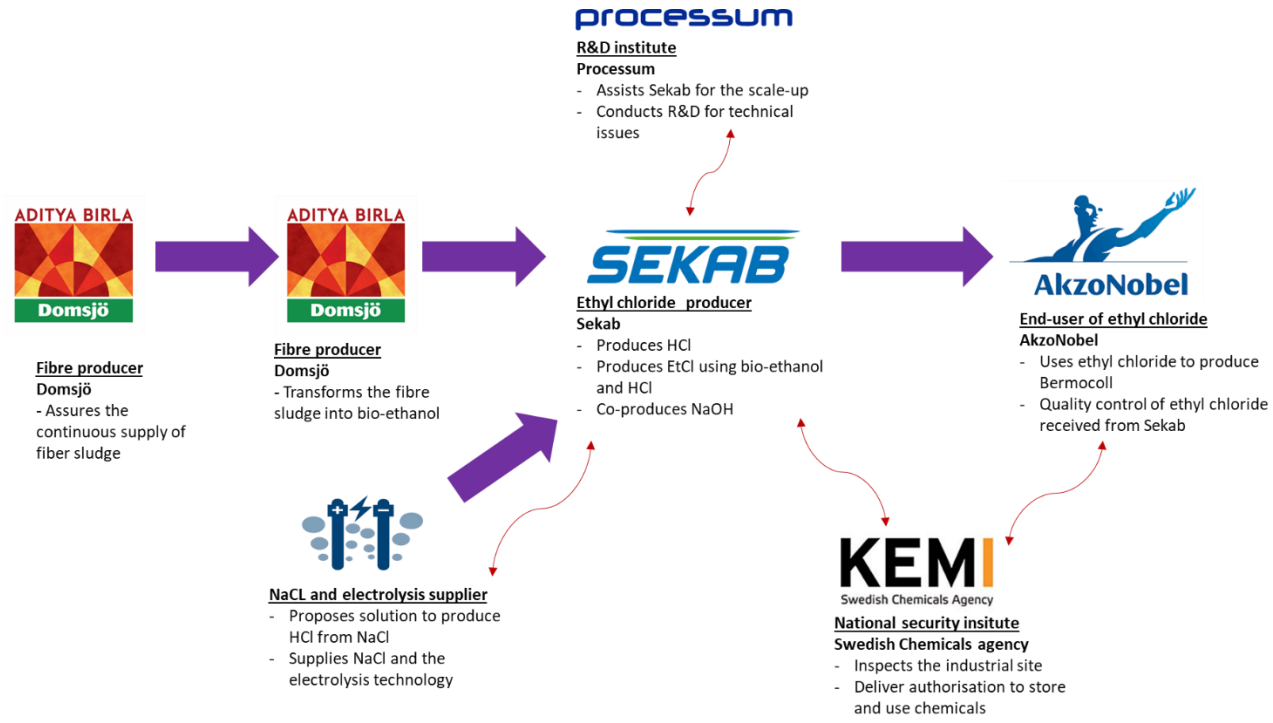

FIGURE 7: VALUE CHAIN OF CIRCULAR CASE 4

In current scenario, for circular case 4, we will see in detail, the following two types of flux/flow: Material & Value flow and Information flow.

Material & Value flow:

Domsjö Fabriker

When producing dissolving pulp, a minor fraction is lost as fibre sludge. Actually two different types of fiber sludges are identified as potential raw material. This fibre sludge(s) will serve as raw material for an enzymatic hydrolysis to obtain a sugar stream to be added to the existing fermentation, based on hemicellulose, into bio-ethanol.

Today all bio-ethanol is sold to Sekab that make different products/derivatives using ethanol as raw material. An increased bio-ethanol production will also be sold to Sekab.

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Sekab

Sekab buys the bio-ethanol from Domsjö and the NaCl from another supplier (to be identified). Sekab produces ethyl chloride, which will be sold to AkzoNobel.

AkzoNobel

AkzoNobel buys the Ethyl chloride from Sekab and use it to produce its Bermocoll.

Information flow

Some of the information which flow in (IN) and out (OUT) from each stakeholder are:

Domsjö Fabriker

(OUT) fiber sludge delivery status

Domsjö Fabriker, bio-ethanol producer

(IN) fiber sludge delivery status

(OUT) bio-ethanol delivery status

(IN) status of the payment made by Sekab for the receipt of bio-ethanol

Sekab

(IN) bio-ethanol delivery status from Domsjö

(IN) NaCl delivery status from the NaCl supplier

(IN) status of the payment made by Akzo, for the payment of EtCl

(IN) authorisation to store and use chemicals from the County Administrative Board

(OUT) EtCl delivery status to Akzo

(OUT) status of the payment to Domsjö for the receipt of bio-ethanol

(OUT) status of the payment to the NaCl supplier for the receipt of NaCl

(OUT) Safety information to the County Administrative Board

(OUT) Technical issues encountered and R&D projects to Processum

AkzoNobel

(IN) EtCl delivery status from Sekab

(IN) authorisation to store and use chemicals from the national safety institute/County Administrative Board (permits for storage, handling and usage of EtCl already in place)

(OUT) status of the payment to Sekab for the receipt of EtCl

(OUT) Safety information to the National Safety Institute/County Admintrative Board (Already in place)

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County Administrative Board

(IN) Safety information from Akzo and Sekab concerning the use and storage of specific chemicals

(OUT) Authorisation to use and store chemicals delivered to Sekab and Akzo.

NaCl supplier

(OUT) NaCl status delivery to Sekab

(IN) status of payment from Sekab for the receipt of NaCl

Processum

(IN)Technical issues encountered from Sekab/Domsjö Fabriker and AkzoNobel

(OUT) Results of R&D projects performed

Value Chain of Circular Case 5

Key stakeholders:

- Paper Company

  BillerudKorsnäs Provision of GLDs: provision of GLDs as wastes from the PPI

- Waste manager

  RagnSells: responsible for the transformation of the wastes into new raw material. The company will manipulate GLDs and build the demonstrator

- End-user company

  BOLIDEN mineral – mining company: Site provision, technical assistance in relation with mining procedures and requirements for soil covers, mining waste provision and handling recommendations

- Research & Development centre

  SP PROCESSUM: responsible for the material characterization and monitoring and the coordination of the demo case.

  LTU (university): Demo planning and evaluation. Support for dimensioning, testing and monitoring of the heavy metals content and their mobilization in the hydrogeological model at Boliden´s waste rock deposit.

- **Government authorities** (GA)/Certification bodies

Flux between key-stakeholders

The following figure shows the stakeholders involved in circular case 5 of PaperChain project including the main fluxes between them:

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FIGURE 8: VALUE CHAIN OF CIRCULAR CASE 5

In the current scenario, for circular case 5, we will see in detail, the following two types of flux/flow: Material & Value flow and Information flow.

Material & Value flow:

Waste Supplier (PPI – BillerudKorsnäs)

Green liquor dregs (GLD) are classified as non-hazardous waste. At the moment it is exempted from landfill taxes meaning that it is "cheap" to dispose it. A landfill taxe would increase the cost to discard GLD by a factor 4 (at least). One issue is that the paper mill has to make sure that the receiver has authorization to handle waste. Otherwise this could be considered as illegal disposal of waste by the authorities. That is one problem we encountered.

Till supplier (local provider)

Provision of Till (natural resource).

Waste Manager and layer construction (RAGNSELLS)

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Transport material from the Supplier to the construction site (BOLIDEN facilities). Manipulate GLDs and build the demonstrator: on-site Till + GLD mixing and homogenization.

Covering Layer construction. Compaction works.

Information flow

Some of the information which flow in (IN) and out (OUT) from each stakeholder are:

Waste Supplier (PPI – BillerudKorsnäs)

(IN) Regulation of GLD manipulation

(OUT) GLDs delivery status

(OUT) Assuring the quality of GLDs

RAGNSELLS, waste manager

(IN) GLDs delivery status & quality of the waste

(OUT) GLS mixed delivery status

(OUT) status for the payment of GLD

BOLIDEN Mineral (Mining company):

(IN) manipulated GLDs delivery status from Waste manager

(IN) status of the payment of GLD made by RAGNSELLS

(IN) authorisation to site provision, mine site

(OUT) technical assistance in relation with mining procedures and requirements for soil covers

(OUT) mining waste provision and handling recommendations.

(OUT) sealing layers delivery status

(OUT) status of the payment to RAGNSELLS

(OUT) status of the payment to the till supplier

(OUT) Quality information to the certification bodies

(OUT) Technical issues encountered and R&D projects to Processum

(OUT) Safety information to the National Administrative Board

Testing demo control Manager (LTU)

(OUT) environmental risk monitoring through the control of the heavy metals content and

(OUT) mobilization in the hydrogeological model at Boliden´s waste rock deposit

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(OUT) Demo planning and evaluation.

(OUT) Authorisation to use GLD mixed delivered to BOLIDEN

Processum

(IN)Technical issues encountered from Waste supplier, RAGNSELLS and Boliden

(OUT) Results of R&D projects performed

2.3 Business Model specific for the 5 demo cases

To represent a first draft of the business model, the Lean canvas was chosen. As presented in the figure below, it is an adaptation of the Osterwalder's canvas, but designed for entrepreneurship projects.

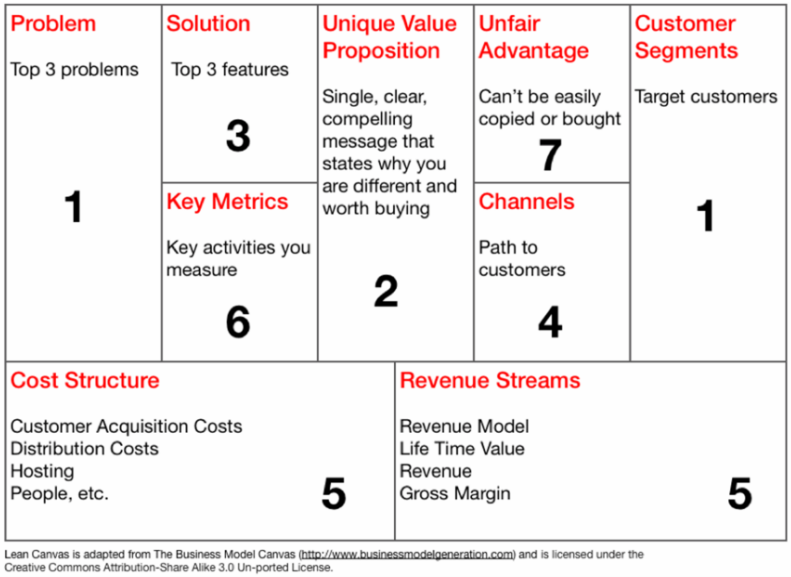

FIGURE 9: LEAN CANVAS METHODOLOGY (SOURCE: (Maurya 2010))

Problem 2) Top 3 problems) His main problem Which job has to accomplish	**Solutions** 4) **Top 3 features** Based on the VP (why it is better than others) Use MVP to test assumptions	**Value proposition** 3) Why you are different and worth buying (How you help customer doing his job,	**Unfair Advantage** 7) Can be easily copied or brought? What are the customer retaining costs? Acquisition costs Switching costs ….	**Customer segment** 1) Who is he Distinguish between users and customers (customers buy, users "use")

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Existing alternatives to address the same problems	**Key Metrics** 8) Key aspects/activities your ned to measure for a feedback	accomplish his mission Improve his position …. better than others. Provide	**Channels** 5) How you contact your customers/early adopters, How you deliver value How you promote value	Split in vertical segments Pick the strongest customer segment Early adopters
Cost structure 9) MVP HR costs, Eng. costs, MFG costs, marketing costs….			**Revenue Streams** 6) Why customers pay How he prefers to pay What is the average price? How many paying customers	

FIGURE 10: LEAN CANVAS TEMPLATE (SOURCE: ASH MAURYA)

The following pictures and paragraphs describe the complete Lean Canvas of the five circular cases considered from the global perspective, i.e. the circular business model as a system.

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Lean Canvas of Circular Case 1

<table>
<tr>
<td rowspan="2">Problem
Pulp and Paper Industries face potential high cost associated with the landfilling of wastes (dregs, grits and lime mud)
New providers of innovative raw materials for road and construction industries

Existing alternatives
Existing providers of raw materials for road and construction companies (Galecia, Eurocalcio, Macoag, etc.)</td>
<td>Solutions
Production of construction and road material benefiting from a reduced environmental impact compared to alternative solutions
Innovative solutions certified by a certifying body
Potentially lower cost compared to classic solutions</td>
<td rowspan="2">Value Proposition

Production of innovative raw materials incorporating transformed wastes from Pulp and Paper companies for the road and construction industries</td>
<td>Unfair advantage

Market leadership
Patent owner potentially
Feedbacks from demo cases
Authorisation from a certification body
Trust among partners / cross-organisational information exchange
Strong network</td>
<td rowspan="2">Customer segments

• Companies in the construction and road industries which are interested in reducing their impact on environment
• Local construction and road companies since transportation aspects (environmental and economic costs, logistic) are crucial
• Raw materials/Aggregates treatment company

• Clusters specialised in construction</td>
</tr>
<tr>
<td>Key metrics
Tons of product saved from landfilled,
Tons of product saved from mining,
Life cycle analysis of the solution implemented,
Price of classic solutions,
Monitoring of the quality of the products over time</td>
<td>Channels

Existing Megavia and Spral portfolio of clients
Visit of the demo cases
Nomination for prize in circular economy conferences</td>
</tr>
<tr>
<td colspan="3">Cost structure
• R&D; Training for employees
• Quality controls over time
• Organisation (logistic)
• Marketing cost</td>
<td colspan="2">Revenue streams
• Public/private tender for roads and buildings construction (more and more tenders give value to the environmental aspect of the solution selected)
• Patent license potentially</td>
</tr>
</table>

FIGURE 11: LEAN CANVAS OF CIRCULAR CASE 1 (SOURCE: PAPERCHAIN TEAM)

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The main components of the Lean Canvas are further described below.

- CUSTOMER SEGMENT

Identify who has the problem, define target customers and users
Innovative bituminous mixtures and precast concretes incorporating wastes (respectively dregs/grits and lime mud) are alternative solutions for construction and road industries. Especially for companies seeking to improve their environmental footprint by reducing their primary material consumption. The distance between the provider and the client is key to assess both the environmental and economic benefits of the circular model implemented. Beyond a certain radius, the cost of transportation and the associated emissions of pollutants nullify the initial added value of the solutions.
EARLY ADOPTERS *- find a small nice that is having the biggest problem, the ones that suffer the most (early adopters)*
Demo cases in SPRAL & MEGAVIA

- PROBLEM

Find 3 main problems you are addressing
In a political context where EU institutions push for circular economy, it would be likely that the cost of landfilling increase in Europe. The higher is the cost for landfilling, the higher is the interest in alternatives solutions. In this perspective, the process developed in the demo case 1 could be a silver bullet for Pulp and Paper Industries. Indeed, it has the potential to create an economic opportunity by reducing at least their cost for landfilling. Furthermore, raw material companies which decides to sell products incorporating wastes could appear as innovative in the eyes of their clients.
Describe ***EXISTING ALTERNATIVES*** *- Find out how they are solving the problem now (today's alternatives)*
• Existing providers of raw materials for road and construction companies (Galecia, Eurocalcio, Macoag, etc.)

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- UNIQUE VALUE PROPOSITION

*Define your **UVP based on the today's alternative**, what makes your product more efficient, a single and compelling sentence that makes everybody understand why you are far better (your features need to be compelling to the customers' needs, other ways are irrelevant to clients).*
The innovative dimension of the solution developed in the demo case one is related to the second life given to pulp and paper wastes in new products for the road and building companies.

- SOLUTION

Outline the main features of your solution. *When your features are similar of the ones of the competitors, this is an equality. What matters are the points of difference! **What you do, that the others do not do and is what matters to the clients**.*
The certified solution developed within the demo case one has the potential to enhance the environmental profile of roads and buildings projects. Beyond the sustainable dimension that could improve the corporate image of road and construction industries, it also demonstrates their interest for innovation and circular economy. Furthermore, depending on the location of the solution providers, road and construction industries could benefit from an economic advantage compared to classic solutions.

- CHANNELS

How will you reach your customers?
The bituminous mixtures and the precast concretes created with wastes from the Pulp and Paper Industries could be a substitutable solution for current clients of Megavia and Spral on the condition that the technical features are the same. Demo case visits, publicity in circular economy conferences and nomination for circularity prize could represent alternatives channels to reach new clients.

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- UNFAIR ADVANTAGE

What is it that gives you an advantage in front of the competition? Something that can't be easily copied or bought
Although the imagined solution may not be patentable, it indubitably offers a position of leader on the market. It could be reinforced by demo case feedbacks that enable adjustments in the proposed solution. Moreover, trust and information among partners stipulated in a commercial agreement offers an edge over competitors.

- KEY METRICS

Key activities you will measure to track the success (e.g. units sold, users registered, retaining users, paying customers, number of complaints …)
Different metrics are key to monitor the success of the solution developed. On a technical perspective, it is important to keep a close eye on the quality of the products over time. It is also a selling point as well as the price of alternative solution and the results of life cycle analysis. On an environmental perspective, it is interesting at least to monitor the tons of products saved from mining.

- COST STRUCTURE (QUALITATIVE)

Which will be the main costs when the solution is ready for the market (e.g. customer acquisition costs, distribution costs, hosting, people etc.)?
Different types of cost should be anticipated to achieve the success of the project over time. First although R&D cost are concentrated at the beginning of the development, it is important to pursue research to at least serve its edge over the competitors. Regarding operating activities, it is important to take into account:

- REVENUE STREAM (QUALITATIVE)

Which will be the main revenue streams when the solution is ready for the market?
The main type of the revenue should be expected from the selling of the solution in the road and construction sector. Another source of revenue linked with the sale of patent license may be potentially imagined

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Lean Canvas - Circular Case 2

<table>
<tr>
<td rowspan="2">Problem
• Concerns about the quality of the final products (roads in this case), as many properties will depend upon the soil or the base material available at the site.
• Concerns about the consistency in WPA before being processed by Waste manager.
• Legal barriers preventing the utilisation of PPI residues in road and highway construction
• Economic viability of the model (specially taking into account the transportation cost)</td>
<td>Solutions
• Approval by a certifying body (INAGA for this DEMO)
• Lobby at national, European and international level
• Work as a consortium</td>
<td rowspan="2">Value Proposition
WPA for soil stabilization replacing Cement without compromising on the final properties requirements.</td>
<td>Unfair advantage
• Demo case sites
• Consortium of industry, academic and R&D experts
• First-past-the-post patent ➔</td>
<td rowspan="2">Customer segments
• Construction companies
• Clusters specialised in construction
• Road Authorities (at local, regional and national level)</td>
</tr>
<tr>
<td>Key metrics
• Tons of WPA saved from landfill
• Tons of Cement being substituted by WPA
• GHG emission reduction owing to less resource (cement utilization)
• Economic viability of the circular model compared to the classic model
• Monitoring, of the site-where WPA is used, over time</td>
<td>Channels
• Visit of the demo case site
• Communication and dissemination trough the PaperChain project
• Conducting workshops
• Face to face meetings</td>
</tr>
<tr>
<td colspan="3">Cost structure
• R&D
• Training for employees
• Quality controls
• Organisation (new logistic to implement)
• Marketing expenses</td>
<td colspan="2">Revenue streams
• Call for construction bids
• Selling binding agent to other Construction Companies</td>
</tr>
</table>

FIGURE 12: LEAN CANVAS OF CIRCULAR CASE 2 (SOURCE: PAPERCHAIN TEAM)

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The main components of the Lean Canvas are further described below.

- CUSTOMER SEGMENT

Identify who has the problem, define target customers and users
Who has the problem: Looking from Socio-economic & environmental point of view, this is a problem for: Waste generators, Waste processors and all stakeholders involved in road and highway construction. **Target customers and users:** Construction Companies: - ACCIONA Construction, - Grupo ACS, - Vinci, - Mostostal, - Bechtel, - Hochtief, - Skanska, - Balfour Beaty, - Royal BAM group, - Bouygues Construction etc. Clusters specialised in Construction: *Regional & National Level*: - Canaria: Cluster Canario- Canary cluster of transport and logistics - Extremadura: Fundacion PYMECON - Andalucia: CLOC-Sustainalble Construction Cluster *European & International Level*: - Construction Cluster Innowater, Poland - Finnish Real Estate & Construction Cluster, Finland - Construction Cluster Dundjer, Serbia - SLOVENSKI GRADBENI GROZD- Construction Cluster of Slovenia - Saint Petersburg Cluster Development Center for Transport and Infrastructures Development-Russia

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EARLY ADOPTERS *- find a small nice that is having the biggest problem, the ones that suffer the most (early adopters)*
Depending upon the acceptance of this innovation by Regional and National Road authorities and environment protection agencies, Waste managers and Construction companies will be among the first to adopt this innovation.

- PROBLEM

Find 3 main problems you are addressing
The main problems addressed are: 1. Natural resource depletion- Cement and/ or lime production requires lots of natural resources, which are getting depleted. WPA as a binder could reduce the amount of the cement and/or lime used in road construction thereby reducing the usage of natural resources. 2. GHG emissions: Manufacturing of cement brings with it, emission of GHG gases. WPA will have a direct-positive impact owing to the reduced usage of Cement / lime and respective GHG emitted during their production.
Describe ***EXISTING ALTERNATIVES*** *- Find out how they are solving the problem now (today's alternatives)*
Using conventional and standard materials like Lime, Cement etc.

- UNIQUE VALUE PROPOSITION

Define your ***UVP based on the today's alternative****, what makes your product more efficient, a single and compelling sentence that makes everybody understand why you are far better (your features need to be compelling to the customers' needs, other ways are irrelevant to clients).*
The circular economy model allows incorporation of WPA, as a road binding agent to be used during the construction of roads, replacing Cement without compromising on the final properties requirements.

- SOLUTION

Outline the main features of your solution*.* *When your features are similar of the ones of the competitors, this is an equality. What matters are the points of difference!* ***What you do, that the others do not do and is what matters to the clients****.*

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- CHANNELS

How will you reach your customers?
Following are the means and modes of reaching potential clients: - Visit of the demo case site - Communication and dissemination through the PaperChain project - Conducting workshops - Face to face meetings

- UNFAIR ADVANTAGE

What is it that gives you an advantage in front of the competition? Something that can't be easily copied or bought
This solution will have following advantages which will make it competitive: - The technology will be validated on-site and will demonstrate its social-economic-environmental benefits to the respective stakeholders. - The Consortium of industry, academic and R&D experts will make possible to resolve any technical issues/queries generated by the final customer.

- KEY METRICS

Key activities you will measure to track the success (e.g. units sold, users registered, retaining users, paying customers, number of complaints …)
Of the various metrics that will be measured are: - Tons of WPA saved from landfill - Tons of Cement being substituted by WPA - GHG emission reduction owing to reduced cement usage. - Economic viability of the circular model compared to the classic model - Monitoring, of the site- where WPA is used, over time

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- COST STRUCTURE (QUALITATIVE)

Which will be the main costs when the solution is ready for the market (e.g. customer acquisition costs, distribution costs, hosting, people etc.)?
The various cost that will be incurred in order to, develop, and bring this solution to the market would be: - R&D cost - Cost associated with the Training for employees - Quality control cost - Organisation (new logistic to implement) etc.

- REVENUE STREAM (QUALITATIVE)

Which will be the main revenue streams when the solution is ready for the market?
The expected revenue generation could be through: (direct revenue) - Selling binding agent to other Construction Companies, - Consultancy services, to PPI industries and Construction Industries, for the usage of WPA in construction of Road and Highway as an alternative to cement and lime. (indirect revenue) - Competitive advantage during the tender stage (for using an environmental friendly solution)

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Lean Canvas - Circular Case 3:

<table>
<tr>
<td rowspan="2">Problem
High cost for waste landfilling
• Problem of slope stabilisation on railway infrastructure
• Depletion of natural resources
• Economic viability of the model

Existing alternatives
• Solution is innovative</td>
<td>Solutions
• Waste becomes secondary raw material
• Slope stabilisation with thinner geotechnical construction
• Use recycled backfill material instead of natural aggregate
• Looking for cheap construction of the landslide support system</td>
<td rowspan="2">Value Proposition
More sustainable and thinner landslide rehabilitation for transport infrastructure.</td>
<td>Unfair advantage
• In situ demo case
• Consortium of companies.
• The solution is innovative
• Knowledge about designing and installation of mixtures
• Advantage of being first on the market</td>
<td rowspan="2">Customer segments
• Construction companies
• Infrastructure operators</td>
</tr>
<tr>
<td>Key metrics
• Tons of product saved from landfilling
• Economic viability of the circular model compared to the classic model
• Monitoring of the quality of the products over time</td>
<td>Channels
• Visit of the demo case
• Communication and dissemination trough the Paper Chain project
• Workshops
• The Third part control for the infrastructure projects</td>
</tr>
<tr>
<td colspan="3">Cost structure
• R&D
• Storage, mixing, construction work
• Maintenance cost
• Training of employees
• Quality control
• Organisation (new logistic to implement)</td>
<td colspan="3">Revenue streams
• Green public procurements
• Product sales</td>
</tr>
</table>

FIGURE 13: LEAN CANVAS OF CIRCULAR CASE 3 (SOURCE: PAPERCHAIN TEAM)

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The main components of the Lean Canvas are further described below.

- CUSTOMER SEGMENT

Identify who has the problem, define target customers and users
Mountainous countries with landslides potentially threating the safety of roads and railways. Landslide stabilisation is often costly and causes traffic jam on an infrastructure. - Target customers: geotechnical construction companies, geotechnical design companies, mining companies, road operators, railway operators at regional, and international level, waste holders, investor of earth works.
EARLY ADOPTERS *- find a small nice that is having the biggest problem, the ones that suffer the most (early adopters)*
Waste holders: they are seeking for more economically and environmental viable solutions. Construction companies who get paid for waste material to be recycled.

- PROBLEM

Find 3 main problems you are addressing
Cost for waste deposit; different industrial sectors (waste holders) need to pay to wastes collectors for waste management. Problem of maintenance works for slope stabilisation on railway infrastructure due to lack of space for conventional geotechnical solutions. Problem of depletion of natural resources due to use of natural aggregates. Current solution includes slope stabilisation with massive gabion structure with backfill of natural aggregate. Economic viability of the model; the new product and its construction should not have higher costs as the natural aggregate.
Describe ***EXISTING ALTERNATIVES*** *- Find out how they are solving the problem now (today's alternatives)*
Alternative solution: Waste becomes secondary raw material which is given away to construction company for beneficial use. Alternative solution: Thinner gabion structure with recycled backfill material (smaller consumption of natural materials and thinner construction).

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- UNIQUE VALUE PROPOSITION

*Define your **UVP based on the today's alternative**, what makes your product more efficient, a single and compelling sentence that makes everybody understand why you are far better (your features need to be compelling to the customers' needs, other ways are irrelevant to clients).*
More sustainable and thinner landslide rehabilitation for different geotechnical conditions near rail and road infrastructure.

- SOLUTION

Outline the main features of your solution. *When your features are similar of the ones of the competitors, this is an equality. What matters are the points of difference! **What you do, that the others do not do and is what matters to the clients.***
Currently there is no similar solution on global market. The solution is innovative.

- CHANNELS

How will you reach your customers?
With industrial symbiosis activities and workshops for geotechnical designers, geotechnical conferences, day to day business contacts. ZAG is a Third part control of new infrastructure project for road and railway construction and also for renovation work for them. In that way it is possible to present the geotechnical solution for landslide stabilization with recycled material as a safe and environmental friendly solution. ZAG, VIPAP and SŽ are members of different international societies as they are; UIC, FEHRL, ERTRAC, EURNEX, Slovenian geotechnical society, Engineering chamber of Slovenia…

- UNFAIR ADVANTAGE

What is it that gives you an advantage in front of the competition? Something that can't be easily copied or bought
- Demo case in a place; results from demo site and long term monitoring could convince customers about the sustainability of the new solution.

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- Consortium of companies; for Slovenian demo case companies along the whole recycling circle are included - Currently there is no similar solution on global market. The solution is innovative. - Advantage of being first on the market. - Knowledge about designing and installation of mixtures.

- KEY METRICS

Key activities you will measure to track the success (e.g. units sold, users registered, retaining users, paying customers, number of complaints …)
- Number of orders for similar geotechnical applications. - Number of successful applications validated on base of long-term monitoring.

- COST STRUCTURE (QUALITATIVE)

Which will be the main costs when the solution is ready for the market (e.g. customer acquisition costs, distribution costs, hosting, people etc.)?
- R&D - Storage, mixing, construction work - Maintenance cost - Training for employees - Quality controls - Organisation (new logistic to implement)

- REVENUE STREAM (QUALITATIVE)

Which will be the main revenue streams when the solution is ready for the market?
- Green public procurements - Product sales

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Lean Canvas - Circular Case 4

<table>
<tr>
<td>Problem
• Now, Akzo relies on the one and only producer of EtCl
• Domsjö has lot of fibre sludge to be transformed into EtOH

Existing alternatives
• EtCl from a German chemical industry (by product of their production line, PVC)</td>
<td>Solutions
Production of EtCl from fibre sludge (improved environmental impact compared to alternative solution)

Reliability/trust in Sekab and Domsjö

Key metrics
• Tons of Bermocoll produced each year
• Price of the alternative EtCl produced in Germany for Akzo
• Production and availability of EtOH by Domsjö</td>
<td>Value Proposition
Production of EthylChloride (EtCl) based on fibre sludge produced by the pulp industry Domsjö Fabriker to improve security of supply</td>
<td>Unfair advantage
• Main stakeholders are neighbours (no transport issue)
• Main stakeholders have been working together for several years and are already partners in other projects
• Market of Bermocoll is already established

Channels
Through the existing clients' portfolio of AkzoNobel</td>
<td>Customer segments
• AkzoNobel for Bermocoll (no other user of EtCl in Europe)

Other users in China</td>
</tr>
<tr>
<td colspan="3">Cost structure
Supply of NaCl and EtOH (from Dosmjö Fabriker)
Operation and management of the electrolysis technology
Investment costs: Scale up at industrial scale for the production of HCl and EtCl
Training for employees</td>
<td colspan="2">Revenue streams
For Domsjö Fabriker: Reduction of costs related to handling of fiber sludge(s).
For Sekab: Increased sales of EtOH and sales of EtCl to AkzoNobel
For AkzoNobel: sales of Bermocoll</td>
</tr>
</table>

FIGURE 14: LEAN CANVAS OF CIRCULAR CASE 3 (SOURCE: PAPERCHAIN TEAM)

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The main components of the Lean Canvas are further described below.

- CUSTOMER SEGMENT

Identify who has the problem, define target customers and users
The Circular model aims at producing ethyl chloride to be used in manufacturing of cellulose ethers, Bermocoll. In Europe, ethyl chloride is used mainly by AkzoNobel for the production of Bermocoll. Nevertheless, as Bermocoll is one of the main products of AkzoNobel, it represents a large market. Other users of ethyl chloride can be found in China. However, it would be too costly to send them the ethyl chloride produced in Sweden, so one solution considered is to transfer the technology used to produce EtCl.
EARLY ADOPTERS *- find a small nice that is having the biggest problem, the ones that suffer the most (early adopters)*

- PROBLEM

Find 3 main problems you are addressing
Today, AkzoNobel uses Ethyl Chloride supplied by a German chemical company. This German company produces Ethyl chloride as a by-product. The ethyl chloride is transported by train to AkzoNobel in Sweden. However, it is a potential business risk for AkzoNobel because there is the only one production plant of Ethyl chloride in Europe. So, if the German company decides to increase drastically its price, the production of Bermocoll could be less profitable. Moreover, Domsjö Fabriker produces each year tons of fibre sludge as waste of its production line. Dosmjö Fabriker is not allowed to use organic material as landfill, which forces Domsjö Fabriker to burn it or recycle it. By transforming fibre sludge into bio-ethanol, Domsjö reduces the quantity of waste they must deal with.
Describe ***EXISTING ALTERNATIVES*** *- Find out how they are solving the problem now (today's alternatives)*
EtCl from a German chemical industry

- UNIQUE VALUE PROPOSITION

Define your ***UVP based on the today's alternative****, what makes your product more efficient, a single and compelling sentence that makes everybody understand why you are far better (your features need to be compelling to the customers' needs, other ways are irrelevant to clients).*

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The unique value proposition is the development of a production technology for Ethyl chloride based on fibre sludge from pulp and paper industry to improve security of supply.

- SOLUTION

Outline the main features of your solution.   *When your features are similar of the ones of the competitors, this is an equality. What matters are the points of difference!* ***What you do, that the others do not do and is what matters to the clients.***
Ethyl chloride produced from fibre sludge enables reducing the environmental impact due to the transport by train of the German alternative product (to be confirmed with the Life Cycle Analysis). Indeed, Domsjö Fabriker (which produces bio-ethanol from fibre sludge), Sekab (which produces ethyl chloride using the bio-ethanol) and AkzoNobel (the end user) are neighbours and can exchange chemicals only using pipelines.   In addition, it is less risk for AkzoNobel to trust one of its neighbours and a long-term partner for the supply of a key chemical, especially if Sekab puts money on the table for the investment for the production plant of Ethyl chloride, than a German partner whose Ethyl Chloride is a by-product of one of its production lines.

- CHANNELS

How will you reach your customers?
The final product, Bermocoll, is already commercialised and represents an important turnover for AkzoNobel. The commercialisation of this product will be done through the same existing channels, e.g. the existing client portfolio of AkzoNobel.

- UNFAIR ADVANTAGE

What is it that gives you an advantage in front of the competition? Something that can't be easily copied or bought
The main stakeholders of this circular case (Domsjö Fabriker, Sekab and AkzoNobel) are located on the same industrial site in Sweden, only a few meters away from each other. So, there is no transport issue. In addition, they have been working together for several years and are already collaborating on other projects. Domsjö

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Fabriker and Sekab were even part of the same company in the past (MoDo). The discussion between the three actors is already ongoing and considered easy. Finally, the market of Bermocoll is already well established.

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- KEY METRICS

Key activities you will measure to track the success (e.g. units sold, users registered, retaining users, paying customers, number of complaints …)
The following metrics are key for the implementation of the circular case 4: • Tons of Bermocoll produced each year: this production rate will define the needs of Ethyl chloride produced by Sekab and Bio-ethanol (produced by Domsjö for this purpose) • Price of the ethyl chloride produced by the German company and currently used by AkzoNobel for Bermocoll: the price of ethyl chloride produced from the bio-ethanol must be competitive • Tons of bio-ethanol produced by Domsjö from fibre sludge: the increase of production scale of bio-ethanol will supply Sekab for the production of ethyl chloride

- COST STRUCTURE (QUALITATIVE)

Which will be the main costs when the solution is ready for the market (e.g. customer acquisition costs, distribution costs, hosting, people etc.)?
Once the solution is ready for the market, there are not many costs: only the supply of NaCl, which can be handled easily since it is a very common chemical. However, for the solution to be ready for the market, several costs must be considered: • The investment cost: the development for the production line of ethyl chloride at an industrial scale represents several million euros • Personal cost: to produce HCl and ethyl chloride, Sekab will have to train and recruit several people

- REVENUE STREAM (QUALITATIVE)

Which will be the main revenue streams when the solution is ready for the market?
For Domsjö Fabriker, the revenues would come from the sale of bio-ethanol to Sekab. Sekab would have revenues from the sale of ethyl chloride to AkzoNobel. Finally, for AkzoNobel, the revenues would come from the sale of Bermocoll.

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Lean Canvas - Circular Case 5

<table>
<tr>
<td rowspan="2">Problem
The use of thicker layers of sealing materials leads to economic and environmental overruns managing the mine waste

- Costly waste stream (GLD) for PPI

Existing alternatives
Clay, local till and bentonite</td>
<td>Solutions
Solving an economic problem

More environmentally efficient production of sealing layer (material & transport)</td>
<td rowspan="2">Value Proposition

A new (and more effective) alternative of sealing layers that neutralize reagents to cover mine waste deposits where appropriate soil is not available.</td>
<td>Unfair advantage

• There doesn't exist similar product in the market

• Main stakeholders have been working together for several years and are already partners</td>
<td rowspan="2">Customer segments

Mining industries

Customers will have a role in defining the technical characteristics of the soil covers they need

Early adopters
BOLIDEN
Demo in PaperChain project</td>
</tr>
<tr>
<td>Key metrics
• Total volume of sealing layers (number of mining sites/surface area)
• Production and availability GLD</td>
<td>Channels

An intermediate company acting as a waste manager – this company will identify potential users, and co-ordinate the logistic</td>
</tr>
<tr>
<td colspan="3">Cost structure
Supply of Waste; Transport costs; and management costs
Investment costs: Scale up at industrial scale for the production of GLD
Training for employees</td>
<td colspan="2">Revenue streams
For PPI: sales of waste
For Waste Manager: sales of GLD</td>
</tr>
</table>

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The main components of the Lean Canvas are further described below.

- CUSTOMER SEGMENT

Identify who has the problem, define target customers and users
Mainly Mining industries. Customers will have a role in defining the technical characteristics of the soil covers they need. There could exist other industrial applications. They will be explored as the project progresses
EARLY ADOPTERS *- find a small nice that is having the biggest problem, the ones that suffer the most (early adopters)*
BOLIDEN Demo in PaperChain project

- PROBLEM

Find 3 main problems you are addressing
To limit water and oxygen infiltration of mine waste: waste rock is covered with borrow materials available on site, which frequently do not possess the best sealing capacities and implies the use of thicker layers of sealing materials, leading to economic and environmental overruns.
Describe ***EXISTING ALTERNATIVES*** *- Find out how they are solving the problem now (today's alternatives)*
Clay, local till and bentonite are identified as potential alternatives

- UNIQUE VALUE PROPOSITION

Define your ***UVP based on the today's alternative****, what makes your product more efficient, a single and compelling sentence that makes everybody understand why you are far better (your features need to be compelling to the customers' needs, other ways are irrelevant to clients).*
A new (and more effective) alternative of sealing layers that neutralize reagents to cover mine waste deposits where appropriate soil is not available.

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- SOLUTION

Outline the main features of your solution. *When your features are similar of the ones of the competitors, this is an equality. What matters are the points of difference!* ***What you do, that the others do not do and is what matters to the clients.***
Solving an economic problem More environmentally efficient production of sealing layer (material & transport)

- CHANNELS

How will you reach your customers?
An intermediate company acting as a waste manager – this company will identify potential users, and co-ordinate the logistic

- UNFAIR ADVANTAGE

What is it that gives you an advantage in front of the competition? Something that can't be easily copied or bought
• There doesn't exist similar product in the market • Main stakeholders have been working together for several years and are already partners

- KEY METRICS

Key activities you will measure to track the success (e.g. units sold, users registered, retaining users, paying customers, number of complaints …)
Total volume of sealing layers (number of mining sites/surface area) Production and availability GLD

- COST STRUCTURE (QUALITATIVE)

Which will be the main costs when the solution is ready for the market (e.g. customer acquisition costs, distribution costs, hosting, people etc.)?
Supply of Waste; Transport costs; and management costs

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Investment costs: Scale up at industrial scale for the production of GLD Training for employees

- REVENUE STREAM (QUALITATIVE)

Which will be the main revenue streams when the solution is ready for the market?
For PPI: sales of waste For Waste Manager: sales of GLD

3 Set of critical elements to create a circular economy model

3.1 Introduction

This chapter is devoted to find in literature other elements that will form the set of critical elements that will be incorporated as components of the reference framework. As mentioned in the Introduction chapter, a critical element concerns to being enough representative within the whole system, either enabling the success in the transition towards circular economy and constraining the operational and/or strategic processes of a circular economy model. Hence, processes, activities, skills, strategic goals, etc. need to be identified as a result of the evaluation of the critical elements.

The main challenge of this section is addressed through a comprehensive literature review on **three main theoretical perspectives** that appeared in circular economy research field:

- Existing frameworks for Circular Models
- Circular business innovation
- Business cases for sustainability

For the purpose of identifying the critical elements within the mentioned literature, we have taken as a basis the reference framework developed in 'FUTURING project' (FUTURING project 2017a) (see Figure 15). Aspects such as technology, society, economy, regulation environment, financial, etc. have been explored in the mentioned literature.

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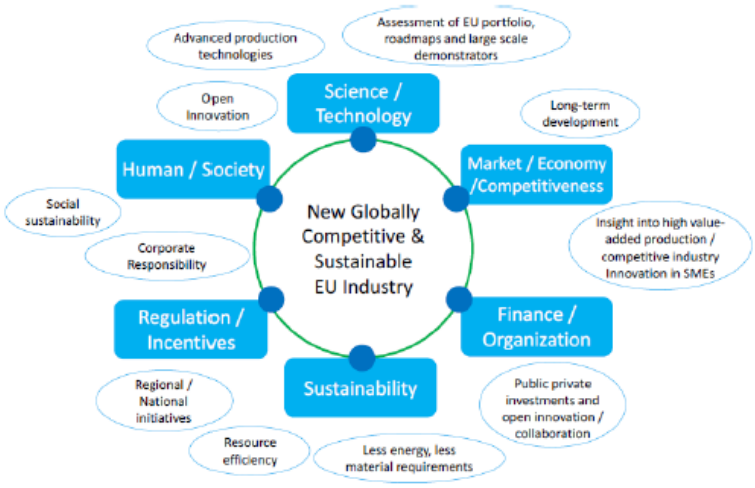

FIGURE 15: BUILDING BLOCKS FOR DEVELOPING THE VISION OF EU RE-INDUSTRIALIZATION (FUTURING project 2017b)

3.1.1 Existing frameworks for Circular Models

From 1970s, both green design and eco-design successively attempted to integrate environmental principles to reduce the impact of manufactured goods. Still under a linear economic logic, these approaches are only 'less bad' compared to business as usual according to Moreno (Moreno et al. 2016). If 'sustainable design' considers economy of resources, life cycle and human design (Kim 1998) as key principles, this approach focuses only on goods . Designing sustainable products is a first step. However, approaches such as "life cycle analysis" or "cradle to cradle" underline how important it is to take into consideration the whole business model of a company to turn completely away from an ultra-consumerist linear economy.

The high resource price volatility, the risks and costs associated with supply but also the evolution of regulation and the technological advances have driven society to a higher acceptance of alternative business models. In this condition, it is normal to observe the blooming of circular economy which offers economic and environmental opportunities Through different approaches such as "biomimicry" or "Blue economy" among others circular economy has the potential, according to Ramos Li (Ramos Li 2016), to:

- Create growth and jobs
- Enable substantial material savings
- Catalyse innovation
- Reduce greenhouse gases emissions and impacts on ecosystem

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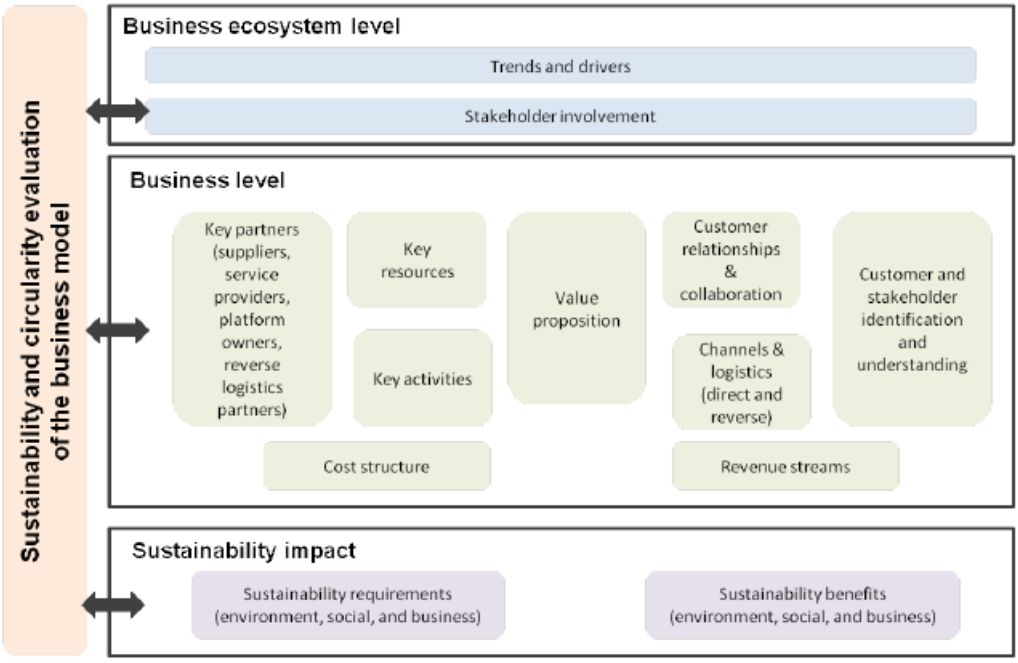
Nonetheless, the transformation of companies cannot be automatic. Academics developed literature about circular frameworks that help companies to imagine their transition from linear to circular economy. Some of these frameworks are presented in this chapter which aims at identifying critical elements that will be used to develop the Theoretical Framework presented in Chapter 5.

As it is a generic and easy-to-use tool, many academics relied on Osterwalder and Pigneur (Osterwalder & Pigneur 2010) work over business canvas to propose their own models.

3.1.1.1 Sustainable Circular Business Model

Built on a multilevel perspective, Maria Antikainen and Katri Valkokari (Antikainen & Valkokari 2016) endeavoured to adapt the nine blocks of the classic business model canvas. As an illustration, "Channels" evolved into "Channels and logistics (direct and reverse)". At the business level, it is also interesting to note the widening of the scope. Not only customers but more generally stakeholders are taken into account. Furthermore, "collaboration" and "understanding" seem to be keywords to describe the stakeholder relationship.



ure 2. Framework for sustainable circular business model innovation

FIGURE 16 : FRAMEWORK FOR SUSTAINABLE CIRCULAR BUSINESS MODEL INNOVATION (Antikainen & Valkokari 2016)

In addition to this classic business level, Antikainen & Valkokari (2016)considered also two more perspectives. First, macro factors such as trends/drivers (economical,

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geopolitical, legal, etc.) and external stakeholders (NGO, media, public bodies, etc.) are taking into account. In a highly connected world, these elements can particularly impact the way a company operates its business. Taking liberties with the model developed by Osterwalder and Pigneur, the authors introduced the "sustainability impact" level. On a "benefit-cost" logic, it enables to assess the sustainability and the circularity of the model.

3.1.1.2 Circular Business Canvas

Lewandowski (2015) developed a "framework of circular business model canvas" by reviewing Osterwalder and Pigneur template (Lewandowski 2016). Based on the ReSOLVE principles, its objective is to design a circular business model practicable from the perspective of every company. Each block is conceptualized in order to integrate circular principles:

- Value proposition. Despite being ownership-based, circular products are designed ideally with remanufactured materials and easily reusable and recyclable. If dematerialized, it becomes a product-service system which can be leased, rented, pooled or paid-per-service.
- Channels. Virtualization is the watchword whether it concerns the value proposition, the delivery channel or the mode of communication.
- The customer relationships. Through the logic of producing-on-order and sensitisation, it is possible to enhance the relation.
- Revenue streams. Different strategies exist to make money through a circular business model. It is possible to mention pay-per-product, pay-per-service, availability-based product-service system, performance-based product-service system among others.
- Key resources. If it is generally not possible to use 100% issued from circular sourcing, it is recommended to employ performing material with the smallest impact on environment. A compatible strategy is to compensate this impact by regenerating the environmental impact.
- Key activities. Spread circular principles is possible through different strategies. Better process control, technology changes, sharing and virtualization may increase the performance of a company. Furthermore, product design enabling easy recycling can help to have an edge over its competitors.
- Key partnerships. "A company can never achieve full circularity on its own: It is dependent on a network of collaborating organizations" (Roos 2014). It is especially true for industrial symbiosis which required a strong culture of collaboration.

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<table>
<tr>
<td rowspan="2">Partners
• Cooperative networks
• Types of collaboration</td>
<td>Activities
• Optimising performance
• Product Design
• Lobbying
• Remanufacturing, recycling
• Technology exchange</td>
<td rowspan="2">Value Proposition
• PSS
• Circular Product
• Virtual service
• Incentives for customers in Take-Back System</td>
<td>Customer Relations
• Produce on order
• Customer vote (design)
• Social-marketing strategies and relationships with community partners in Recycling 2.0</td>
<td rowspan="2">Customer Segments
• Customer types</td>
</tr>
<tr>
<td>Key Resources
• Better-performing materials
• Regeneration and restoring of natural capital
• Virtualization of materials
• Retrieved Resources (products, components, materials)</td>
<td>Channels
• Virtualization
Take-Back System
• Take-back management
• Channels
• Customer relations</td>
</tr>
<tr>
<td colspan="3">Cost Structure
• Evaluation criteria
• Value of incentives for customers
• Guidelines to account the costs of material flow</td>
<td colspan="2">Revenue Streams
• Input-based
• Availability-based
• Usage-based
• Performance-based
• Value of retrieved resources</td>
</tr>
<tr>
<td colspan="5">Adoption Factors
• Organizational capabilities
• PEST factors</td>
</tr>
</table>

FIGURE 17: FRAMEWORK OF THE CIRCULAR BUSINESS CANVAS (LEWANDOWSKI, 2015)

To further engage companies on circular economy, Lewandowski designed two additional blocks. "Take-back system" puts in light the principle of reverse logistic that is at the centre of circular economy. It supposes the implementation of a "take-back" management system to assure the collection of used products and the setup of incentives that may impact the relation with customers.

Furthermore, Lewandowski stresses the coherence of the circular business model imagined. Especially concerning three imbrications that drive the transition toward a circular business model. It is what Lewandowski calls the "triple fit challenge" (the "triple fit challenge" is developed in next section).

3.1.1.3 Business Cycle Canvas

Although Mentink (2014) used the business model canvas as a reference framework, his approach is noticeably different (Mentink 2014). Focusing on the circular dimension, Mentink proposed a framework on the "whole business cycle instead of only the individual" business model. Moreover, his approach highlights the role of every stakeholder as well as the necessity of collaboration in circular economy.

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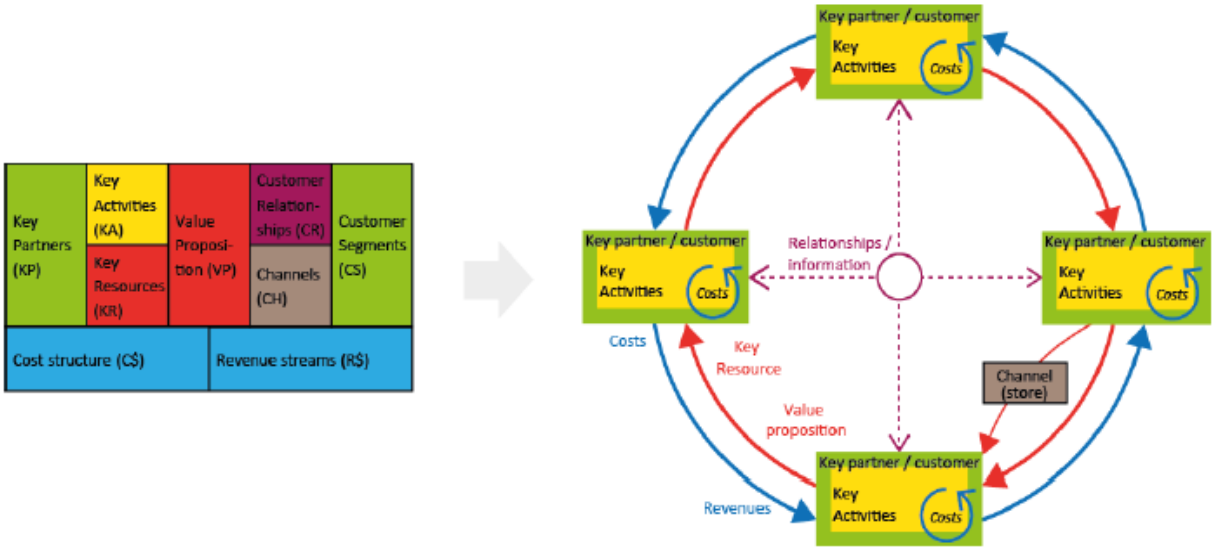

FIGURE 18: TRANSFORMATION OF THE BUSINESS MODEL CANVAS IN TO THE BUSINESS CYCLE CANVAS (MENTINK, 2014).

In detail, the value proposition symbolised by a red arrow, is considered as a key resource of another partner/client represented in a green box. Company's activities specified in the yellow box implies external and internal cost (respectively the purchasing of key resources and the production of a good/service) – and generate revenues from sales. The nature of these cost and revenues are mainly financial but can also include environmental and sociological aspects. These flows are represented by blue arrows while collaboration occurs through information flows (purple arrows) between actors of the circular model.

Considering mainly four components of business modelling (who, what, how and why), Mentink proposes a systemic approach which adapt easily to different organisations.

3.1.1.4 Critical analysis

Based on the literature, this section conducts a critical analysis of the circular framework presented above. Its objective is also to emphasize critical element that could feed the Reference Framework.

In his work, Talukder (Talukder 2017) gives an overview of many circular frameworks. According to this author, the model developed by Maria Antikainen and Katri Valkokari (Antikainen & Valkokari 2016) could be improved. Although the Sustainable Circular Business Model introduces the principles of "sustainability impact" and collaboration, it suffers from certain limits. System thinking is poorly addressed since the model is only company-centred. Even worse, competition is not even considered. He observes the same issues in the Circular Business Canvas. Lewandowski built a practical tool to realize the transition from a linear to a circular economy but according to the

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author himself, the framework could be difficult to implement. Talukder criticises Mentink model for being incomplete. Despite its systemic approach, the Business Cycle Canvas put aside some building blocks. Especially the "channels" and the "customer relationship". Competition and sustainable are neither addressed in this model.

TABLE 6 : EVALUATION OF BUSINESS MODEL FRAMEWORK (TALUKDER, 2017)

Business Modes	System thinking	Collaboration	Sustainability impact	Competition
Sustainable Circular Business Model		X	X	
Circular Business Canvas		X		
Business Cycle Canvas	X	X		

As stated by Lewandowski (Lewandowski 2016), these frameworks support "the process of designing a business model, but do not indicate how the principles of the circular economy or the business actions implementing circular economy are related to particular components of these business models". In other words, designing a circular business model is not enough to operate the transition from a linear to a circular economy. Although these tools rely on circular economy principles, they are conceptual and do not consider any implementation aspects. To operate the transition, these circular business frameworks should be incorporated in a larger process framework for circular transition.

On this basis, Mentink (Mentink 2014) proposed a framework for Circular Business Model Innovation. This approach drives consortium of companies toward circularity based on five steps:

- Preparation phase. It enables the creation of a solid team and the share of knowledge about circular economy. It is important to build a team with members with different backgrounds who share at least a common language over circular economy.
- An initiation phase. It enables the analysis of both the internal and external ecosystem. This phase is key to understand influences, interests and positions of stakeholders and to understand the impacts of potential factors (social, economic, legal, environmental, technological, etc.). In this step, it is important to adopt a systemic approach in order to conduct an effective mapping

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- An ideation phase. Based on the results of the previous step, the team collected crucial information that serve the design of circular business models
- An integration phase where all the pieces of the business model are consolidated. This step is crucial for collaboration. Partners should coordinate their efforts and share information for the success of the circular project
- An implementation phase which validates the conceptual work realized and defines pilots, trials and prototypes. To be completely effective, the circular model should be able to compete in a "linear" environment

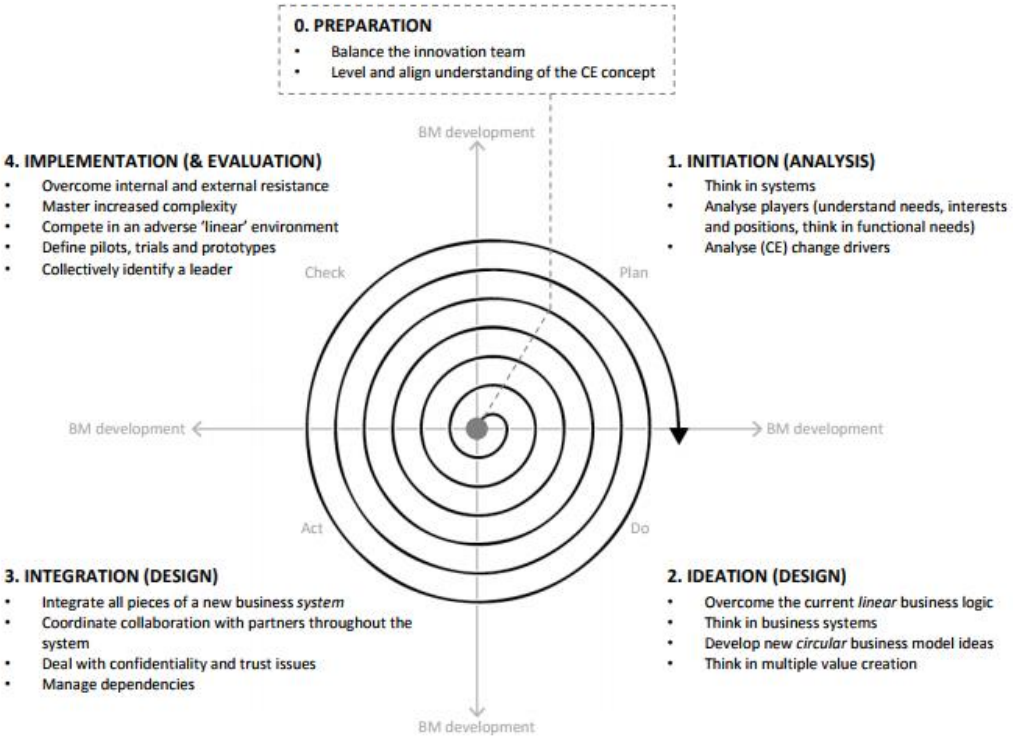

FIGURE 19: CIRCULAR BUSINESS MODEL INNOVATION FRAMEWORK (MENTINK, 2014)

As represented in the figure, this incremental process requires system thinking and collaboration to be effective.

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Although his framework seems less practical, Mouazan (2016) developed a circular transition framework that focuses on both internal/external ecosystem and results.

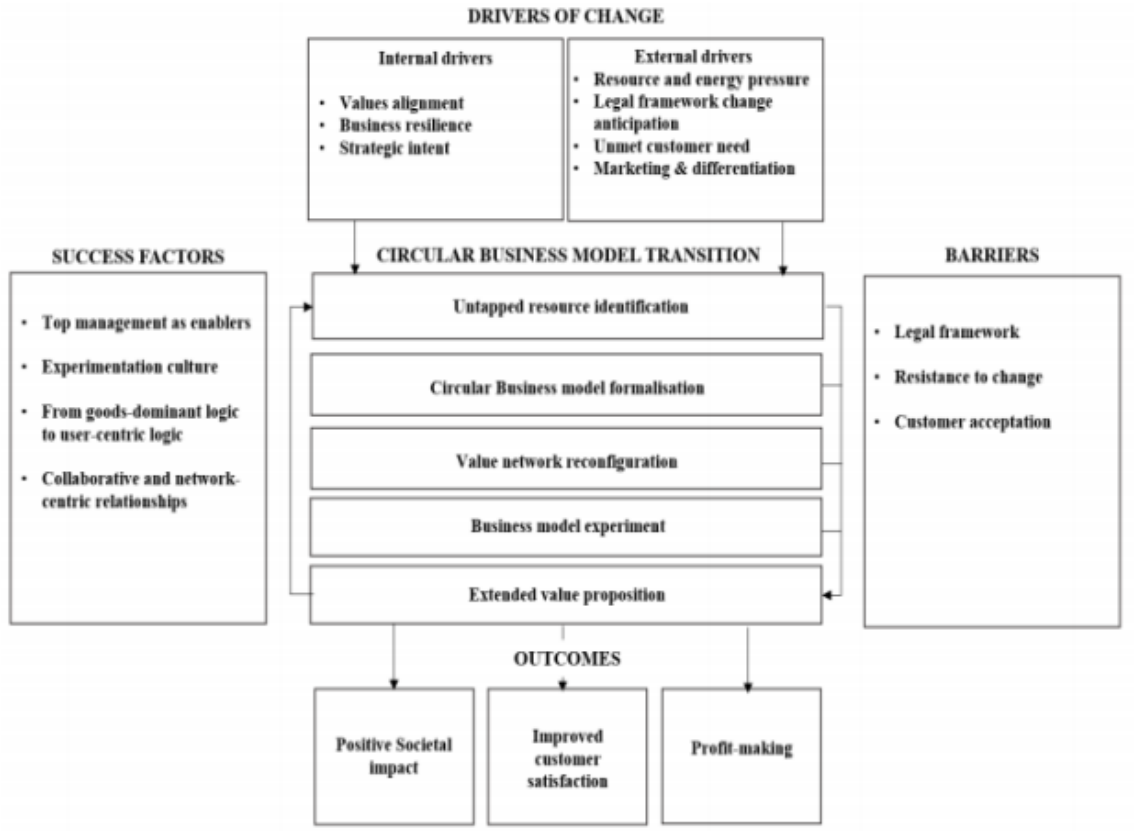

FIGURE 20: CIRCULAR BUSINESS MODEL TRANSITION FRAMEWORK (MOUAZAN, 2016)

Mouazan introduces different elements such as "success factors", "drivers for change" and "barriers" that assess the capability for a company to operate the transition toward circularity. Unlike Mentink, Mouazan takes an interest on the results of transition process. Given the nature of the results, it is possible to redesign precisely the circular business model.

At the end of this literature review, it is clear that the transition toward circularity supposes deep modifications. Focus on the design of a good/service is not enough. Approach such as eco-design or green design offered limited results. Focus on business models is neither enough. What is needed is **a systemic approach centred not only on one company but on a partner network that collaborates.**

Furthermore, the proposed framework should offer an overview by considering the different parts of its ecosystem (i.e. internal and external) as well as it should provide at the same time a conceptual and a practical approach.

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3.1.2 Circular Business Model Innovation

To continuously improve existing frameworks and design valuable and viable circular models, companies and researchers use business model innovation. The objective of this section is to identify critical elements related to circular business model innovation that could be integrated in the framework developed in the last section of this deliverable.

Several definitions of business model innovation can be found in the literature. Amit and Zott suggest that business model innovation refers to the changing "the way of doing business" and not only "what you do"(Amit & Zott 2012). Thus, it is not only about products and services but encompasses a wider scope. For Jonhson and Suskewicz, business model innovation involves "shifting the focus away from developing individual technologies towards creating new systems"(Suskewicz 2009). Osterwalder and Pigneur, who act as referent when talking about business model, state that business model innovation is "the novel way of creating, delivering and capturing value that is achieved through a change of one or multiple components in the business model"(Osterwalder & Pigneur 2010). All the definitions have in common to take into account not only a product or service but state that business model innovation should rethink the three value dimensions, i.e. what value is proposed, how the value is created and delivered and how the value is captured.

> *"Implementing circular strategies often requires* ***more holistic and radical changes beyond the boundary of a company****"*
>
> (Nußholz 2017)

Compared to "regular" business model, most of the definition of circular business models consider resource efficiency strategies or changes in Resource Flows (Nußholz 2017). Mentink explains that in a circular business model an organisation creates, delivers and captures value with and within closed material loops"(Mentink 2014). In this definition, a circular business model does not have to close material loops by itself within internal system boundaries but can rely on other organisations. In the same way, Wells and Seitz identified four archetypical closed-loop value chains, whom only one is realisable at company level: the "internal loop" in which material is reused within the point of manufacture (Wells & Seitz 2005). The archetype closer to the PaperChain demo cases are the "post business loop" in which material is exchange between distinct companies. For this loop, they indicate that coordination and alignment of business models between at least two companies are required.

Then, a circular business model can be seen as a network of business models, which together close a material loop. As a result, circular business model innovations are networked and entail collaboration, communication and coordination within

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"complex networks of interdependent but independent actors/stakeholders" (Antikainen & Valkokari 2016).

To make a circular business model viable over time, it is important to consider all these interdependencies and different actors. The main challenge is then to find a "win-win-win" situation in which self-interests of the different actors are respected (Antikainen et al. 2013). These interests can be economic, but also strategic (ensuring security of supply, access to information, etc.), social, environmental, etc. The win-win-win setting will enable a good cooperation and thus facilitates actions that form the circular model.

> *"If the benefits of a circular economy are so obvious and the basic concepts are available for more than three decades, then* ***why have circular economy business models not yet made the world a better place****?*
>
> (Planing 2014)

When designing a business model, and a fortiori, a circular one, several buildings blocks must be considered (as presented in the previous subsection). Lewandowski states that not all building blocks have the same importance, some of them must be studied very carefully. In this sense, Lewandowski developed the "triple fit challenge" Figure 21to facilitate the transition between a linear model and a circular one and reduce the inevitable uncertainty when designing a new model (Lewandowski 2016). The first challenge to be overcome in the triple fit challenge is the alignment of the value proposition (including the take-back system) with the customer segments. This idea was also developed by Osterwalder et al. with the methodology Value Proposition Design (Osterwalder et al. 2014). Then, to build an economically viable model, the cost structure must fit the revenue streams. These two first fits are not specific to a circular model unlike the last one, which recommends a fit between the changes a company implements towards a more circular business model and adoption factors that can hamper this process. Such adoption factors can be internal like motivation or ability to change or external such as political or technological factors.

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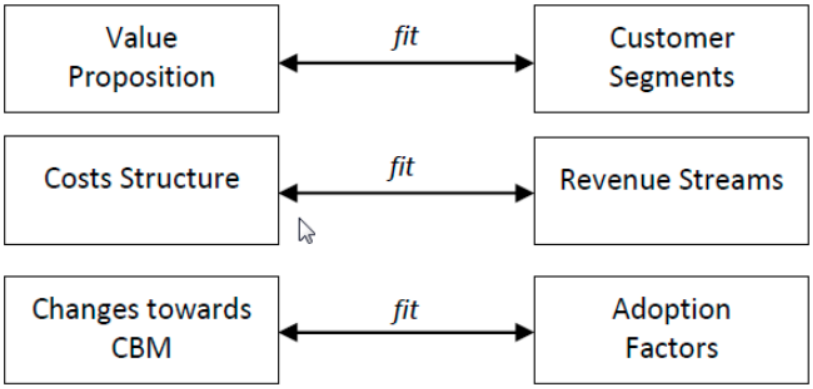

FIGURE 21: THE TRIPLE FIT CHALLENGE (SOURCE: LEWANDOWSKI, 2016)

Even if, when building a circular model, some building blocks are more important than others, Poutiainen showed that implementing a circular model by designing out of waste impacts a majority of the nine building blocks of the Business model Canvas (Poutiainen 2015). After studying the business model of four companies designing out of waste, she found out that between seven and nine blocks were affected by the circularity character of the model. As a result, a system thinking approach is recommended to optimise the whole circular business model.

The growing consciousness of the non-sustainability of the linear model, the new technologies that make possible the implementation of a circular model and the available circular business model framework suggest that circular economy models should be predominant. However, it is not yet the case. According to Planing, the reasons for this are numerous (Planing 2014). From an economic point of view, he explains that profit-share along the value chain are misaligned, which leads to an imperfect product design to the customer. This emphasizes the importance of the win-win-win situation as well as the triple fit challenge mentioned above. The following table presents other reasons for non-acceptance of circular business models based on Ellen McArthur Foundation.

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Reason for non-acceptance	Short explanation	Origin
Customer irrationality	Customers only evaluate the transaction cost at the point of sale (purchase price) even if the net present value of upgrading to a more expensive but more durable product would be more economical. Consumers prefer ownership of a product, even if temporary usage is more economical.	Consumer behavior
Conflict of interest within companies	Higher capital or cash required to change an existing product design or to move from a sales-based to a usage-based revenue model	Short-term oriented corporate management
Misaligned profit-share along supply chain	Imperfect design at the beginning of the supply chain if the profits from a better design would only occur at the end-of-use phase	Lack of consistent legislation regarding end-of life phase of products
Geographic dispersion	Since the value chain of today's product is spreading over multiple countries, national initiatives often lose their potential impact	Transnational authorities and lack of national collaboration

TABLE 7: REASONS FOR NON-ACCEPTANCE OF CIRCULAR BUSINESS MODELS (SOURCE: PLANING, 2015)

In the deliverable D3.3, when creating the circular economy models for the five demo sites of PaperChain, the previous findings must be well-though-out. Hence, we conclude that the reference framework should be developed under a holistic approach, considering all the stakeholders involved in the model and respecting the self-interest of each of them, thus creating a win-win-win situation. Both internal factors such as company's culture or ability to change and external factors like political and legal factors must be taken into account. Finally, we must keep in mind the triple fit challenge when designing the circular model to ensure that the value proposition fits the customers' needs, the costs and the revenues are aligned and the changes towards a circular model fit the adoption factors.

The following table presents a list of critical elements that will be incorporated to the Reference Framework. These critical elements were identified when looking at innovation for circular economy business models.

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TABLE 8: CRITICAL ELEMENTS RELATED TO CIRCULAR BUSINESS MODEL INNOVATION

Critical elements	Description	Dimension of the Reference Framework - How do we translate to the RF?	Source
Self-interest respected	The self-interest of each stakeholder involved in the circular model must be respected to create a win-win-win situation.	Multi-stakeholder involvement	Antikainen, 2013
Avoid or control Geographic dispersion of stakeholders	Implementing a circular economy model may require that the different suppliers and users of the value chain are geographically close (to avoid high transport cost).	Multi-stakeholder involvement	Ellen Mc Arthur Foundation, 2014
Short-term oriented corporate management	Implementing a circular economy model involves important changes and investments which must be consistent with a company's long-term strategy.	Vision	
Lack of consistent legislation regarding end-of-life phase of products	The legislation regarding use of different types of waste is not always clear in the different countries in Europe and may sometimes prevent the implementation of a circular model.	Legal dimension	
Customer irrationality	This critical element concerns a barrier a product produced from waste has to overcome: the idea that it is not as good as a new product.	Value proposition	
Alignment of value proposition with customers' needs	The value proposition offered in the circular model must be aligned with customers' needs. Thus, the model will find customers and be sustainable over time.	Value proposition	Lewandowski, 2016
Economic viability of the model	The cost structure of the model must be inferior of the revenue stream for the circular model to be viable.	Financial dimension	
Internal changes within the company to adopt the circular model	The transition towards a circular model must be supported by various organisational capabilities (new competencies, new value chain, etc.).	Internal changes	
Misaligned profit-share along the value chain	Along the value chain, the economic interest of the different actors must be preserved and ensured compared to other competitive solutions on the market.	Financial Dimension	Planing, 2015

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3.1.3 Business Cases for Sustainability

"The concept of the business case for sustainability guides researchers and practitioners alike to find answers to the crucial question: ***How can the competitiveness and business success of a company be improved with voluntarily created outstanding environmental and social performance****?"*
Schaltegger & Lüdeke-Freund (2012)
CSM (Centre for Sustainability Management)[4]

"When done well, sustainability is ***a tool for engaging current and future employees****,* ***efficient use of resources*** *and cost savings,* ***encouraging innovation****,* ***stimulating business growth*** *and keeping your business ahead of the regulation curve in a rapidly changing,* ***disruptive and technologically-connected market place****."*
Sustainable Business Council (New Zealand) [5]

In this section, the research has been focused on identifying which critical elements could take a role in favour of circular economy while creating business cases for sustainability. The concept of sustainability has been toughly related to Circular Economy. Many scholars have devoted their researches to such connection [e.g. (Rauter et al. 2017);(Witjes & Lozano 2016)] or even stress that circular economy has emerged as a consequence of companies that going beyond placing sustainability core to their company's business strategy. Some of them have turned the focus towards the creation of business cases for sustainability [e.g. (Schaltegger et al. 2012); Bocken et al., 2014; Bohnsack et al., 2014; Demill andLecocq, 2009)], looking for the positive impact of embedded sustainability efforts on business performance. Furthermore, business case for sustainability perspective has been taken as a basis for conceptualizing frameworks within the context of circular sustainable models.

Since several expressions referring to "Business Case for Sustainability" have appeared in literature e.g., 'Sustainable Business Cases', 'sustainable business model', 'business models for sustainability', etc., we aim firstly to set up a common understanding about this concept within the field of Circular Economy. After having the key aspects around this concept clarified, we propose extracting from the developed literature review those elements that will constitute part of the critical elements' list. **From the sustainability perspective, we aim to identify those drivers or enablers that favour business performance in a circular economy context**.

[4] http://www2.leuphana.de/umanagement/csm/content/nama/downloads/download_publikationen/Schaltegger_Luedeke-Freund_Business%20Case%20for%20Sustainability.pdf
[5] http://www.sbc.org.nz/__data/assets/pdf_file/0006/118473/SBC_Business-CaseForSustainability_Aug2016.pdf

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Some insights about 'Business cases for Sustainability'

> *"A business case for sustainability results from the intelligent design of voluntary or mainly **voluntary social and environmental management** and **creates a positive business effect** based on a distinct management or **entrepreneurial activity**."*
> *Stefan Schaltegger & Florian Lüdeke-Freund (2012)*
> *CSM (Centre for Sustainability Management)*[6]

The integration of Corporate Sustainability into the traditional way of creating business models has lead companies to redesign "*their business models to better engage with stakeholders, while creating competitive advantages for customers, the company, and society*" (Witjes & Lozano 2016:40). In line with this argument, the study developed by Bocken et al. (2014) represents a good example of combining sustainability principles and business model components. They categorise sustainable business models (archetypes) based on three types of redesign processes: technological, social and organisational (Bocken et al. 2016). These authors make a comprehensive review of overviews which sought to identify **unifying research agendas for sustainability in business** include: **the business case for Corporate Social Responsibility** (Caroll and Shabana (2010); **the business case for sustainability** (Dyllick and Hockerts (2002), Salzmann et al. (2005) and Schaltegger et al. (2012); **value creation and business models** (Bisgaard et al. (2012)), **"green' business models** (Beltramello et al. (2013)), **closed loop supply chains** (Wells and Seitz (2005)), **business models for sustainability** (Wells and Bristow (2007) and Lüdeke-Freund (2009), Boons et al. (2013) and Boons and Lüdeke-Freund(2013)). Mentink (Mentink 2014) argues that circular business models do not necessarily aim to balance ecological, social and ecological needs, in contrast to business models, although at the same time they can serve sustainability goals.

In the literature related to sustainability, we can find some conceptual frameworks which are worthy to mention because they fit with the aim of this section which is to discover the critical elements for the Circular Economy (CE) derived from business case for sustainability. Some of them have been identified by Lewandowski (2016) in his comprehensive review of conceptual models in Circular Economy (e.g. (Roome & Louche 2016; Gauthier & Gilomen 2015; Abdelkafi & Täuscher 2016; Stubbs & Cocklin 2008) while some others have been selected in sustainability business model literature (e.g., Schaltegger et al. 2012; Witjes & Lozano 2016).

Stubbs & Cocklin (2008) conceptualize the concept of 'sustainability business model' in different ways or in a combination of these as:

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- a narrative of sustainability practices;
- a description of features, attributes, and/or characteristics;
- a list of necessary and sufficient conditions;
- a representation of business processes;
- a firm-level description;
- a systems-level description;
- or some combinations of these.

As a result of case study-based research, they propose **an "ideal type" of a Sustainable Business Model (SBM)** (Figure 22) which, from a generic perspective, consists of two types of attributes: structural and cultural (Stubbs & Cocklin 2008:114).

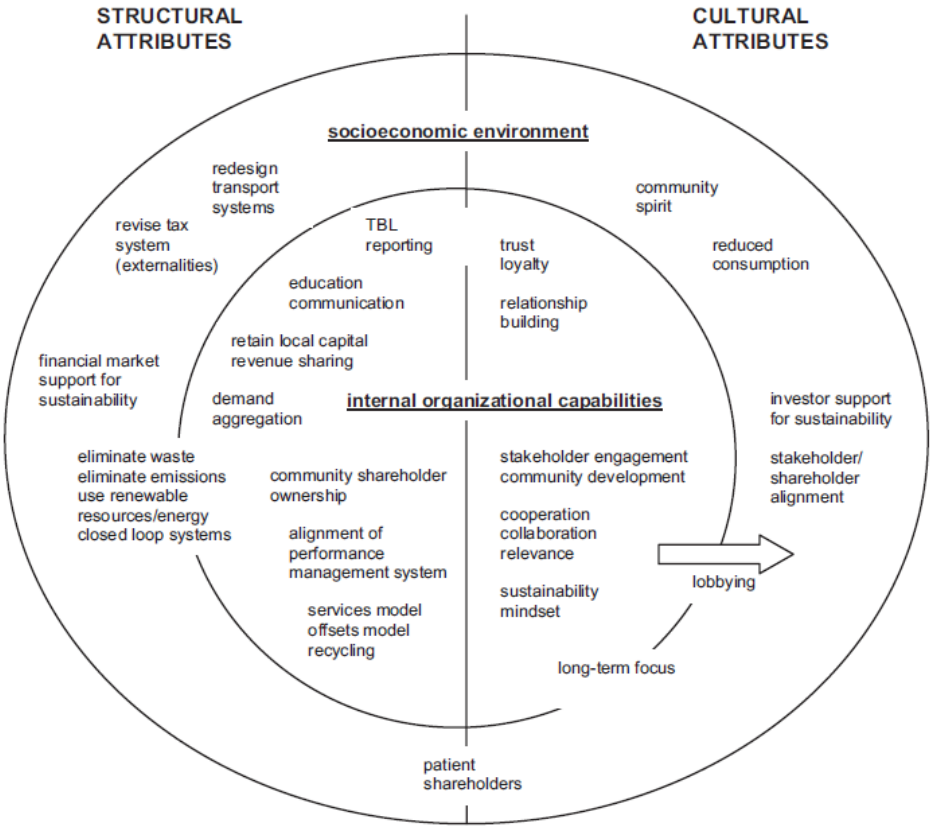

FIGURE 22: STUBBS & COCKLIN'S SUSTAINABILITY BUSINESS MODEL ATTRIBUTES

More specifically, these authors identify economic, environmental and social characteristics for both attributes. Thus, **structural attributes within economic perspective** are depicted for example by *external bodies expecting triple bottom line performance, lobbying for changes to taxation system and legislation to support*

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sustainability, keeping capital local. The following table provides the global list of attributes identified by (Stubbs & Cocklin 2008).

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TABLE 9: ATTRIBUTES OF SUSTAINABILITY BUSINESS MODEL (STUBBS & COCKLIN, 2008)

	STRUCTURAL ATTRIBUTES	CULTURAL ATTRIBUTES
Economic	- external bodies expecting triple bottom line performance - lobbying for changes to taxation system and legislation to support sustainability - keeping capital local	- considering profit as a means to do something more - ("higher purpose"), not as an end, which is also a reason for shareholders to invest
Environmental	- threefold strategy (offsets, sustainable, restorative) - closed-loop systems, implementation of services model - operating in industrial ecosystems and stakeholder networks	- treating nature as a stakeholder
Social	- understanding stakeholder's needs and expectations - educating and consulting stakeholders	- balancing stakeholders' expectations, sharing resources among - stakeholders, and building relationships

The seminal research work developed by **Schaltegger et al. (2012)** provides a comprehensive view of the main literature about creating 'business cases for sustainability' (Schaltegger et al. 2012). The foundations of their research's motivation lay on the vision of a business case for sustainability as created for achieving economic success through *voluntary social and environmental activities* instead of increasing economic success while performing in environmental and social issues. Although theoretical and empirical research has proved that most companies have potential for one or more business cases for sustainability but it is often not recognised due to because of inaccurate accounting and management information systems (Schaltegger et al. 2012). According to Schaltegger et al.'s research, the creation of business case(s) for sustainability will require "***strategic management*** *to identify, create and strengthen the links between non-monetary social and environmental activities*

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on the one hand and business or economic success on the other hand". Therefore, it will be necessary to manage business cases for sustainability and consequently to understand **how the drivers of a business case can be positively influenced with societal and environmental activities**. Looking into the drivers of the business case for sustainability they propose, as variables which directly and indirectly influence economic success or performance, we find relevant insights for identifying critical elements to take into consideration (Table 10). We suggest analysing all voluntary social and environmental projects in terms of their influence on these drivers (Schaltegger et al. 2012).

TABLE 10: DRIVERS TO BUSINESS CASE FOR SUSTAINABILITY (ADAPTED FROM SCHALTEGGER ET AL. (2012))

Drivers of business case for sustainability	Description
Costs & cost reduction	Related to energy savings, the reduction of material flows or cleaner production
Risks & risk reduction	The reduction of technical, political, societal and market risks
Sales and profit margin	Increase of the benefits of the company
Reputation and brand value	If the company's reputation and brand value are increased, the sales could also increase
Attractiveness as employer (indirect influence)	Recruiting and selection, induction and development programmes oriented towards circular economy culture
Innovative capabilities (indirect influence)	The capability to innovate which sustainability can improve because thinking in diverse dimensions is encouraged; more diverse knowledge sources

Furthermore, these authors argue that **business model innovation may be required to support a systematic, ongoing creation of business cases for sustainability** and they provide *"a framework for business model innovation as a means to strategically create business cases on a regular basis as an inherent, deeply integrated element of business activities" (pg. 96)*. Such a framework results in a **basic typology of sustainability-oriented business innovation** based on sustainability strategies. Thus, we have the following combinations of sustainable strategy-business model innovation-business case drivers to help practitioners:

- Defensive strategic management to protect the current business model; it affects few business case drivers and in a modest way → does not create substantial business cases for sustainability.
- Accommodative strategic management to experiment within the given business model; exerting some influence on business case drivers by experimenting within the current model → less fundamental influence than proactive strategies.

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- Proactive strategic management leading to business model redesign; address many business case drivers strongly and continuously, with the effect of regular creations of business cases for sustainability.

In his attempt to develop a new scheme of Business Model Canvas – The Circular BMC - Lewandowski (2015) provides an adapted explanation of all its dimensions taking into account the CE principles (Lewandowski 2016). He adds two new constructs: **Take-Back-System** (the design of the *take-back management system* including channels and customer relations related to this system) & **Adoption factors** (transition towards circular business model must be supported by various *organizational capabilities and external factors)* (Lewandowski 2016, p.20). According to this author's statements, some key advantages of its CBMC in comparison to other existing alternatives (original canvas or the archetypes of sustainable business models) should be highlighted such as, among others, "***it combines the original components of the canvas with CE principles in one framework***, which as a practical tool is easier and more user friendly than the triple-layered business model canvas (TLBMC) aimed to support the creation of sustainable business models developed by (Joyce & Paquin 2016).

Within the field of Public Procurement, considering it as the acquisition of goods and services by the public sector through a public contract (Witjes & Lozano 2016), the opportunity to link "sustainable business models" (SBM) to "Sustainable Public Procurement" (SPP) is described in detail by **Witjes & Lozano (2016).** They assure that there is scarce academic research focusing on linking SPP and SBM. Their study is one of the result of the EU funded project "REBUS" (http://www.rebus.eu.com/) which refers to Circular Procurement. These authors develop the **ProBiz4CE framework** (**¡Error! No se encuentra el origen de la referencia.**), which **includes technical, non-technical and socio-cultural specifications and sharing responsibility of the product/service combination**.

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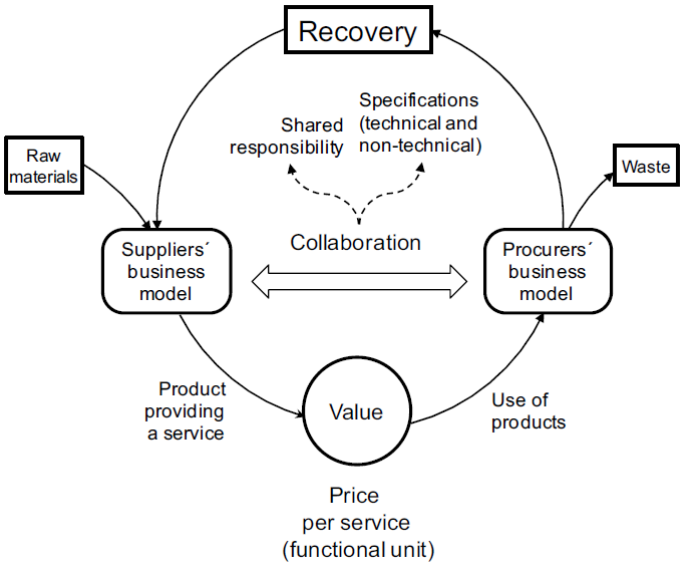

FIGURE 23: PROBIZ4CE FRAMEWORK - COLLABORATION BETWEEN PROCUREMENT AND BUSINESS MODELS FOR CE FRAMEWORK (WITJES & LOZANO, 2016)

This framework proposes that *"such technical specifications, as well as non-technical ones (e.g., maintenance and end-of-life take-back), are co-developed and decided between the government agency and the potential suppliers (e.g., office furniture manufacturers)"* (Witjes & Lozano 2016). According to their study, several countries are taking the advantage of including Sustainable Public Procurement into their public policies (e.g., Japan, Philippines). At European level, the European Commission (EC) has also included sustainability criteria in their procurement processes (European Commission, 2011[7]) and some countries are leading the application of SPP such as Germany, Austria and the United Kingdom (Witjes & Lozano 2016). Also derived from their study we find that despite the large number of authors discussing sustainable business models, studies focused on the link between SPP and more sustainable business models is still limited (Brammer & Walker 2011). The aspect of collaboration appears of critical importance, mainly with regards to supplier engagement. Exploring such collaboration will be considered as a critical element due to the fact that it affects the company's business model elements and activities. These authors also highlight that adjustments throughout value chains, connecting producers, consumers, investors, distributors, and recyclers will ensure a fair distribution of costs and benefits as far as SPP is concerned (Witjes & Lozano 2016). Uyarra et al. (2014) state that *"in the SPP process, these adjustments are the result of a collaborative*

[7] http://www.europarl.europa.eu/meetdocs/2009_2014/documents/com/com_com(2011)0681_/com_com(2011)0681_en.pdf

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process between suppliers and procurers and the combination of their multiple business models" (Uyarra et al. 2014).

Based on the review of the Witjes & Lozano (2016)'s study, we can conclude that **the collaboration between procurement scheme (procurers and suppliers) and business models** are critical elements that could boost the creation of circular business models.

Revising the study developed by **Giurco et al. (2015)** in which they explore the Australian metals and minerals sector and its potential to create new business models orientated towards sustainable futures and they aim to characterise contemporary business models and the policy landscape for metals recycling industries in Australia, as well as to evaluate potential opportunities for value creation with new business model concepts applicable to metals (Giurco et al. 2015). From their study, some critical elements, identified as 'key success factors and capacities', will serve to deal with our analysis in this section. Taking into account the differences in the conceptualisations of circular economies between the countries, they noted some common key success factors (Table 11). Giurco et al. (2015) point out that these success factors underline the government support that reinforces appropriate policies and regulation boosting infrastructures investment for scaling up from individual firm initiatives to system scale.

TABLE 11: KEY SUCCESS FACTORS FOR IMPLEMENTING CIRCULAR ECONOMIES (GIURCO ET AL. 2015)

Perspective	Description
Political	Governmental structures providing long-term and consistent support frameworks, enabling circular economy activities
Legal	Legal and regulatory support (e.g., product and material eco-design)
Financial	Availability of investment capital (e.g., for new infrastructure)
Organizational	Capabilities for developing and disseminating knowledge
Business Innovation	Capacity for innovation and support for entrepreneurial activities
	New business models (e.g., sharing economy models, and businesses utilising waste stream flows as process inputs)
Economic	Methods and indicators for measuring and monitoring progress (social, economic and environmental)
Social	New consumption modes and lifestyles (underpinned by greater awareness)
	Recognition of natural limits and systems' boundaries (material, water, energy reduction)

As explored by **Mentink (2014),** many actors (business, government, universities and other organizations) interact with all the aspects of CE reflecting their specific goals and interests in CE and focusing on different aspects (Mentink 2014). The author illustrates in a radar diagram the different actors that want to implement CE and their underlying interests to do it (Figure 24). All these aspects are classified taking into

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account the three main goals of sustainability and some 'not covered' issues of CE are clearly recognised.

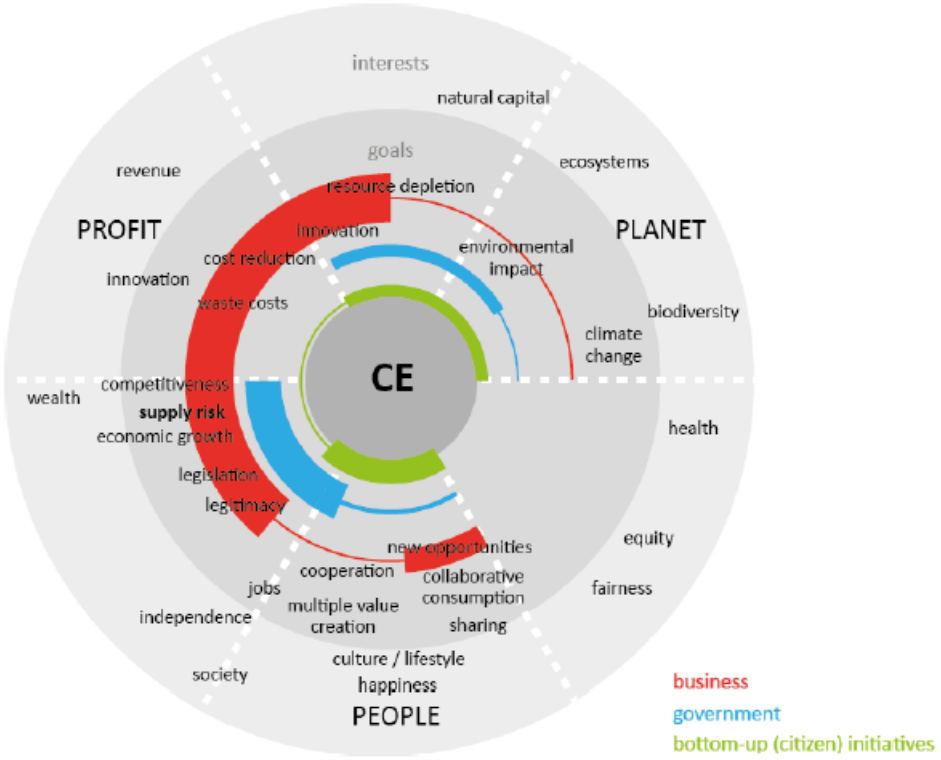

FIGURE 24: DIFFERENCES IN GOALS AND INTERESTS IN THE CONCEPT OF CE (SOURCE: MENTINK, 2014)

According to Mentink (2014), none of the actors covers the complete circle as far as all the elements of sustainable development are concerned (i.e.: balance social, ecological and economic values)d, 2012) and it could indicate that "*the concept of CE does not support them very well to set goals to balance the three sustainability values (People, Planet, Profit)*" (Mentink 2014: 21). Moreover, he asserts that since CE often depends on **collaboration between different agents, it is important to align goals of a CBMI process**. In that sense for instance, business's main goal with implementing a CE is to reduce risks of continued (long term) supply of resources however, CEOs do not usually project large investments rather the focus remains on acquiring new customers and improving operational effectiveness (i.e. economic growth and more profit) (see Schoolderman, Van den Dungen, & Van den Beukel, 2014 in (Mentink 2014)).

This author grounded his Circular Business Model Innovation (CBMI) framework on the following statement: methods and tools to support thinking in business systems and to manage and organize the implementation of a new CBM are still absent in empirical literature. While developing the CBMI framework, this author has been able to identify

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some gaps in the fields of business, organization, change management and transition management for creating new methods and tools. This author further highlights some key aspects to take into account for operating in CE with success (Table 12):

TABLE 12: LIST OF RECOMMENDED FUTURE RESEARCH BY MENTINK (2014)

Perspective	Description
Organizational	Challenges such as overcoming internal resistance, setting up pilots and organizing learning processes adjusted to CE
Organizational	Translate the application of existing strategies, methods and practical experiences of **transition management** to the **transition to a CE**
Organizational	Improved methods or tools to describe **functional needs or performances**
Organizational	Practical guidance - support companies on a practical (e.g., step by step) level **to determine the evolution stage** of both the industry and product or component
Economic, environmental	A rapid **circular performance evaluation tool** that can monitor which material loops are actually being closed
Organizational	Tools for finding the **right partners and organizing collaboration and co-operative arrangements**

Within organizational theory, innovation studies research has a strong empirical orientation that commonly provides distinctive and different kinds of innovations, as well as external drivers, governance features and competencies underlying sustainable innovation versus 'normal' innovation (Christensen et al. 2017). Recently, academic literature highlights that 'sustainable innovations' deal with particular commercialisation barriers that make them more dependent on public regulation and support (Christensen et al. 2017).

Drawing from their own research, **Whelan and Fink (2016)**[8] create a sustainability business case for the 21st century organisation. According to these authors sustainability-based management can provide benefits that are feasible through a set of organizational sustainable practices that *at minimum do not harm people or the planet and at best create value for stakeholders* and *focus on improving environmental, social, and governance (ESG) performance* (Whelan & Fink 2016).

The following table gathers all those practices that yield positive impacts for companies (From sustainable business case perspective, they will be included in the list of critical elements for PaperChain reference framework.

TABLE 13: ORGANISATIONAL PRACTICES THAT FORM SUSTAINABLE BUSINESS MODEL (SOURCE: WHELAN & FINK (2016)

[8] [Last access 10th Nov 2017] https://hbr.org/2016/10/the-comprehensive-business-case-for-sustainability

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Organisational practice	Description
Driving a competitive advantage through stakeholder engagement	Sustainable businesses models create value for the whole corporate ecosystem - The strategic value of sustainability comes from the need to continually talk with and learn from key stakeholders
Improving risk management	Sustainable business models require managing risks which in turn requires making investment decisions for longer-term capacity building and developing adaptive strategies
Fostering innovation	Investing in sustainability can also drive innovation
Improving financial performance	There exists the erroneous perception among business leaders that companies can have profits or sustainability, but not both. Companies are realizing significant cost savings through environmental sustainability-related operational efficiencies - better ESG performance drives towards better financial performance.
Building customer loyalty	Currently consumers expect more transparency and tangible global impact from companies, and moreover, sustainability information has a significantly positive impact on consumers' evaluation of a company, which translates into purchase intent.
Attracting and engaging employees	Companies that invest in sustainability initiatives tend to create sought-after culture and engagement due to company strategy focusing more on purpose and providing value to society. In addition, companies who embed sustainability in their core business strategy treat employees as critical stakeholders, just as important as shareholders.

Selection of those critical elements in terms of Business Case for Sustainability

Aligned with one of the objectives of this deliverable and following a similar approach than in previous section 3.2.2, we present in this section the list of critical elements derived from the perspective of Business Case for Sustainability that will be incorporated to the Reference Framework.

In the following table some additional information is provided as well as its classification, based on the proposed dimensions mentioned at the beginning of this section 3.

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TABLE 14: CRITICAL ELEMENTS RELATED TO BUSINESS CASE FOR SUSTAINABILITY

CRITICAL ELEMENTS from 'Business Case for Sustainability'	Description	Dimension of the Reference Framework - How do we translate to the RF?	Source
Proactive strategic management	Address many business case drivers strongly and continuously, with the effect of regular creations of business cases for sustainability	Process - *description of the process* Organizational – *establish a strategic goal*	(Schaltegger et al. 2012)
Costs & Cost reduction	Related to energy savings, the reduction of material flows or cleaner production	Economic & Finance - *Establish a KPI*	
Risks & Risk reduction	The reduction of technical, political, societal and market risks	Process - *Establish a process for risks management in terms of sustainability*	
Sales and profit margin	Increase company's benefits	Economic & Finance - *Establish a KPI*	
Reputation and brand value	If the company's reputation and brand value are increased, the sales could also increase	Economic & Finance - *Establish a KPI* Market Strategy/Organizational -	
Attractiveness as employer (indirect influence)	Recruiting and selection, induction and development programmes oriented towards circular economy culture.	Social – *Cultural Values (impulse cultural change that favour the transition)* Organisational – *Skills*	
Innovative capabilities (indirect influence)	The capability to innovate which sustainability can improve because thinking in diverse dimensions is encouraged and more diverse knowledge sources	Business Model Innovation – *Skills*	

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CRITICAL ELEMENTS from 'Business Case for Sustainability'	Description	Dimension of the Reference Framework - How do we translate to the RF?	Source
STRUCTURAL Attributes of a Sustainable Business Model	**Economic Perspective:** e.g., lobbying for changes to taxation system and legislation to support sustainability **Environmental Perspective**: e.g., closed-loop systems, implementation of services model; operating in industrial ecosystems and stakeholder networks **Social perspective**: understanding stakeholder's needs and expectations	Strategic / Organisational – *Define organization strategy on economic, environmental and social terms as well as the structural and cultural design characteristics accordingly* *"A SBM Draws on Economic, Environmental and Social Aspects of Sustainability in Defining an Organization's Purpose"* *"A SBM Uses a TBL Approach in Measuring Performance"* *"A SBM Considers the Needs of all Stakeholders Rather than Giving Priority to Shareholders' Expectations"*	(Stubbs & Cocklin 2008)
CULTURAL attributes of a Sustainable Business Model	**Economic Perspective:** e.g. considering profit as a means to do something more ("higher purpose"), not as an end **Environmental Perspective**: e.g. treating nature as a stakeholder **Social perspective**: e.g. balancing stakeholders' expectations, building relationships		
Sustainable Public Procurement – collaboration for Sustainable Business Models	The collaboration between procurement scheme (procurers and suppliers) and business models Includes technical, non-technical and socio-cultural specifications that are co-developed and decided between the government agency and the potential suppliers	Organizational – *Strategy for boosting new CE models through the SPP* Political & Legal –*Finding Appropriate governmental support from Public Procurement*	(Witjes & Lozano 2016)
KEY SUCCESS FACTORS – Implementation	Governmental structures providing long-term and consistent support frameworks, enabling circular economy activities	Political & Legal support framework	(Giurco et al. 2015)
	Legal and regulatory support (e.g., product and material eco-design)		

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CRITICAL ELEMENTS from 'Business Case for Sustainability'	Description	Dimension of the Reference Framework - How do we translate to the RF?	Source
	Availability of investment capital (e.g., for new infrastructure)	Financial – *Searching process for (public/private) investment*	
	Capabilities for developing and disseminating knowledge	Organizational - *Appropriate Skills*	
	Capacity for innovation and support for entrepreneurial activities	Organizational - *Appropriate Skills*	
	New business models (e.g., sharing economy models and businesses utilising waste stream flows as process inputs)	Business Innovation – *Innovation management process adapted to CE*	
	Methods and indicators for measuring and monitoring progress (social, economic and environmental)	KPIs – selection of the appropriate KPIs and monitoring tool Aligned to Organisational Strategy in Sustainability, in Business Innovation, in CE…	
	New consumption modes and lifestyles (underpinned by greater awareness)	Social – *Company's contribution to Social Aspects of Sustainability*	
	Recognition of natural limits and systems boundaries (material, water, energy reduction)		
Transition Management	Translate the application of existing strategies, methods and practical experiences of transition management to the transition to a CE	Organizational – *set up strategies, methods and best practices for transition to a CE model*	
Collaboration & formal agreements (stakeholders)	Tools for finding the right partners and organizing collaboration and co-operative arrangements	Organizational – *stakeholders' network*	
Driving competitive advantage through stakeholder engagement	Continuous talk with and learn from key stakeholders	Organizational – *stakeholders' network*	(Whelan & Fink 2016)

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CRITICAL ELEMENTS from 'Business Case for Sustainability'	Description	Dimension of the Reference Framework - How do we translate to the RF?	Source
Improving risk management	Managing risks requires making investment decisions today for longer-term capacity building	Support - *Processes*	
Fostering innovation	Investing in sustainability drives innovation	Circular Business Innovation	
Improving financial performance	Significant cost savings through environmental sustainability-related operational efficiencies; better ESG performance drives towards better financial performance.	KPIs - ESG performance	
Building customer loyalty	Currently consumers expect more transparency and tangible global impact from companies	Business Model Innovation – *Customer perspective* Organisational – *Market dimension*	
Attracting and engaging employees	Companies that invest in sustainability initiatives: company strategy focused more on purpose and providing value to society.	Social dimension	

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3.2 Selection of critical elements

To sum up, all the critical elements have been grouped and listed in the fooling table after joining the inputs from Chapter 2 and from the section in this chapter 3. All those critical elements will be appropriately translated to the reference framework in Chapter 5.

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CIRCULAR BI

- Proactive strategic management
- Innovative capabilities
- Building customer loyalty
- Previous experience in circular economy projects based on other ongoing process streams and products
- Limited initial awareness of the positive impact of the CE model in road and highway construction
- Fostering innovation: Investing in sustainability drives innovation

TECHNICAL

- Implementation of new process to meet the required quality standard
- Demonstration (at industrial scale) planning process is quite relevant
- Investment planning process adapted to CE model of resource recovery
- Supply chain management
- Waste transportation is challenging
- Diversity and quality of wastes that influence the properties of the new product
- Technical challenges are mainly linked to the scale-up of the technology
- There is a need to have specialised skill and adapted machinery
- Product design that make disassembly difficult, or impossible

ECONOMIC & FINANCE

- Cost structure of the model must be inferior of the revenue stream for the circular model to be viable
- Major up-front investment costs: for the waste manager; in the construction phase; the cost of homogenisation and mixing of material at the construction site.
- Considerable amount of cost involved for on-site machine modifications
- Improved security of products supply.
- Economic viability analysis of the new solution:
- Economic viability analysis of the investments:
- Loss of competitiveness of the GLD transport can be compensated by a constant GLD availability and considering the overall cost/benefit balance analysis
- PESTEL analysis – periodical review of the macroeconomic aspects evolution or legal changes
- It will be implemented an efficient QA/QC
- Long term Environmental Monitoring costs
- Extra financing alternatives or 'the regulation/economics stream" - political regulation on enterprises' environmental practices and financial performance

ENVIRONMENTAL

- Some KPIs on environmental performance have been identified:
- Tons of landfill avoid per year; Recycled material will replace the natural aggregate which will contribute to the lower CO2 emission for the whole construction; less environmental impact due to less transport; reduction of carbon footprint
- Risks management/LCA analysis
- Best practice document needs to be developed by the Waste manager for the logistics and construction company.

SOCIAL

- To inspire attractiveness as employer - recruiting and selection, induction and development programmes oriented towards circular economy culture.
- Some KPIs on environmental performance have been identified: job creation, e.g. in transport and processing raw materials; the use of new geotechnical structure for landslide support could increase the number of employees in the Slovenian railway (SZ) company;
- Encouraging cultural transition towards CE in order to gain target stakeholders (society, employees, government) attention and acceptance in general but in particular in those sectors introducing in the CE field

LEGAL

- Lack of consistent legislation regarding end-of-life phase of products
- Authorisation license delivered by a certification body to enable the use of the products created
- The legal status over the utilisation of waste as a new raw material is not allowed at the moment of initiating the CE model

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4 Systemic analysis

Once the critical elements were identified, the interactions of those elements were evaluated following a systemic approach in order to discover the role of each critical element in the complexly interlinked circular economy model or system. The role of those critical elements is related to **how their interactions with other elements of the ecosystem** (all stakeholders that operate in the circular economy model) **enable or hinder the development of a circular economy**.

First the advantages of System Dynamics to the critical analysis that has been made in the precedents chapters are highlighted. Then, a qualitative analysis of the main relationships between the critical elements and their interactions are completed. Such analysis has allowed us to discover the leverage points. They represent those elements that promote and sustain the circular economy model. Then we portray a graphical representation of a System Dynamics causal diagram which helps define the key interactions among the elements of the Reference Framework that is described in Chapter 5.

4.1 Introduction

> *"System dynamics is a powerful method to gain useful insight into situations of dynamic complexity and policy resistance. It is increasingly used to design more successful policies in companies and public policy settings."* (Sterman 2000, p.3910)

> *"The field of system dynamics today is healthy and growing.* [It] *is increasingly used in corporations, government and other organizations. It is taught in a growing number of universities and schools, including secondary, middle, and even primary schools. It is applied to issues from organisational change to climate change, physiology to fiscal policy."* (Sterman 2007, p.90)

Decisions makers sometimes are forced to make decisions with incomplete information that they can only explain with the best available representative models. To represent the real world in the most complete way taking into account an increasing complexity is difficult and it is possible to obtain wrong conclusions about the behaviour of the system. Sterman (2000) suggests that every model should allow us **to understand the imperfections and constraints of the system** that we are aiming to represent. System Dynamics as a simulation methodology was specifically developed to support the study of dynamic behaviour in complex systems (Hjorth & Bagheri 2006).

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For the purpose of Task 3.2, System Dynamics (SD) modelling has been chosen as a modelling technique to model complex systems which involves interactions and feedbacks (Sterman 2000).

We would like to illustrate **a foundational basis for choosing this method in PAPERCHAIN project**. In order to better understand the reasons for selecting SD firstly, some fundamental premises of SD are summarized following, and then its main definitional characteristics are illustrated in order to show in a next step the main advantages of this modelling technique for the task's purpose. Additionally, and more importantly, some examples of SD in practice are provided related to circular economy field.

Foundations of System Dynamics

Derived from systems thinking, as art and science of linking structure to performance, and performance to structure (Richmond 1991), System Dynamics combines the theory, methods, and philosophy needed to analyse the behaviour of systems in many research fields such as management, environmental change, politics, economic behaviour and engineering (Hjorth & Bagheri 2006).

System Dynamics is a construct that has been used to define a simulation methodology, computational based and originally created and applied by Forrester (Forrester 1961) to develop and analyse models of systems and their behaviour. The focus is on modelling the behaviour of the system as a whole, rather than modelling the behaviours of actors within the system (see Forrester, 1961).

The premises of SD are the following:

1. The models created by applying SD focus on modelling the behaviour of the system as a whole, rather than modelling the behaviours of actors within the system (Harrison et al. 2007, p.10). From the organisational point of view, **the behaviour of the organization is caused mainly by its structure** (tangible and intangible aspects dominate the decision making in organisations).

2. At the system level, these models simulate the processes that lead to changes in the system over time (Sterman 2000). From the organisational point of view, **management decisions are made over such structure** that is represented by information feedback systems.

3. Although all the models are a simplified representation of reality which aims to provide a higher understanding of it, with SD we will be able to know **how the interrelations between the elements of the system originate unexpected or side effects over the system as a whole** (Sterman 2000).

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Models created with SD could help decisions makers (for this research, circular economy management) in giving structure to a problem, in reviewing several intervention options and in assessing their impact over the results; furthermore, they allow different agents to debate about several dimensions of the same problem. Their individual and shared mental models will improve and, as consequence, they will be able to learn (Morecroft 1992). Kunc and Morecroft reveal that system dynamics modelling can support the process of strategic development. They also state that "*Modelling is fundamentally the art and science of interpreting complexity, and there is always a choice about how much detail to include, depending on the purpose*" (Kunc & Morecroft 2007, p.188). Through the application of SD, managers are able to develop a shared understanding of complex situations and test the effect of specific business policies.

Characteristics of System Dynamics

SD methodology is rooted in engineering control theory and has been used to model and analyse companies, industries, complex projects, and more. Having described the advantages of SD in general, its fundamental principles are listed as follows:

1) **Non-linearity in relations between elements**: System Dynamics is characterised by abandoning the typical linear vision that is usually applied to organisational problems and it is focused on cause-effect relationships. The non-linearity in the relations of the variables of the system can originate that different systems respond in a different way to the same corrective action applied to address the same problem.

2) **The feedback loop is the basic structural element of systems**. SD highlights feedback processes, or circular causal relationships in which variables influence and, in turn, respond to each other. They represent cause-effect relations between the variables. Since the decision maker is part of the feedback process, he or she receives influence from the reality and he or she influences over it. In all systems there will exist one or more feedback loops that interact each other defining its dynamic behaviour as a consequence of a combination of positive and negative feedback loops.

A causal diagram consists of variables connected by arrows denoting the causal influences among the variables. The important feedback loops are also identified in the diagram. Figure 25 shows an example and key to the notation. In the example, the birth rate is determined by both the population and the fractional birth rate. Each causal link is assigned a polarity, either positive (+) or negative (-) to indicate how the dependent variable changes when the independent variable changes. The important loops are highlighted by a loop identifier which shows whether the loop is a positive (reinforcing) or negative (balancing) feedback.

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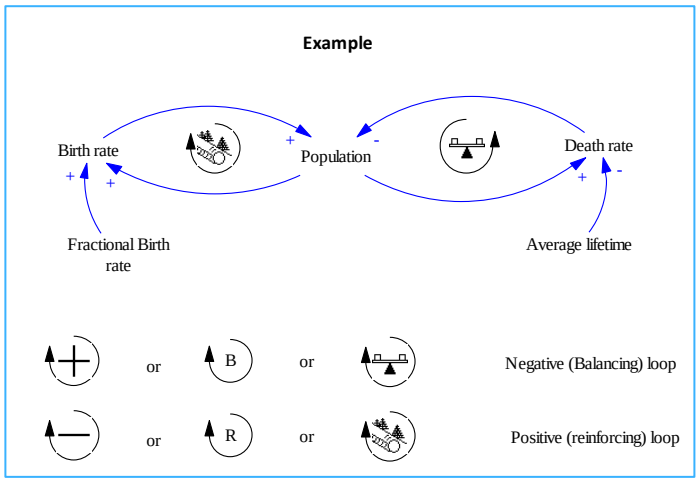

FIGURE 25: CAUSAL LOOP DIAGRAM NOTATION (ADAPTED FROM STERMAN, 2000)

A balancing loop (**positive** link) means that if the cause increases, the effect increases above what it would otherwise have been, and if the cause decreases, the effect decreases below what it would otherwise have been[9]. A reinforcing loop (**negative** link) means that if the cause increases, the effect decreases below what it would otherwise have been, and if the cause decreases, the effect increases above what it would otherwise have been[10].

3) Variables typology - **stocks and flows**: Stocks represent the accumulation of resources in a system while flows represent the rates of change that alter those resources (Sterman, 2002: 34). Sterman explains in detail its distinctive features (Sterman, 2002: 192):

- Stocks characterize the state of the system and generate the information upon which decisions and actions are based (e.g. the inventory of a manufacturing firm is the stock of product; the number of people employed by a business is a stock);
- Stocks are altered by inflows and outflows (flows variables) and they create delays by accumulating the difference between the inflow to a process and its outflow (e.g. a firm's inventory is increased by the flow of production and decreased by the flow of shipments);

[9] *In the example in Figure 25 an increase in the fractional birth rate means the birth rate (in people per year) will increase above what it would be, and a decrease in the fractional birth rate means the birth rate will fall below what it would be. That is, if average fertility rises, the birth rate, given the population,will rise; if fertility falls, the number of births will fall. (Sterman, 2000:139)*

[10] *In the example, an increase in the average lifetime of the population means the death rate (in people per year) will fall below what it would be, and a decrease in the average lifetime means the death rate will rise above what it would be. That is, if life expectancy increases, the number of deaths will fall; and if life expectancy falls, the death rate will rise. (Sterman, 2000:139)*

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- Failure to understand the difference between stocks and flows often leads to underestimation of time delays, a short-term focus, and policy resistance.

4) In the system also occur **delays**. The existence of delays implies that the effects of decisions do not appear immediately; instead they occur along the time. For instance, when a business organization orders supplies, the supplies usually arrive only after a delay. Two types of delays can be considered or studied: delays resulting from the time involved in processing physical materials and delays resulting from the time involved in perceiving and acting upon information. This characteristic of dynamic modelling offers a great benefit over static modelling: it allows focusing on time changes and it provides the opportunity to anticipate the consequences that, in short, medium and long term, the adopted decisions will have.

Systems perspective: contribution to PAPERCHAIN project

System Dynamics emerges from the so called systems movement. Some distinctive features of SD have been cited in the previous section that fit to the notion of considering a circular economy model as a complex problem that should be evaluated from a systemic perspective (e.g. Hjorth & Bagheri 2006; Abdelkafi & Täuscher 2016; Haack 2017). In line with this argument, findings in sustainability literature provide various examples that attempt to conceptualize a systemic analysis of circular economy models.

From a global perspective, the impact or the transition towards a more circular economy is one of the concerns to the European Commission. The EEA (European Environment Agency) highlights that for the time being, there are pending answers to some unknowns with regards to the practical implications of circular economy transition such as, among others, how the benefits or negative effects of a more circular economy can be assessed. The appropriate answers to such questions can help policymakers, investors, businesses, consumers and civil society to find the most promising transition pathways (European Environment Agency (EEA) 2016, p.5). The EEA acknowledges that the current knowledge base is rather fragmented: "***Better insight is needed into various aspects of system dynamics****, such as production structures and functions, consumption dynamics, finance and fiscal mechanisms, and triggers and pathways for technological and social innovations*"(European Environment Agency (EEA) 2016).

In their study, Schaltegger et al. (2012) already highlight the fact that the path of influence (or cause-and-effect link) of the business or economic effect of environmental and social activities could be indirect as well as involving non-market links and actors such as political initiatives, and NGOs (pag. 101). A basis for discussion of the link between three dimensions is established: **business cases for sustainability**, **sustainability-oriented strategies**, and **business model management**. These authors

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place the business case drivers as "*intermediating variables which **link** the **corporate sustainability strategy** with the '**architectural' business model level** of a firm*" (Schaltegger et al. 2012, p.102).

Within the field of Systemic Design, the RETRACE project uses systemic design as an effective methodology for the transition to circular economy (The RETRACE project 2017). The RETRACE project faces stimulating challenges with regards to the role of circular economy according to a sustainable development and how policymakers can address it in their activities. One of its objectives lays on discovering an appropriate methodology that policy managers can use in order to define a clear path towards a circular economy in their regions. The authors (Barrero, S. in Chapter 2.4) state that the connections between circular economy and the systemic design approach, helps to define a methodology for reaching the common goal of local sustainable development that all policymakers aim to achieve. One of its publications, 'SYSTEMIC DESIGN METHOD GUIDE FOR POLICYMAKING. A Circular Europe on the Way' gives large space to a design method that helps all the actors involved in policymaking processes to define a successful way towards the circular economy. In this respect, effective policy making implies a combination of many policy interventions that require stimulating the cooperation among different actors over networks (Ruggieri et al., 2016). Thus, circular economy transition should be dealt from "*a holistic and integrated approach where the number of variables and relations generates a complex environment*" (Barrero, S. in The RETRACE project 2017, p.9).

Within the research field of business models for sustainability, a huge variety of approaches dealing with understanding exists, developing or analysis those business models (Abdelkafi & Täuscher 2016). However, "*they do not fully conceptualize the relationship between the company, its customers, and the natural environment*" (Abdelkafi & Täuscher 2016).

> "*Specifically, they* [BMfS] *do not explain how value creation, natural environment, and profit generation (captured value) can mutually complement and reinforce each other.*"(Abdelkafi & Täuscher 2016, p.75)

According to these authors **system thinking is a promising approach to study business models for sustainability**. Among other complementarities that they found in literature, they highlight for instance that business model components lead to reinforcing feedback loops as well as the basic reinforcing feedback loops between the firm's value creation and profit generation.

In their study, **Abdelkafi & Täuscher (2016)** provide insights that help to graphically represent the dynamics of business models for sustainability and moreover, to identify the main causal loops in the system structure. Their attempt to develop a conceptual model for BMfS finally demonstrates how value creation capacity, value to the

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customers, value to the natural environment, and captured value can reinforce each other (Abdelkafi & Täuscher 2016). The new perspective on BMfS that these authors provide to the academic arena, combining many insights from the literature into a coherent conceptual model that uses system dynamics notation, allows to set up relevant managerial implications at four different levels: the firm, the environment, the decision maker, and the customer. **Some of their model's recommendations will be an invaluable input for the SD model that this deliverable aims to portray**. They are the following:

- Their model supports decision makers in understanding how the business model can affect the natural environment.
- Their model reveals the direct, and mostly indirect, impact of the natural environment on the firm.
- Their system dynamics model illustrates the different types of stocks and flows that relate the main stakeholders of a BMfS.
- Their model represents important feedback loops explaining the rationale of a BMfS from a stakeholder perspective.

Grounded on the perspective of considering sustainable development as a dynamic process (nor a state of the system or a static goal), it is formed by reinforcing and balancing feedback loops in which balancing loops are allowed to act normally, as they must do in order to guarantee the system to work everlastingly by controlling destroying reinforcing loops (Hjorth & Bagheri 2006). As **Hjorth & Bagheri (2006)** state, from the perspective of ecosystems, the 'planning for sustainable development' should be based on identifying the **viability loops** and to keep them functional in any sustainable development process. In their study, these authors show the causal loop diagrams for human needs, economic, environmental, and life services structures and exhibit how the sustainability dynamic process actively adapts the system to changes (Hjorth & Bagheri 2006, p.90).

"The System dynamics approach helps us to better understand the dynamic relations in the system and become aware of their changes through a learning process. This perception would be helpful to set moving targets for the system." (Hjorth & Bagheri 2006, p.90).

Having explained different perspectives that favour the complementarity of SD in circular economy, we analyse the main advantages of SD and link them to the purpose of this deliverable as detailed in Table 15:

TABLE 15: SD METHODOLOGY IN PAPERCHAIN PROJECT

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Strengths[11]	Applicability to PAPERCHAIN purpose
Focus on feedback-driven, mainly internally generated dynamics. **A SD model is a network of closed loops of information but it is not a representation of "closed systems" - (a) flows can originate from outside the system's boundaries, (b) exogenous factors can be incorporated into any model and, (c) new information can be accommodated via changes to a model.**	The Reference Framework should consider the **global interaction of critical elements when implementing** any circular economy model. Thanks to a systemic analysis we will be able: • to identify the appropriate combination of the critical elements • to identify their feedback-driven interactions • to identify the external factors – parameters or change rates (e.g. R&D investment rate)
The focus is on the generation of insights into the patterns of behaviour generated by the systems under study.	The implementation of a circular economy model will have **effects on the whole organization** (business strategy, operations, costs structure, etc.) **that may be (desirably) measured through several qualitative and quantitative indicators**. The reference framework will (help managers to) set up relevant KPIs and SD provides both type of interpretations and measurement.
The representation of dynamic systems in terms of stocks and flows is a generic form, which is adequate for an enormous spectrum of potential applications.	As SD suggests, **any kind of capability can be modelled as a stock, or a set of related stocks, that accumulates or depletes over time** as a result of in-flows and outflows of the stock. When implementing the circular economy model: • the effectiveness of most of the strategic paths that the model provides will be proved in the long term, • Some elements (e.g. capabilities) have an accumulated effect through the whole system and,

[11] *Source: System Dynamics and the Evolution of Systems Movement: A Historical Perspective. Markus Schwaninger. No 52 - June 2005*

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Strengths[11]	Applicability to PAPERCHAIN purpose
	• other elements act as a change rate over other elements (e.g. labour costs).

To sum up, **for this study we propose developing the SD model based on previous studies in the field of circular economy as an exercise of identifying the whole system as well as facilitating global understanding of the dynamic behaviour of the circular models**. Looking at circular models in PAPERCHAIN as a means for fostering the balance between sustainability strategies and the appropriate dynamic capabilities while allowing their adequate organisational and system innovation, SD appropriately fits with the objective of understanding such dynamic behaviour. In doing so, this chapter provides relevant management recommendations to be included in the PAPERCHAIN Reference Framework.

Before representing the SD causal diagram of the circular economy model that PAPERCHAIN contemplates, we need to establish the system boundaries that are going to be explored. It concerns to identifying and determining what the elements of the circular model that will be explored under System Dynamics methodology are.

4.2 System boundaries

As mentioned before, system dynamics includes a variety of tools to help communicate the boundary of the model and represent its causal structure. These include model boundary diagrams, subsystem diagrams, causal loop diagrams, and stock and flow maps (Sterman 2000). A model boundary chart "*summarizes the scope of the model by listing which key variables are included endogenously, which are exogenous, and which are excluded from the model*" (Sterman 2000). Before starting the process of developing the causal loop diagram, we define the dynamic problem and its key variables and concepts.

The system boundary chart includes endogenous variables (variables whose evolution generates the dynamics of a system through the interaction of the variables and agents represented in the model), exogenous variables (those "arising from without," that is, from outside the boundary of the model) and the variables that are out of the system.

Within the research field of business models for sustainability, there is yet a limited body of knowledge on BMfS from a SD perspective and a knowledge gap remains (Haack 2017) however, **the reviewed literature provides us with relevant insights to define the dimensions that will be explored through SD**.

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Haak (2017) explains in his study how the system dynamics between the value configuration, partner network, and capabilities work in a Business Model for Sustainability of small and large architecture firms (Haack 2017).

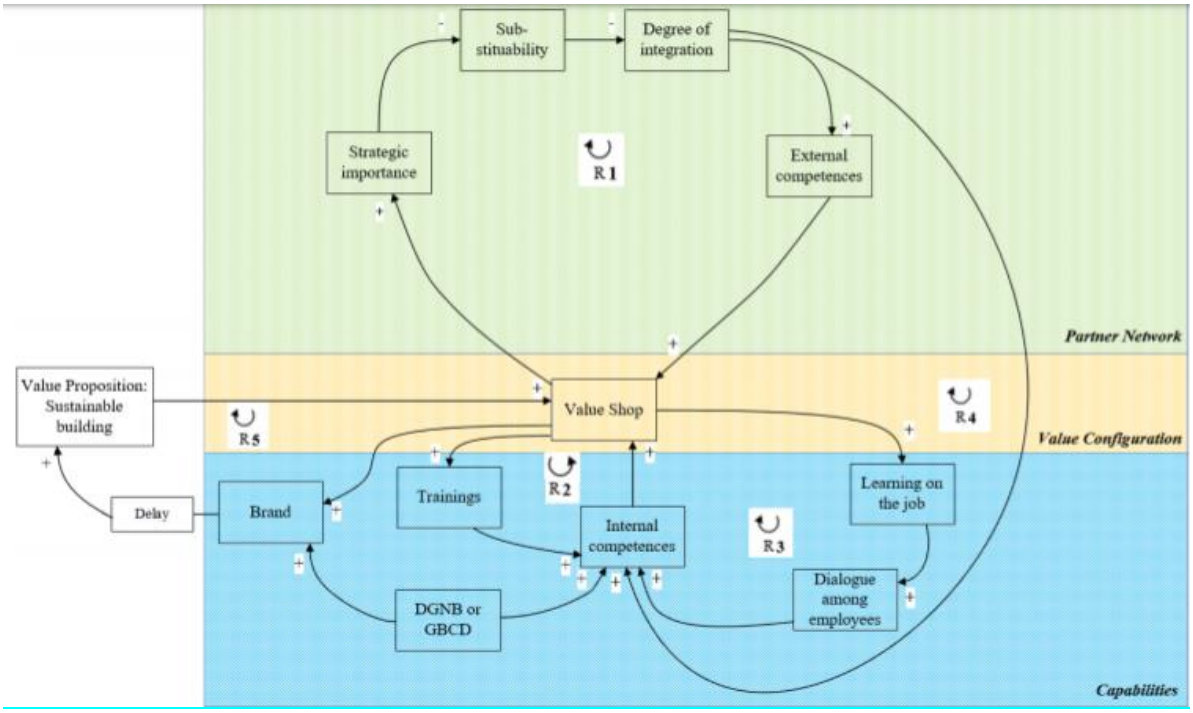

FIGURE 26: CAUSAL LOOP DIAGRAM OF BMFS (Source: Haack 2017)

In the SD model above, the Value Shop (that shows the activities of a firm, whose main activities are problem finding and acquisition, problem solving, choice, execution and control, and evaluation) is for most parts the connector between the Partner Network (external competences) and the Capabilities (internal competences). Based in interviews and literature, this author discovers the following feedback loops:

- R1 allows us to understand that firms are able to constantly deliver on sustainable projects.
- R2 - reinforcing loop, as the trainings are ongoing and reinforce themselves up to a point where firms are starting to integrate the trainings in-house to improve the experience.
- R3 - as firms offer to the market sustainable products, they are learning about how to design them and spread that knowledge with other employees in the firm, eventually increasing the Internal Competences. Those then allow improving the projects done in the Value Shop.
- Through parts of the R1, the learning effect leads to yet another reinforcing feedback loop, R4 - Stemming from the close integration of partners, the firms

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are able to increase their own, internal competences and hence strengthen the sustainability project they can do in the Value Shop.

According to Haack (2017), we notice that working together with partners enhances the quality of the buildings that firms can design. Consequently, any factor that increases the quality of the building will automatically increase the Brand effect. In the same way, Trainings, Learning on the Job, and the high Degree of Integration have an independent effect on the Internal Competences, but rather that all amplify each other (Haack 2017, p.51). The sum of all parts and the product of its interactions determine the overall functionality of the BMfS.

The SD model created by Hjorth & Bagheri (2006) identifies viability loops within four perspectives: human needs, economic, environmental, and life services (Hjorth & Bagheri 2006).

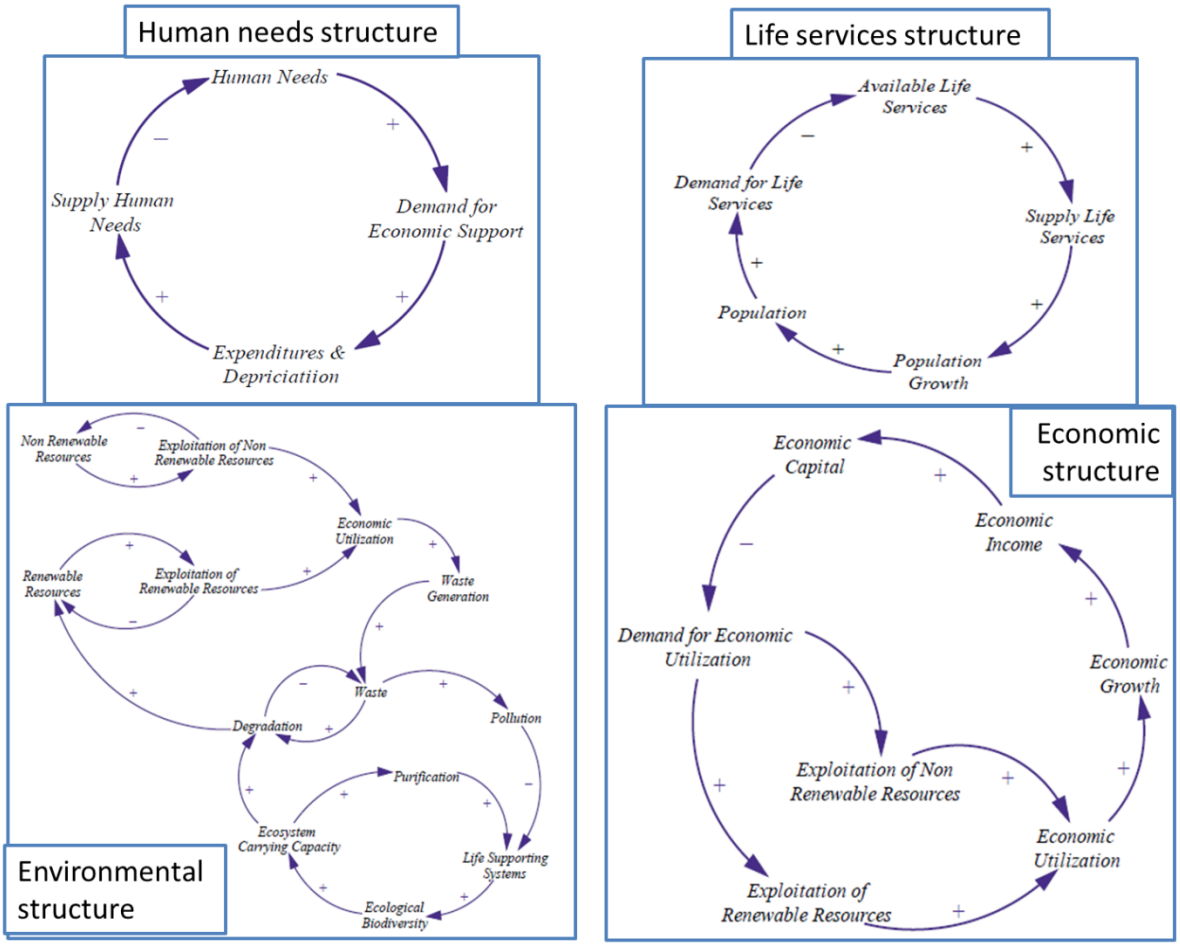

FIGURE 27: SD CAUSAL DIAGRAM FOR BMFS (SOURCE: Hjorth & Bagheri 2006)

The viability loops (Figure 27) that comes from Hjorth & Bagheri's study are described as follows:

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- One loop is associated to *meeting human needs* (balancing loop): Human Needs cause the Demand for Economic Support to be increased which in turn leads to increase in Expenditures and Depreciation to be able to more Supply Human Needs and then, to make them decrease.

- The *economy* loop (balancing loop) begins with Economic Capital which is reduced due to Expenditures and Depreciation, so its decrease will result in increase in Demand for Economic Utilization, the Exploitation of Renewable Resources as well as Exploitation of Non Renewable Resources will be increased resulting in more Economic Utilization. This will enhance Economic Growth which through increasing the Economic Income will close the loop leading to more Economic Capital.

- The *environment* loop starts with Renewable Resources as well as Non Renewable Resources which account for both Exploitation of Renewable Resources and Exploitation of Non Renewable Resources that in turn support Economic Utilization. Economic Utilization increase results in more Waste Generation and consequently more Waste, more Waste causes more Pollution which reduces Life Supporting Systems. This results in less Ecological Biodiversity which will cause the Ecosystem Carrying Capacity to decrease. The environmental loop is not closed back to the Non Renewable Resources and therefore, an alarming signal appears: the trial to reduce the dependency of real life structures on the Non Renewable Resources.

- The *life services structure* loop starts with Available Life Services which support to Supply Life Services, which enhances Population Growth which in turn results in more Population. The increasing Population closes the loop through more Demand for Life Services.

The dynamics of a system arise from the interaction of networks of the different types of feedback loops. In the Hjorth & Bagheri's model, all balancing structures tend to control the state of the system making it sustainable as long as the viability loops function properly. Nevertheless, exogenous changes may cause the loops go into a destroying mode if these threats are not identified and counteracted (Hjorth & Bagheri 2006).

In the Abdelkafi & Täuscher (2016) study, a graphical representation of business models for sustainability is developed through investigating their inner logic as well as integrating different perspectives and system levels (Abdelkafi & Täuscher 2016). The following figure (Figure 28) shows a simple stock and flow diagram of a firm's business model. The model represents three main stocks in the system represented by 'Customer Value Proposition' which is influenced by 'Value Creation Capacity' that in turn influences 'Value captured'.

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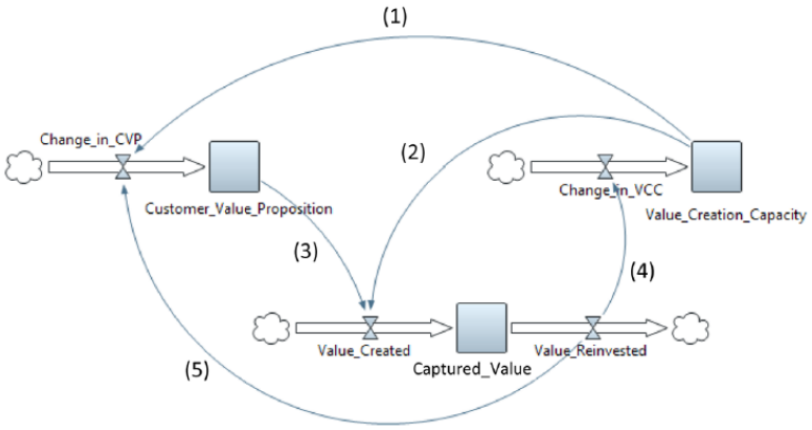

FIGURE 28: SD CAUSAL DIAGRAM FOR BMFS (SOURCE: (Abdelkafi & Täuscher 2016)

Basically, most of these authors have grounded their SD analysis on dimensions similar to those used to represent their causal loop diagrams. After reviewing them, we have compiled them as it is shown in the following table (Table 16).

TABLE 16: DIMENSIONS IDENTIFIED IN LITERATURE FOR DEFINING THE BOUNDARY SYSTEM

Literature sources	Dimensions
Haack (2017)	**Value Configuration**: activities to generate and transfer value, in connection with the relationship thereof, being in house Capabilities and those obtained via the corporation's Partner Network. **Partner Network**: portrays the network of cooperative agreements with other companies necessary to efficiently offer and commercialize value. **Capabilities**: these need to be developed through (1) trainings, (2) internal collaboration, (3) and external collaboration.
Hjorth & Bagheri (2006)	**Human needs**; **Economic**; **Environmental**; **Life services**
Christensen & Truffer (2017)	- The **economic perspective** ('pays-to-be-green'): addresses the questions whether and under which conditions sustainability initiatives pay for private enterprises to go green; i.e. green initiatives and environmental regulation may impose cost disadvantages (or advantages) on enterprises. - The **strategic management perspective**: includes the predominantly organizational economics-based research on how and under which circumstances private enterprises may (or may not) integrate sustainability objectives as part of their commercial business or corporate strategies. - The **institutional perspective**: conceives the enterprise as a social system embedded in a social context of expectations, values and norms and constrained by a broader set of stakeholders than primary market actors, including public authorities, professions, interest groups and the media. - The **innovation studies perspective:** has a strong empirical orientation and an inclination to apply different kinds of theories, in particular organizational and evolutionary economics, and organizational and institutional theory. - The transition (or **systems of innovation) perspective**: addresses the institutional and strategic context for firms' (and other organizations') engagement in radical, systemic and sustainable technological innovation and transition of industries or sectors.

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Abdelkafi & Täuscher (2016)[12]	**Customer Value Proposition**; **Value Creation Capacity**; **Value captured**; **Environmental Value Proposition** (following the logic of the customer value proposition, this stock represents the intended impact from the firm's perspective).
Ruggieri et al. (2016)	A meta-model of inter-organisational cooperation in a circular economy: • **Regulation**: the set of compulsorily laws and norms for business organizations. • **Stimuli**: incentives to business organizations, usually by policymakers. Fiscal and financial incentives (e.g. to grant tax reliefs) or financial contributions to organizational innovation processes that increase environmental sustainability of production and processes. • **Consumer behaviour**: the behavioural choices of consumers that orient their decision whether to buy or not products or services. • **Organisational innovation** in (a) process; (b) product; (c) business innovation. Actions related to organisational innovation lead to increased environmental sustainability through **reduced use of resources** and **reuse of waste**. • Both the organisational innovation process and the potential reuse of waste enable **inter-organisational cooperation** for the mutual exchange of resources[13].- **Inter-organisational symbiosis:** situation in which a business organization is symbiotic with another one or more.

Based on the reviewed literature sources as well as on the inputs we have received from Circular Cases in PAPERCHAIN project, we have structured all the main components that should be taken into consideration for designing the model boundary chart and it is represented in the figure below (Figure 29).

[12] *To demonstrate the connections between the four key value dimensions, these authors integrate the business case drivers identified by Schaltegger et al. (2012) as mediating variables: Costs & cost reduction; Risks & risk reduction; Sales and profit margin; Reputation and brand value; Attractiveness as employer (indirect influence).*

[13] "*The literature uses the concept of inter-organisational symbiosis to describe a form of cooperation among different business organizations in which they partner each other in exchanging resources by setting in place initiatives that lead to the circularity of production processes and industries. These business organizations can work together through the exchange of resources that are of less value if not exchanged, but that acquire value when shared, and targeted to specific uses. Inter-organisational symbiosis is enabled by the possibility of cooperating to reduce resource used, which eventually turns into a reduction of costs, or to reuse waste as secondary raw materials, which creates new business opportunities*". (Ruggieri et al. 2016)

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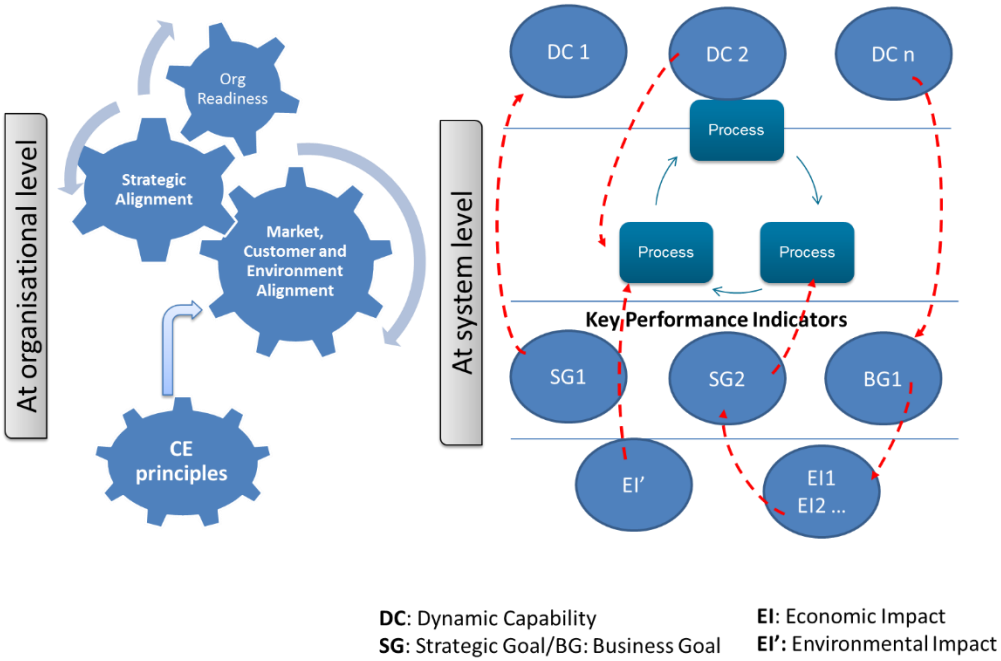

FIGURE 29: THEORETICAL SCHEME FOR SD MODEL'S BOUNDARY (SOURCE: *PAPERCHAIN TEAM*)

At organisational level, there are three main aspects that, under the perspective of the CE principles, will influence the behaviour of the circular economy model as a system: the organisational readiness, the strategic alignment and, the market, customer and environmental alignment. Grounded on those aspects, we identify those variables that will form, endogenously or exogenously, part of the system. As for the system level, some of the variables represent the Dynamic Capabilities that the system owns to effectively implement the new processes. While some others take the role as key performance indicators (KPIs) of the system that will enable us to monitor the progress of the actions implemented derived from the circular economy model. Those KPIs come from the strategic goals of the company (e.g. economic, environmental impact) as well as from the business goals (e.g. increasing market share). The following table (

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Table 17) shows the 'Model boundary chart' for a long term model of circular economy in industrial symbiosis.

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TABLE 17: MODEL BOUNDARY CHART IN PAPERCHAIN PROJECT

Dimensions	ENDOGENEOUS	EXOGENEUS
Circular Business Innovation *(Business goals)*	Consumer behaviour Value Creation Capacity Value captured Partner Network Suppliers' power	
Technology (technological innovation)	Organisational Innovation System innovation (transition innovation)	Digitalization Path dependency
Economic & Finance *(Strategic goals)*	Costs & cost reduction Risks & risk reduction Sales and profit margin Investment; ROI Savings (reduced resources)/Re-used waste	Interest rates
Environmental	Environmental Value Proposition	
Legal		Stimuli: Fiscal and financial incentives by policymakers Regulation: set of compulsorily laws and norms
Social	Employment generated (locally) Attractiveness as employer	

There are variables that are out of the scope of the analysis such as for instance other elements of the cost structure, organisation structure or culture, etc. Having established the list of variables that the SD model will include, the next step is to represent by a causal diagram the main interactions between them. This aims at providing a deeper understanding of the main forces that interact in a circular economy model.

4.3 Causal diagram

In this section, the casual representation of the main feedback loops that represent the link between the main dimensions affected by the circular economy model is described.

For the development of the SD model we have taken as a reference the following **six dimensions** that were presented in Chapter 2:

- **Circular Business Innovation**: it addresses the main elements for innovative business model that will generate business cases for sustainability that in turn will increase sales and profit margin.

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- **Technology**: it includes the technological innovation that is needed to create new processes or new products
- **Economic & Finance**: it comprises the key performance indicators
- **Environmental**: intended impact from the firm's perspective
- **Legal**: it relates to the set of compulsorily laws and norms for companies operating in industrial symbiosis
- **Social**: it represents the main socio-economic indicators in which the circular economy model should affect positively. For instance, CE strategies require more labour, require new educational training programs, or awareness and sense of urgency needed to change.

In order to properly show the connection between dimensions and variables and the circular economy model represented by PAPERCHAIN project, all the components that have been included in the model and are going to be explored through System Dynamics are portrayed in the following conceptual model (Figure 30):

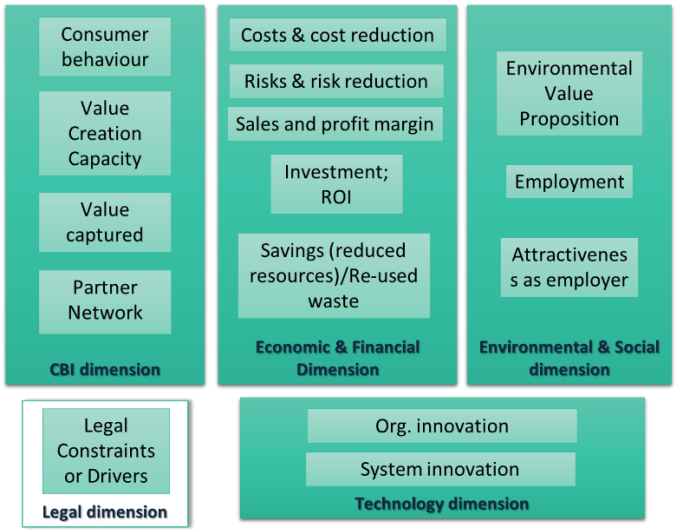

FIGURE 30: CONCEPTUAL MODEL EXPLORED THROUGH SYSTEM DYNAMICS (SOURCE: PAPERCHAIN TEAM)

The interactions between the variables described above will determine the dynamic behaviour: how the firm/system combines investments in new technology and value creation in line with the sustainability goals within CE perspective. Figure 31 presents the feedback interactions and overall dynamics of the key variables that intervene in the dynamic process for creating a sustainable circular economy model of industrial symbiosis. The SD model helps better understand how the new technological capabilities interact with the elements of circular business innovation through different stages of the process. Three reinforcing loops dominate the behaviour of the system:

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'Reinforcing market share through investment in CE-Industrial Symbiosis', 'Top management commitment reinforced by Market Share' and 'Sustainability Orientation reinforcing loop'. The positive effect of these three feedback loops are controlled by two main constraining forces: new or raised operative costs which will have a negative impact in sales and profit margin; and the potential increase of suppliers' power (from Pulp & Paper Industry) which in turn also increases operative costs. These restricting forces are strong enough to control the system so that capabilities or profit will not grow indefinitely. In addition, we find two external forces that on the one hand, could delay the positive growth of the system as expected and, on the other hand could impulse the reduction of cost structure:

- Legal regulation: whose role could be stimulating circular economy by setting limits to waste treatment that affect reuse or foster innovation. However, regulation could also hinder CE if it is complex or fragmented.

- Legal incentives: fiscal and financial incentives that could reduce operative costs once the investment in capabilities is implemented.

In this SD causal diagram, the reinforcing loop 'Reinforcing market share through investment in CE-Industrial Symbiosis' explains that direct investment in capabilities boosts value creation capacity which in turn increases the market share. However, it also increases the operative costs of the system with a delay, derived from the time of implementation of the new technological innovation (process or product). Achieving higher levels of technical capabilities will be guaranteed if the firm/system's managers counts on the appropriate commitment represented by the reinforcing loop 'Top-management commitment' which will impulse the system innovation, that is, the strategic context for firms' engagement in technological innovation (organisational innovation) under the sustainability perspective. Additionally, the SD model represents how such a commitment could be increased by increasing levels of market share.

Increased or improved technical capabilities match the 'reused waste level' which demonstrates the strategic commitment of the firm/system with 'environmental value proposition' representing the intended impact from the firm's perspective, and it has a direct positive impact on the business case driver of 'customer behaviour'. The customer behaviour will favour the value creation capacity of the firm and the process of boosting organisational innovation starts again. Consumer behaviour can be influenced by the innovation introduced by environmental sustainable products that have immediate and concrete advantages and can also stimulate the firm/system to move on more environmental sustainable business initiatives (through demanding for more environmentally sustainable products).

Finally, it is noticeable that 'Value Creation Capacity' also will enhance 'Partner Network' as the external capability that portrays the network of cooperative

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agreements with other companies necessary to efficiently reach the required organisational innovation.

It is out of the scope of this research work to take a step forward and formalize the causal diagram with the corresponding simulation exercises as SD methodology establishes. The attempt of this section is made to better understand how the drivers and constraining factors of circular economy models identified in literature could manage the behaviour of the whole system. The main recommendations from this analysis are further explained in the next section.

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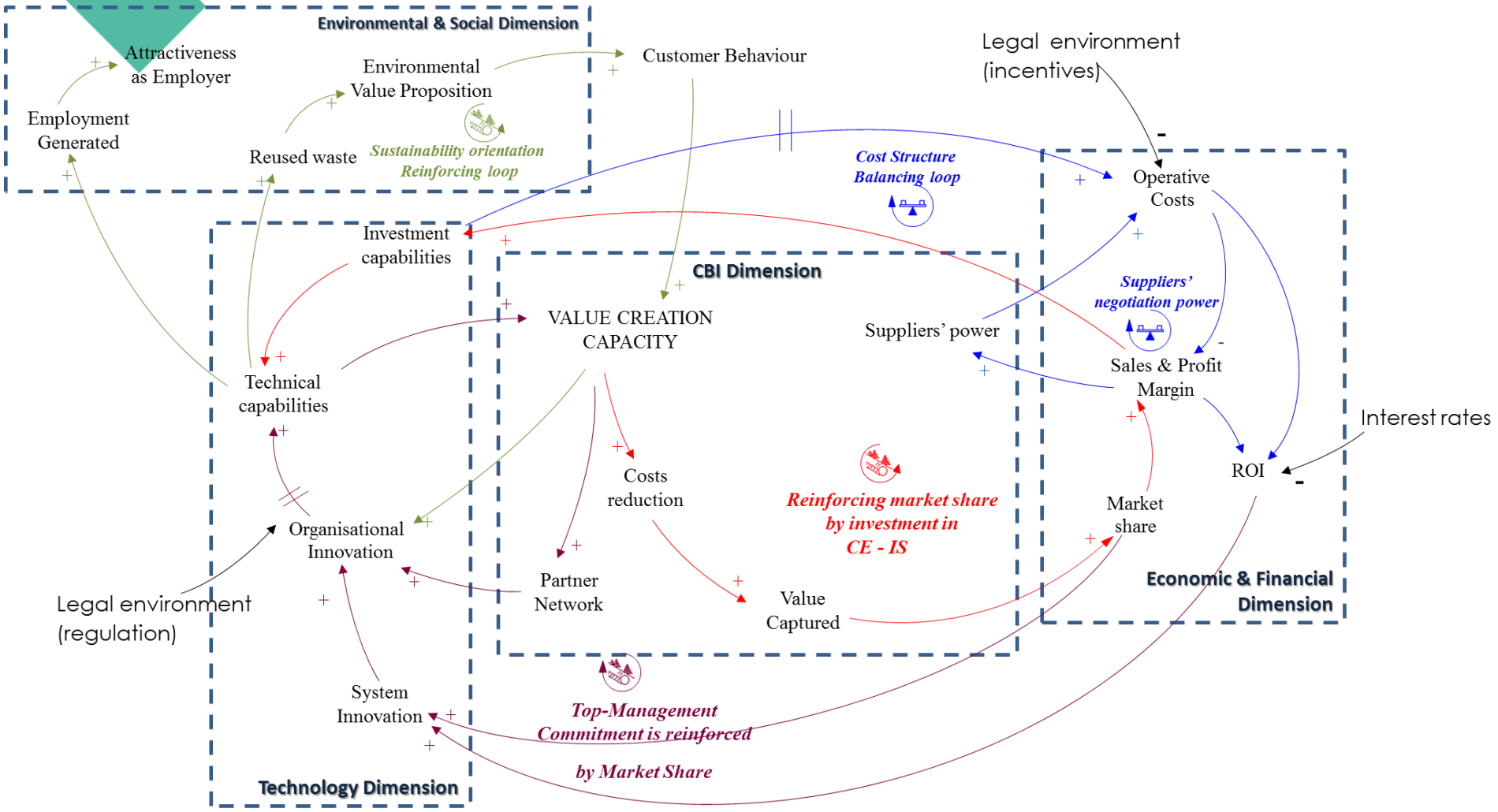

FIGURE 31: CAUSAL DIAGRAM OF THE CIRCULAR ECONOMY MODEL (SOURCE: *PAPERCHAIN TEAM*)

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4.4 Discussion from SD analysis

The previous analysis provides a new perspective on CE models combining many insights from the literature and from the characterisation of the circular cases into a coherent conceptual model that uses system dynamics notation. It offers some valuable insights in the quest for defining or better completing the theoretical framework for circular economy models that is shown later in Chapter 5:

- The changing paradigm from static towards dynamic condition of circular economy models is provided.
- The model connects two strategic levels, the organisational and the system level in which all stakeholders involved in the industrial symbiosis model are represented: the firm, the partner network, the environment, the decision maker and the customer.
- The SD model shows how the sustainability strategy of the firm/system can result in changes in the firm/system's circular business model and how the business model feeds back to the environmental value proposition, to the socio-economic performance and to the customer behaviour.
- Through the SD model we have identified the role of the interactions between variables of the six dimensions included in the conceptual model (Figure 30). It supports decision makers in understanding how the circular business model can affect the natural environment through the direct impact of the environmental value proposition and value creation capacity and an indirect impact through the customer's behaviour. Moreover, the model represents important feedback loops explaining the rationale of the circular economy model as system from a stakeholder perspective. For instance, including the role of top-management commitment, the suppliers' negotiation power, the costumer behaviour, employment, the partner network as well as institutional bodies. Besides, two relevant links have been identified that can cause delays in the whole system: from the legal dimension to the new technical capabilities implementation and from the new capabilities investment to the cost structure of the business model.
- Promote the acknowledgment of the contribution of the investment in dynamic capabilities, in the long term, to improve operational capabilities or processes. This means that it is important to identify the mechanisms that lead to financial profit and their relative importance that gives valuable insights to the dynamics of the circular business model. Capabilities change over time, hence, their accumulation and depletion processes are central to the firm/system's performance. Whereas operational capabilities directly contribute to performance, dynamic capabilities only impact the "rate of change" of

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operational capabilities. For example, operating costs, sales or reused waste (operational capabilities) directly contribute to sales, whereas value creation capacity, partner network, organisational and system innovation or environmental value proposition (dynamic capabilities) helps the firm/system to build a sustainable circular economy model guaranteeing a fruitful transition from linear to circular business initiatives.

Additionally, some specific challenges have risen from the previous analysis that result in specific managerial recommendations to be considered in the development of the theoretical framework that are described as follows:

1. Top-management commitment, from each of the firms participating in the system: the prior awareness and the resulting commitment from decision makers will support the initiatives of organisational innovation as well as system innovation.

2. Creation of a well-defined Partner Network in favour of organisational innovation and market share growth: the circular economy model process involves engaging a wide range of stakeholders. Several roles of stakeholder should be considered along the path from conception to implementation (e.g. government, citizens, customers, suppliers, etc.) and thus, a well-structured process for supporting the firm/system in the stakeholders' selection from the beginning of the process. Moreover, the influence of Value Creation Capacity over such a Partner Network should be monitored.

3. The performance of the circular business model should be measured through the selection of the appropriate KPIs that will be specific for each context: from the socio-economic perspective (e.g. employment generated, volume of reused waste), from financial perspective (e.g. cost reduction, ROI of the total investment), from business innovation perspective (e.g. value creation capacity, (waste) suppliers' power).

4. There are relevant aspects that have been excluded from the model but,, due to their relevance to the CE model, they will be considered in the theoretical framework. First, the organisational readiness which is embodied in individuals, in the structures, in routines and in the cultural values of organisations must be previously evaluated for guaranteeing a good progress of the model implementation. Second, the strategic alignment of the CE model to the organisation's strategic goals is required from the very beginning of the process. And finally, the CBI model should be aligned to the market, customer and environment perspectives.

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5. The relationships between capabilities, processes, culture and strategy on the one hand, and several mechanisms for their adaptation and integration in the global system on the other, should allow the firm/system to generate initiatives of organisational innovation and system innovation.

5 Design of the Reference Framework

A generic preliminary reference framework for circular economy models, specific for resource recovery that synthesizes and formalizes the main components interacting among themselves is provided in this section. The base concepts, principles, critical elements in the form of processes, activities, roles and responsibilities as well as characteristics of the whole system for implementing a circular economy model have been selected and explored throughout task 3.2.

Taking as baseline previous reference frameworks within the CE field (see Chapter 3), the topics covered to develop the reference framework are grounded on the set of critical elements identified in previous sections and on the inputs received from circular cases and, they have been extended according to the PaperChain project's scope. It is important to notice that a common **definition of 'Circular Economy Model' in the PaperChain project** shall be established for appropriately addressing the configuration and definition of the objectives, concepts, components and characteristics that the Reference Framework shall encompass:

"*A circular economy model in the PaperChain project will be a new organisation of partners (businesses, governments, researchers, citizens) working together into a system to create new ways of preserving natural resources (extending product lifetimes) or turning waste into a resource (recycling), requiring new changes in the value chain and involving innovative business models. The new models may lead to new norms and practices, new modes of consumer behaviours and changes at policy levels.*"

Consequently, the **main objective of a circular economy model** in the PaperChain project shall be:

"*to create new innovative and added-value products from the valorisation of PPI waste enhancing systemic economic, social, environmental and resources benefits within a collaborative setting*".

In order to achieve this objective, a whole set of critical elements, components and characteristics need to be provided in an integral approach that will constitute the reference framework. This reference framework will help companies and managers to create, implement and monitor the circular economy models in an industrial symbiosis scenario. Thus, a tentative definition of the reference framework for PaperChain shall be provided:

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"The Reference Framework for creating and implementing a circular economy model of industrial symbiosis stands for a structure that supports firms (or systems) in producing innovative and value added solutions (waste valorisation-based products) under a collaborative perspective. It encloses a collection of various elements that provide orientation, guidance, support and a basis for communication. These elements can be used to model, plan, operate and control corresponding innovation projects on a CE basis."

Some essential elements shall be considered when defining the Reference Framework(Wilkes 2012)(Wilkes 2012)(Wilkes 2012)(Wilkes 2012)(Wilkes 2012): a reference model, a conceptual model and a support scheme. The reference model will include the CE principles with regards to Industrial Symbiosis. This model should enable the firm/system to define the strategic goals of the circular economy model to be created. The main pillars are based on the main output derived from Deliverable 3.1 and they shall pervade all the aspects of the circular economy model. Those strategic goals would be defined taking into account their alignment to the firm/system vision, mission and objectives with regards to sustainability perspective. The Conceptual Model shall encompass the dimensions, patterns and monitoring components necessary to fulfil the main objective of a circular economy model that has been previously defined. The third component raises the support scheme which shall provide the appropriate configuration of processes, roles and responsibilities and skills or capabilities (including dynamic capabilities) required to carry out the activities that shall contribute to operationalize the circular economy model.

According to the defined reference framework to be outlined in the following sections, the guidelines, procedures and methods, rules, and tools that will be developed during task 3.3 will be provided when the opportunity of a hands-on approach by each circular case and scenario is possible within the PaperChain project.

Below a graphical representation of the reference framework is presented and the description of its elements is offered in the following sections.

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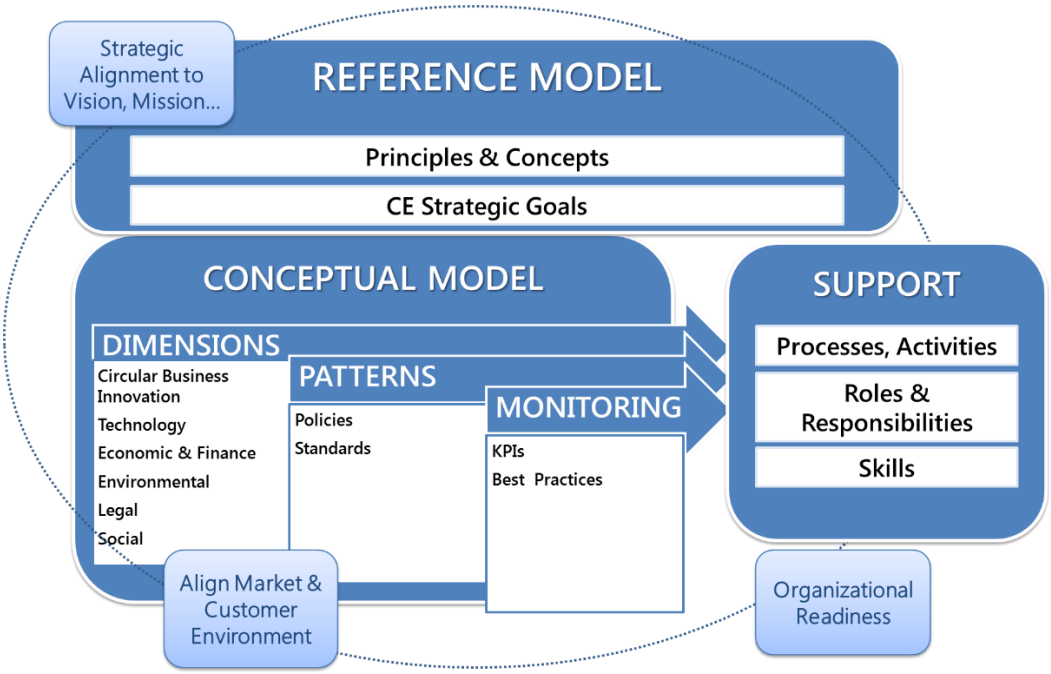

FIGURE 32: GENERAL OVERVIEW OF THE REFERENCE FRAMEWORK'S COMPONENTS

5.1 Reference model: principles and CE strategic goals

Under this element of the reference framework the concepts and principles that a circular economy model must fulfil are described. Based on the PaperChain project's scope, when defining the reference model, the characteristics of circular economy in general, and of industrial symbiosis in particular, should be taken into account.

Derived from the research work developed in deliverable 3.1, five different types of circular economic models were identified and described in detail: "product-extension", "circular supplies", "resource recovery", "sharing platforms" and "product as a service". A special attention was given to the "resource recovery" model insofar as the five case studies of the PaperChain project are developed according to this approach.

Generally speaking, the principles and concepts pillar accounts for those aspects that need to be considered from the strategic point of view. These are to be included in the quest for capture and described the specific characteristics that a circular economy model of resource-recovery must encompass. These characteristics represent the industrial symbiosis background that the model shall lay on in order to fulfil its goals. They are listed as follows:

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- The circular principles are not fully understood by many executives. Harvesting parts from returned products delivers a higher value when reused in a service channel for repair purposes or remanufacturing practice instead of scrapping the product to receive the recycling value of the material.
- Commitment to Sustainable Development - Organizational strategy, goals, and performance measures have to motivate managers to develop and participate in the synergy projects, contributing to the company's and regional development.
- Information - the detailed qualitative and quantitative data on waste streams and local industries' material/water/energy requirements provide the starting point for the development of (regional) resource synergies.
- Cooperation – the cooperation and trust between key players, sharing of information, and network development are crucially important factors for new synergy projects.
- Technical feasibility – a lack of technical knowledge within the industries may be an additional barrier for a new project.
- Regulatory – the uncertainties in environmental legislation and difficulties to obtain approvals for waste reuse projects from the regulatory authorities.
- Economic feasibility may result in an increased revenue, lower input costs, lower operational costs, and diversifying and/or securing water, energy, and material supplies.
- Developing the industrial symbiosis will create a new way to improve product innovation, while new knowledge is gained bringing new businesses.
- New innovations help to reduce the overall operation costs and risks and help to achieve long-term resource security - Value can be captured through joint cost reductions (accepting collaborative agreement for reducing costs across the networks).
- Social networks and innovation are identified as key themes to complement existing IS research - geographic proximity and trust between companies are essential for the realization of IS; however, economic geography could yet provide more insights into the pro-active development of IS.
- Companies most sophisticated at 'Resource recovery' embed circular practices into the lifecycles of their products. They even reuse waste from other value chains in their production. And those that used to outsource waste management can now make money from it instead.
- Reduced costs of waste management.

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- Increased revenue streams from selling unwanted outputs.
- Diminished environmental impact with lower demand for virgin resources and energy.
- Convenient options for customers to dispose of unwanted products.

Through the analysis of industrial examples of circular economy, the mentioned deliverable also provided a first collection of recommendations that could benefit to the PaperChain circular cases within the demo stages because they are based on best practices identified during the research process. These recommendations are taken into account for setting up the pillar of CE strategic goals of the reference model as it is explained as follows:

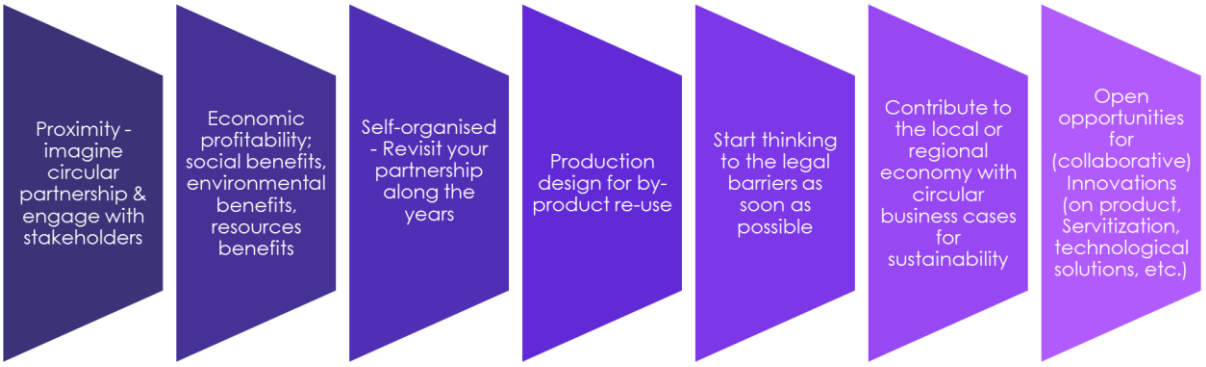

FIGURE 33: RECOMMENDATIONS FROM THE ANALYSIS OF BBPP IN RESOURCE RECOVERY MODELS (SOURCE: D3.1 PAPERCHAIN PROJECT)

5.2 Conceptual model

When defining the conceptual model that the reference framework might have, it is important to take into consideration those components that the circular economy model might require in order to fulfil its main objective as defined above.

Therefore, it is necessary to analyse first, all organisational dimensions affected by the model; secondly, the patterns that influence (positive or negatively) the viability of the model with regards to standards or policies (regional or European); and finally, a monitoring system which shall enable the monitoring of the progress of the performance of the model. These three pillars of the conceptual model represent the interactions between the circular economy model and its surrounding environment and they shall be further addressed below. Therefore, all the components of the conceptual model should be designed taking into account the interaction of the firm/system with the **market and customer environment** as well as with the external agents of the ecosystem in the CE model. The market positioning and market strategy will be also defined taking into account the interactions of the CE model with all new

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potential members (customers, suppliers). Therefore, under this dimension elements such as identification and recruitment of new members, marketing strategy and branding strategy will be included.

5.2.1 Dimensions

This component of the conceptual model represents the building blocks that group all critical elements identified previously (Chapter 3). All these critical elements shall be viewed as the set of enablers, success factors and barriers of a circular economy model of resource recovery. In order to better explain and characterize these components, six dimensions are presented and described:

Circular Business Innovation dimension

According to the EEA report (2016), "*business models aiming to use waste as a resource promote cross-sector and cross-cycle links by creating markets for secondary raw materials*". These will result in reducing the use of energy and materials during production and use stages. Under this dimension we are not addressing the configuration of the business model that originates the circular economy model chosen from a strategic point of view. Instead, we attempt to provide valuable insights for generating innovative business cases drawn from such a circular business model. Thus, this dimension addresses the main elements for innovative business model that will generate business cases for sustainability that will in turn increase market share of the companies involved in the CE model.

The main challenges affecting this dimension based on the findings of this research are summarised as follows:

- The **innovation management process** may be adapted according to the 'Circular Business Model Innovation' perspective.
    - Under the strategic point of view: Proactive strategic management is expected. The firm/system shall address many business case drivers strongly and continuously, with the effect of regular creations of business cases for sustainability.
- In terms **of appropriate capabilities**: Encourage the sustainability orientation of innovative capabilities thinking in diverse dimensions and more diverse knowledge sources.
- In terms of **strategic goals** of the Business Model: The value proposition should guarantee building customer loyalty.
- In terms of **available tools** for the firm/system to design the CBM: Circulab developed an approach to transform classic linear business model into circular

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business models; The Circulator helps to navigate potential circular strategies and learn from inspiring cases; The Business Cycle Canvas (BCC) (Mentink 2014); Play it forward is a Game-based tool for Sustainable Product and Business Model Innovation in the Fuzzy Front End (Dewulf 2010). It is also derived from the business model canvas, adding the building blocks for a triple bottom line, which means taking into account the perspectives of sustainability, in other words, integrating environment, business, and society views.

- **Experience on other ongoing circular economy projects** based on other process streams will provide a competitive advantage to the firm/system.
- **Limited initial awareness of the positive impact** of the CE model in some industrial sectors (for instance, in road and highway construction).
- New market opportunities for SMEs involved in the new value chain of the CE model (e.g. for Sekab to commercialise a new product).

Technology dimension

It is a relevant aspect often mentioned in the literature related to CE: "*A circular economy goes beyond the pursuit of waste prevention and waste reduction to inspire technological, organisational, and social innovation throughout the value chain in order to 'design -out' waste from the beginning, rather than relying solely on waste recycling at the end of the chain*" (Ellen MacArthur Foundation, 2013). However, its presence into current frameworks for CE model is scarcely addressed mainly because this aspect deeply depends on the sectors operating in the circular model. This dimension can include all critical elements related to technical barriers, technological innovation, eco-innovation, technological path dependency, etc. that are needed to create new processes or new products.

Most of the challenges affecting this dimension are based on the findings coming from the characterisation of the circular cases of the PaperChain project and they are summarised as follows:

- In terms of **processes**:
    - The implementation of new process to meet the required quality standard.
    - The demonstration (at industrial scale) planning process is quite relevant: too large testing process at demo site - iterative process until the optimum solution is achieved; and, climate conditions will affect the thaw/freezing resistance of components at the construction site. In the laboratory special care is needed on these tests.

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- Investment planning process adapted to CE model of resource recovery.
- Supply chain management: specific requirements in terms of the supply of components or other materials shall constraint the process -for instance, the production of NaOH and HCl (a supplier of NaOH and electrolysis technology is required); geographical barriers affecting the waste supply process: supply of waste is limited by nearness of the waste manager to PPI.
- Waste transportation: it could increase the costs of the final product – for instance, GLD transportation may increase the costs due to its lower density comparing to till material. It may risk the competitiveness of GLD use comparing to till transport.

- In terms of **diversity and quality of wastes** that influence the properties of the new product (e.g permeability in sealing layers' production):
  - Diverse availability of waste (WPA) and quality of recycling material
  - The waste' (GLDs) properties variation (especially its water content and its water absorption capacity) for each mill influences the packing properties of the sealing layer.
  - Also different mills have different chemicals used in the process as well as different de-watering processes.
  - There is not yet a standard "GLD product", thus there is not a product specification, data sheet, etc. Each mill generates different GLDs qualities due to different the pulp processes.
- Explore and try to anticipate the requirements in terms of **technology development or equipment investments** from the very beginning: for instance, availability of special equipment for ash mixing and metering; homogenisation of the new recycled material (composite MUDIPEL) at the construction site could find high difficulties; associated limits of recycling technologies to manage complex and diverse products.
  - Technical challenges are mainly linked to the scale-up of the technology
- In terms of **new skills and knowledge**:
  - There is a need to have specialised skill and adapted machinery: for instance, for GLDs handling and compaction.
  - Product design that make disassembly difficult, or impossible.
  - Lack of recycling infrastructure (particularly in developing countries).

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- Greater digitalisation of the recycling chain (sensors, design tools).

Economic & Finance dimension

The economic benefits of the circular economy are widely recognised and communicated. "*It could offer a platform for innovative approaches, such as technologies and business models to create more economic value from fewer natural resources*." (European Environment Agency EEA 2016). AMEC Environment & Infrastructure and Bio Intelligence Service (2014)[14] estimated that the annual net benefits for European business that implemented resource-efficiency circular economy models (e.g. the recovery of materials, the re-design of products) reached from EUR 245 billion to EUR 604 billion, representing an average of 3–8 % of annual turnover.

More specifically, positive economic effects arise from the availability of cheaper materials diverted from waste, including avoiding the costs of waste disposal and capturing the residual economic value of existing material streams (European Environment Agency EEA 2016).

Grounded on such positive benefits, creating a circular economy model shall offer the firm/system relevant economic advantages making the resource recovery-circular economy model in a highly attractive business opportunity. However, there exist relevant barriers that constraint organisational impulse to initiate such business model. For instance, there still exists the underlying assumption that green initiatives and environmental regulation may impose cost disadvantages on organisations (Christensen et al. 2017). Thus, it must be noticed that the definition of effective KPIs from the economic and finance point of view will take high relevance supporting managers to identify the key performance indicators.

The economic and finance dimension in this reference framework shall address the following challenges:

- In terms of **cost structure and revenue streams**:
  - The cost structure of the model must be inferior of the revenue stream for the circular model to be viable.
  - Major up-front investment costs: for the waste manager; in the construction phase; the cost of homogenisation and mixing of material at the construction site.

[14] AMEC Environment & Infrastructure and Bio Intelligence Service, 2014, *The opportunities to business of improving resource efficiency — Final report on behalf of the European Commission*, Contract Ref. 070307/2011/610181/ETU/F.1., Northwich. In (European Environment Agency EEA 2016)

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- Considerable amount of costs involved for on-site machine modifications.
- Improved security of products supply. For instance, sustainable EtCl for AkzoNobel (currently only one producer of EtCl in Europe).

- In terms of **processes**:
  - Economic viability analysis of the new solution: assessment of the economic competitiveness of the solution compared to classic ('linear') solutions available in the market. For instance, EtCl produced by Sekab should be less expensive or in the same range as the product sold by the competitor supplier.
  - Economic viability analysis of the investments: large investment to produce at industrial scale.
  - Loss of competitiveness of the GLD transport can be compensated by a constant GLD availability and considering the overall cost/benefit balance analysis (layer better performance, and potential future landfilling taxes).
  - PESTLE analysis – periodical review of the macroeconomic aspects evolution or legal changes: for instance, in some countries landfilling is still "cheap", since there is not of application any landfilling tax (e.g. to GLDs). But this scenario may change in the future.
  - An efficient QA/QC will be implemented in order to assure the optimal GLD and GLD mix qualities, and minimize the control costs, so that the valorisation process is not economically uncompetitive respect to standard materials.
  - Long term Environmental Monitoring costs
- Some **KPIs** on economic performance have been identified:
  - Cost reduction - Related to energy savings, the reduction of material flows or cleaner production
  - Sales & Profit margin
  - Increase company's benefits
  - Reputation and brand value: If the company's reputation and brand value are increased, the sales could also increase
- Extra financing alternatives or **'the regulation/economics stream"** - political regulation on enterprises' environmental practices and financial performance:

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- Enterprises' economic incentives or disincentives to engage in environmentally sustainable development:
- No subsidies from local government
- More financial and economic incentives at national, regional and local level could motivate the stakeholders, e.g. missing economic recycling incentives
- Shifting taxes from labour to natural resources and pollution;
- Phasing out environmentally harmful subsidies;
- Internalisation of environmental costs;
- Finance mechanisms supporting circular economy approaches

- **Sustainable Public Procurement** & Sustainable Business Models:
  - Collaboration between procurement scheme (procurers and suppliers) and business models
  - Includes technical, non-technical and socio-cultural specifications that are co-developed and decided between the government agency and the potential suppliers
  - Availability of investment capital (e.g. for new infrastructure)
- Guarantee **economic benefits for the ecosystem**: avoid misaligned profit-share along the value chain - the economic interest of all stakeholders must be preserved and ensured.

Environmental dimension

There are other measures beyond waste recycling that could further reduce greenhouse gas emissions. As estimated by AMEC (2014) resource efficiency measures could avoid around 100–200 million tonnes of carbon dioxide equivalent emissions annually in fabricated metals and food services sectors (AMEC Environment & Infrastructure and Bio Intelligence Service, 2014). Within this dimension, the reference framework points out to the positive environmental effects with regard to the net reduction in environmental pressure from waste disposal and the production of virgin materials (European Environment Agency (EEA) 2016).

The environmental dimension shall address the following challenges:

- Some **KPIs** on environmental performance have been identified:
  - Tons of landfill avoid per year: e.g. considering 1 mill site, and considering the application of all the dregs/grits produced, about 4500 tons/year.

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- Recycled material will replace the natural aggregate which will contribute to the lower CO2 emission for the whole construction.
- The circular model will replace another product imported by train: less environmental impact due to less transport.
- Reduction of carbon footprint: Ffnal product Bermocoll will be produced using EtCl from renewables and not from fossil-fuel-based chemicals.
- Green liquor dregs (GLD) are classified as non-hazardous waste.

- In terms of **processes**:
  - Risks management/LCA analysis: there could be some potential risks which needs to be studied in detail and analysed: e.g. (i) contamination of soil by rain water after getting mixed with the chlorides present in the new product, (ii) the dry particle of the new material being very light in weight can float in air during transportation or handling and settle down over the plants and crops, which would later have a detrimental effect on them.
  - A best practice document needs to be developed by the Waste manager for the logistics and construction company.

Social dimension

This dimension covers the interaction between the CE model and the society in general. Taking into consideration the broadness of this dimension, the focus shall be centred in the potential impact of the CE model on the society and in the constraints and facilitating elements that society provides to the development of the CE model.

Thus, it shall concern to how the CE model influences the society and/or human needs. The main socio-economic indicators can help to monitor the mentioned influence but other elements shall be considered such as whether and how the firm/system establishes the strategic goals in terms of social benefits as well as sociological and cultural factors (creating jobs, new educational training programs, or awareness and sense of urgency needed to change).

Social dimension can be seen as the 'institutional perspective' of the CE model according to EEA report (2016). This perspective "conceives the enterprise as a social system embedded in a social context of expectations, values and norms and constrained by a broader set of stakeholders than primary market actors, including public authorities, professions, interest groups and the media"(European Environment Agency (EEA) 2016).

The social dimension shall address the following challenges:

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- In terms of **processes**:
    - To inspire attractiveness as employer - recruiting and selection, induction and development programmes oriented towards circular economy culture.
- Some **KPIs** on environmental performance have been identified:
    - Job creation, e.g. in transport and processing raw materials.
    - The use of new geotechnical structure for landslide support could increase the number of employees in the Slovenian railway (SZ) company, which produces gabions.
    - If the circular model reaches the industrial scale, Sekab may create numerous jobs.
- **Encouraging cultural transition towards CE** in order to gain target stakeholders (society, employees, government) attention and acceptance in general but in particular in those sectors introducing in the CE field:
    - Intense communication efforts - disseminating the positive impact resulting from this innovation, that is, the benefits of the new application (waste reduction) and the obtained results (performance)
    - For instance, in the construction sector, initial resistance is expected because that sector has always been a very conservative in terms of new materials, methodology and technology implementation.

Legal dimension

Finally, the legal dimension of the conceptual model relates to the set of compulsorily laws and norms for companies operating in resource recovery circular economy model. In this sense, the legal framework should enable the transition to circular thinking (Mouazan 2016). However, as Mouazan (2016) highlights and the circular cases in PaperChain project show, one of the main difficulties that companies deal with when designing circular business approaches concerns to the fact that the external legal environment is not necessarily ready to embrace the new concepts. As suggested through the SD analysis, strong delays in receiving the corresponding environmental licences or approvals due to the higher complexity of the new solutions could emerge. These delays put strong pressures on the company and threaten the viability of the model (Mouazan 2016).

The legal dimension shall address the following challenges:

- Lack of consistent legislation regarding end-of-life phase of products: the legislation regarding use of different types of waste is not always clear in the

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different countries in Europe and may sometimes prevent the implementation of a circular model.

- Authorisation license delivered by a certification body to enable the use of the products created.
- The legal status over the utilisation of waste as a new raw material: for instance, the production and commercialisation of WPA as a "by-product" generated after recycling of a waste product is not allowed at the moment of initiating the CE model.
    - Permissions could be obtained after modification of the WPA by addition of some performance enhancing additive and demonstrating the social, economic and environmental benefits to the respective legal authorities.
    - Legal authorisation required to allow the use or production at industrial scale: for instance, large amounts some new chemicals (HCl, H2, Cl2) in the industrial site; for instance, specific authorization is needed when GLDs are used. There is not a specific regulation for the use of GLDs in construction works. Constructive requirements defined in local regulations for capping. For example, hydraulic conductivity <10-08 m/s.
- Legal barriers can be of very different nature depending on the selected country in UE. In terms of replicability/reproducibility a specific analysis should be done for each country of interest.

5.2.2 Patterns

This element of the conceptual model refers to all documentation of practical knowledge that is relevant to the problem(s) that the CE model is dealing with. In practice many patterns will be available in the general industry domain, but enterprises will customize and extend them to make them relevant to the enterprise task.

Regulations regarding the environment and the use of natural resources, with constraints to industrial activities in term of input materials, processes, wastes, outputs, are expected to become stricter in the EU, as a response to the request of citizens for a healthier, safer and more sustainable way of living (FUTURING project 2017a). In this sense, any attempt to promote the first line of action, functional and leading to a more sustainable and competitive EU industry, it's necessary to evaluate ex-ante the impact of the new regulations on EU firms competitiveness and to provide public support to the efforts of the firms, by setting up innovative models of Public-Private Partnership (PPP) (FUTURING project 2017a).

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Patterns' perspective shall cover all the standards (for example the upcoming eco-design directive) accounting for social and environmental impacts, and business for Circular Economy (such as International regulation on waste and recycling). The firm/system needs specific support with regard to Business Intelligence with activities devoted to the searching process of standards that could favour the CE model. For instance, high quality standards have to be set and collection points have to be made responsible for the quality of the collected materials.

In the PaperChain project, the process and support mechanisms for defining new standards will be provided taking advantage of the experienced knowledge of the consortium partners.

According to the EEA report (2016): "New and innovative business models often require carefully designed policy interventions to become mature, competitive and economically viable, while at the same time avoiding market distortions". Hence, the second element that should be included in patterns dimension of the conceptual model is devoted to policies, concerning not also to policy interventions related to the materials and sectors affected but also concerting to influencing in policy decision makers at local, regional or European level.

According to EEA report, one of the established policies that supports the move towards a circular economy is the EU's five-step waste hierarchy established in the 2008 EU Waste Framework Directive, prioritising the prevention of waste generation (European Environment Agency (EEA) 2016). The Directive required EU Member States to adopt waste prevention programmes by December 2013, and many countries included measures to foster innovative business models, repair, reuse and eco-design in their programmes. The Ellen MacArthur Foundation highlights some examples of existing regulation frameworks to foster CE (Ellen MacArthur Foundation 2015):

- EREP – European Resource Efficiency Platform, Manifesto & Policy Recommendations (2012)[15]. A call for a circular, resource-efficient and resilient economy in the EU to be achieved by taking the following actions: encouraging innovation and accelerating public and private investment in resource-efficient technologies, systems and skills; implementing, using and adopting smart regulation, standards and codes of conduct; abolishing environmentally harmful subsidies and tax breaks; creating better market conditions for products and services that have lower impacts across their life cycles, and that are durable, repairable and recyclable; integrating current and future resource scarcities and vulnerabilities more coherently into wider policy areas, at national, European and global level; providing clear signals to all economic actors by adopting policy goals to achieve a resource-efficient

[15] http://ec.europa.eu/environment/resource_efficiency/documents/ erep_manifesto_and_policy_recommendations_31-03-2014.pdf

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economy and society by 2020, setting targets that give a clear direction and indicators to measure progress relating to the use of land, material, water and greenhouse gas emissions, as well as biodiversity.

- UK House of Commons Environmental Audit Committee, Growing a circular economy: ending the throwaway society (2014)[16]. A parliamentary enquiry into the circular economy that consulted businesses trying to exploit circular economy business models. The committee recommends that the UK government: (i) reforms taxation and producer responsibility regulations to reward companies that design more circular products; (ii) improves information about the location of materials; (iii) gives direct guidance to local authorities on what materials are collected and recycled, including separate food waste collections and banning sending food waste to landfill; (iv) sets longer warranty periods for consumer products; (v) sets new standards for eco-design; (vi) stops businesses using materials that cannot be recycled when better alternatives exist; (vii) uses government procurement standards to promote a more circular economy; and (viii) encourages the Green Investment Bank to finance innovative circular economy technologies.

It is worthy to note that positive feedback loops have to be built in order to realize fruitful interactions among the needs and the evaluations coming from citizens or costumers and the strategy and policies designed by the top layers of the society (public authorities and scientific, technological and industrial stakeholders) (FUTURING project 2017a). The research developed in the FUTURING project results in some relevant insights concerning the Policies element (FUTURING project 2017a):

- A widespread technological culture is also needed so that refusal of some radical innovation such as the integration "Nano-Bio-ICT".
- Large effort for communication and education initiatives from public bodies and private organizations towards citizens and firms, particularly SMEs, is required.
- The culture of technology innovation shall be the basis for changing the consumption patterns of EU citizens towards circular products.
- The top-down actions of public authorities and private stakeholders have to be joined and synergies with the bottom-up initiatives that flourish, thanks to the social networks all through Europe, have to be made.

Examples as mentioned above shall be selected and evaluated according to the contexts of the five circular cases as the PaperChain project progresses.

[16] www.publications.parliament.uk/pa/cm201415/cmselect/cmenvaud/214/214.pdf

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5.2.3 Monitoring

A monitoring system shall be a prerequisite for evaluating the transition towards the circular business model. One current limitation derived from the literature review developed in this task is the lack of a measurement system as well as the lack of a monitoring tool specific of CE models, relevant for any transition or change management. Not only common linear KPIs should be identified and monitored, but also the circular KPIs, that is, those indicators that can measure the advancement of circularity within each circular business model.

The main goal of this element of the reference framework is to support the measurement of the progress towards a circular economy at industry and at system level. A database of indicators of the CE model will be elaborated. The collective efforts for streamlining the data collection and analysis will be particularly focused on the lessons learnt and the key indicators in terms of economic, environmental and societal performance.

The list of KPIs shall be elaborated taking into account the specific characteristics of the five circular cases. Evaluation tools and precise indicators that allow tracking and quantifying the financial and sustainability benefits of the resource recovery circular economy model are needed.

As for the best practices element, it accounts for identifying relevant lessons learnt from other sectors, other industries and other scenarios of resource recovery models that could help us, if possible, to develop a maturity model for CE models in the context of the PaperChain project. The list of best practices will be enriched in the next task of WP3 based on the explorative process explained at the beginning of this report.

5.3 Support scheme

This element of the reference framework shall address the operational structure of the constituting elements of a circular economy model, namely, the process, the activities, its participants and the roles performed by those elements. As far as the functional aspects are concerned, within this dimension we will identify the activities and processes (base functions/operations) required to operationalise the CE model and the execution of time-sequenced flows of operations related to the different phases of the model.

Components of this dimension shall be the operations and processes that guide the setting up of the CE model, operation handling, the management of innovation, etc. It will define the global management system adapted for the resource recovery circular economy models. When necessary, governance rules will be defined as far as

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the whole ecosystem is concerned. Thus, aspects such as contracts and agreements, trust management and the value system will be included.

As described in section 5.2.1, some relevant processes have been envisioned and they should be adapted to the characteristics of the five circular cases. Although new elements could rise while defining the reference framework of the five circular cases, in the following table (Table 18) we have compiled previous findings from the literature review and the characterisation of the circular cases:

TABLE 18: CROSS-CUTTING ISSUES FOR DEFINING THE SUPPORT SCHEME

	PROCESS	SKILLS	ACTIVITIES	STRATEGY	CULTURE
Recruiting and selection, induction and development programmes oriented towards circular economy culture.	x	x			x
Cultural attributes of a Sustainable Business Model					x
Innovation management process	x			x	
Proactive strategic management - Address many business case drivers strongly and continuously, with the effect of regular creations of business cases for sustainability	x			x	
Risk management in terms of sustainability; Risks Reduction: The reduction of technical, political, societal and market risks	x				
KPIs – selection of the appropriate KPIs and monitoring tool	x	X	x	x	
Capabilities for developing and disseminating knowledge		X			
Capacity for innovation and support for entrepreneurial activities		X			
Transition Management - Translate the application of existing strategies, methods and practical experiences of transition management to the transition to a CE				x	
Collaboration & formal agreements (stakeholders) - Tools for finding the right partners and organizing collaboration and co-operative arrangements	x		x	x	
Avoid or control Geographic dispersion of stakeholders	x				

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Driving competitive advantage through stakeholder engagement			x	x	
Building customer loyalty				x	

With regard to this component of the reference framework, it is worthy to mention the relevance of the transition perspective (Christensen et al. 2017). Under this perspective, *the institutional and strategic context for firms' (and other organizations') engagement in radical, systemic and sustainable technological innovation and transition of industries or sectors* is addressed. According to Christensen et al. (2017) it concerns the interplay between a diversity of actors and institutions that enable or inhibit sustainable technological innovation and transition of industries or sectors. Hence, the system's features, rather than enterprise features, are the core of this perspective.

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6 Conclusions and next steps

Although circular economy has become a hallmark in the literature related to sustainability and, more recently, also to organisational theory, as an attractive alternative for businesses, the form in which its principles fit in the creation of new circular business models for companies is still incomplete. Moreover, it has paid less attention to comprehensive framework that enables companies the design of new circular business models in a practical way.

Based on an exhaustive review of current advances in this field, we provide in this report a reference framework that allows companies to successfully design and implement new circular business models with the consideration of the entire value and supply chain. Within the context of the Paperchain project, an appropriate definition of reference framework is provided:

"The Reference Framework for creating and implementing a circular economy model of industrial symbiosis stands for a structure that supports firms (or systems) in producing innovative and value added solutions (waste valorisation-based products) under a collaborative perspective. It encloses a collection of various elements that provide orientation, guidance, support and a basis for communication. These elements can be used to model, plan, operate and control corresponding innovation projects on a CE basis."

This thorough reference framework contains all critical elements identified in this study and their relations which influence the possibilities of organizations to cooperatively operate at circular economy level from a systemic perspective The three main pillars or building blocks of the reference framework we have identified as enabling the goal of a circular economy model in PaperChain are: (i) a reference model including the CE principles with regards to Industrial Symbiosis that should enable the firm/system to define the strategic goals taking into account their alignment to the firm/system's vision, mission and objectives with regards to sustainability perspective; (ii) a conceptual model encompassing the dimensions, patterns and monitoring components necessary to fulfil the main objective of a circular economy model that has been defined; and, (ii) a support scheme which provides the appropriate configuration of processes, roles and responsibilities and skills or capabilities (including dynamic capabilities) required to carry out the activities that shall contribute to operationalize the circular economy model.

The development process has been based on an streamlining approach for a theoretical, empirical and practical exploration. Firstly, the collective efforts for the data collection and analysis has been focused on identifying the success factors, enablers, drivers, lessons learnt and the key indicators in terms of economic,

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environmental and societal performance from the characterisation of the circular cases and from the literature review. Many findings in literature coincide with the conclusions from the case studies.

We have found in sustainability and business model innovation literature, existing frameworks to assist companies in developing new circular business models. Derived from the analysis of existing frameworks on circular economy it is clear that the transition toward circularity supposes deep modifications and that focusing on the design of a good/service is not enough; approaches such as eco-design or green design offers limited results. Besides, focusing on business models is also not enough. Instead, there is a need for a systemic approach centred not only on one company but on a consortium that collaborates (ecosystem). We conclude that a reference framework should offer an overview by considering the different parts of its ecosystem (i.e. internal and external). In this regard, the systemic analysis deployed in this study, taking as a basis the relevant findings after the explorative analysis of the circular cases in the PaperChain project, has shown the global picture of the connection among the elements of the system that interplay in the CE model. The SD causal diagram represents how the two strategic levels, the organisational and the system level in which all stakeholders involved in the industrial symbiosis model are represented: the firm, the partner network, the environment, the decision maker, and the customer.

The challenge was to improve (or promote) the understanding of circular economy model itself. Some specific challenges have risen from the previous analysis. This has resulted in specific managerial recommendations that have been considered in the development of the reference framework: top-management commitment from each of the firms participating in the system; creation of a well-defined partner network in favour of organisational innovation and market share growth and monitoring of the influence of value creation capacity over such a partner network; the performance of the circular business model should be measured through the selection of the appropriate KPIs that will be specific for each context: from the socio-economic perspective (e.g. employment generated, volume of reused waste), from financial perspective (e.g. cost reduction, ROI of the total investment), from business innovation perspective (e.g. value creation capacity, (waste) suppliers' power); the relationships between capabilities, processes, culture and strategy on the one hand, and several mechanisms for their adaptation and integration in the global system on the other, should allow the firm/system to generate initiatives of organisational innovation and system innovation.

Derived from the analysis detailed in this deliverable, we finally conclude that a hands-on development of the reference framework for circular economy models in industrial symbiosis should possess a twofold aim: to develop at the same time a conceptual and a practical approach. The conceptual approach has been overcome in this D3.2.

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Then, in the next task (T3.3) we will go beyond the conceptual recommendations and a step forward will be given throughout the adaptation of the reference framework to the five circular cases.

7 Annex I: Questionnaire for Characterisation of circular cases

Technical: What are the technical barriers that your company must overcome in terms of:

- Technical innovation: will the demo involve technical development of new components or new processes?
- Product development
- Transport or logistic or supply chain
- Scale-up
- Quality insurance
- Norms (EU regulations, others)
- Organisational
- Has your company established any way (or strategic process) for identifying the key stakeholders of the circular model?
- In this multi-stakeholders' project, how are relationships handled? Are there any pre-agreement contracts?
- Have you identified any supplier challenges?
- Replicability → Do you know other markets in Europe? Other sites to replicate the model? Are you thinking of developing other circular models in your company?
- Are you part of any cluster that can ease the replicability of the model?

Business innovation:

- Does the new circular model bring you a competitive advantage compared to other market players?
- How are your current businesses impacted by the circular model? Positively (new incomes)/ Negatively (high initial investments)/Other?

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Economic & finance:

- Have you started to assess the economic viability of the model?
- Has your company identified the economic advantages of this circular model?
- Does the solution include a decrease of the cost structure?
- Are there any national incentives to promote industrial symbiosis/projects?

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Social:

- Are there any advantages for the employees (training, sustainability awareness, working conditions)?
- Will the model create jobs?
- Are there any intern obstacles/ barriers to implement the model? (fear of change, new techniques to learn, new persons to talk to, etc.)

Legal:

- Within your industries, what are the norms that you must respect? In terms of product development based on waste, transport, etc.?
- What are the legal barriers that can slow down the development of the model? Are you allowed to use waste for the production and commercialisation of the final product?

Environmental:

- Is the expected environmental impact of the new circular model high enough to justify new developments, new investments?
- What are the main environmental risks of the new product on the ecosystem? (particles emissions, etc.)
- How many tons of landfill do you plan to avoid per year?

8 Annex II: Results from the Working session with demo partners

During the 1st GA meeting in Tecnalia in November, 2017, a two-hours working session was organised by TECNALIA, as the WP3's leader in order to receive feedback from all the stakeholders participating in the five circular cases. The first part of the workshop was devoted to identifying critical elements and the second one was focused on the Lean Canvas development. The following pictures show the participants contributing to the exercise.

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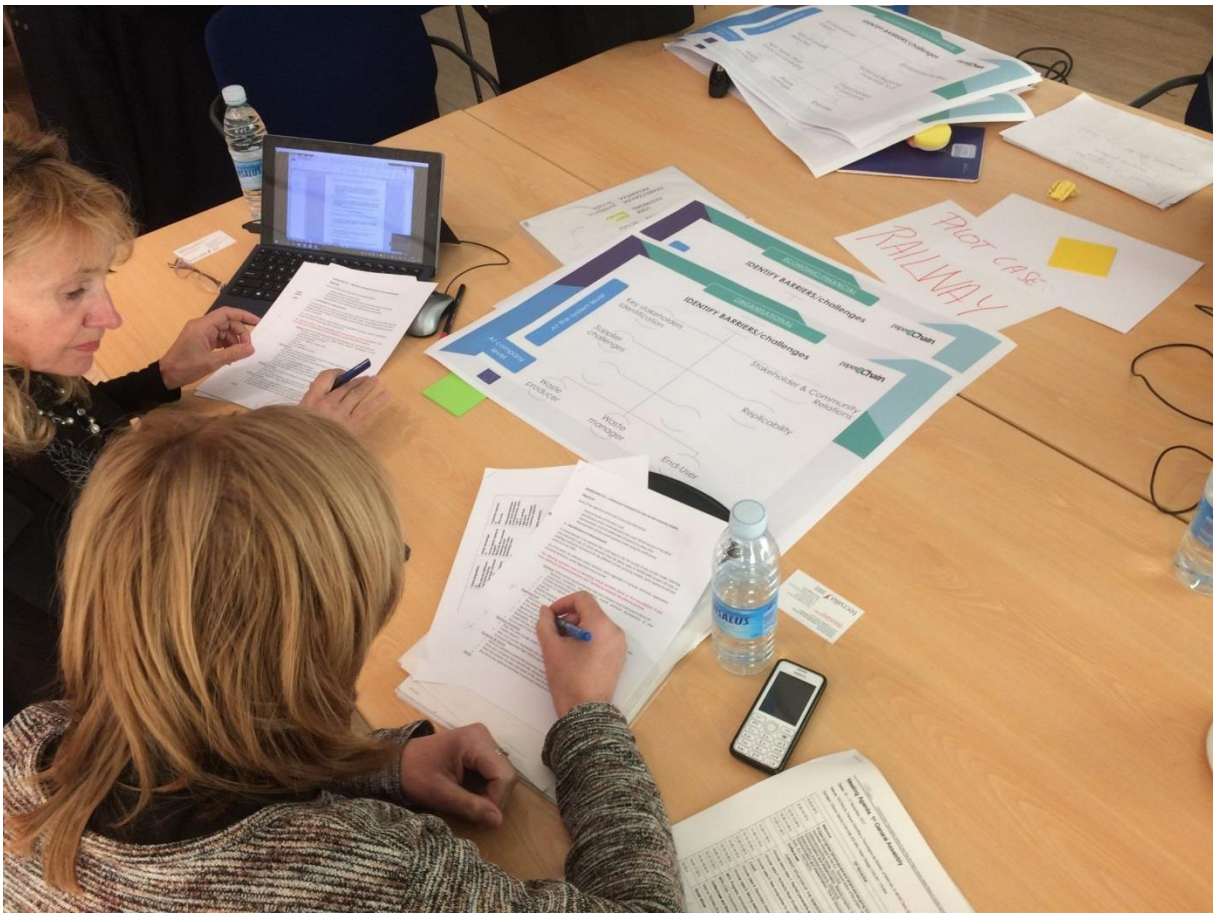

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9 Bibliography

Abdelkafi, N. & Täuscher, K., 2016. Business Models for Sustainability From a System Dynamics Perspective. *Organization & Environment*, 29(1), pp.74–96. Available at: http://journals.sagepub.com/doi/10.1177/1086026615592930.

Amit, R. & Zott, C., 2012. *Creating Value Through Business Model Innovation*,

Antikainen, M. et al., 2013. Exploring networked innovation in order to shape sustainable markets. In *ISPIM Conference Proceedings*. The International Society for Professional Innovation Management (ISPIM), p. 1.

Antikainen, M. & Valkokari, K., 2016. A Framework for Sustainable Circular Business Model Innovation. *Technology Innovation Management Review*, 6(7), pp.5–12.

Bocken, N., Miller, K. & Evans, S., 2016. Assessing the environmental impact of new Circular business models. In *Conference 'New Business Models' - Exploring a changing view on organizing value creation*. Toulouse, France, 16-17 June 2016.

Brammer, S. & Walker, H., 2011. Sustainable procurement in the public sector: an international comparative study. *International Journal of Operations & Production Management*, 31(4), pp.452–476. Available at:

This project has received funding from the European Union's Horizon 2020 research and innovation Programme under grant agreement N° 730305

http://www.emeraldinsight.com/doi/10.1108/01443571111119551.

Christensen, J.F., Truffer, B. & Hekkert, M., 2017. Enterprise Strategies for Sustainable Development – Towards an Integrative Research Foundation. , pp.1–80.

Dewulf, K.R., 2010. Play it forward: A Game-based tool for Sustainable Product and Business Model Innovation in the Fuzzy Front End. In *Knowledge Collaboration & Learning for Sustainable Innovation, Proceedings of the ERSCP-EMSU Conference, Delft, The Netherlands*. pp. 1–16. Available at: http://www.narcis.nl/publication/RecordID/oai:tudelft.nl:uuid:eb7556af-8f93-4a3a-826b-e8ed6de72aa1.

Ellen MacArthur Foundation, 2015. Delivering the Circular Economy: A Toolkit for Policymakers. , pp.19–32.

European Environment Agency (EEA), 2016. *Circular economy in Europe - Developing the knowledge base*,

European Environment Agency EEA, 2016. Circular economy in Europe - Developing the knowledge base. , (2), p.37.

Forrester, J.W., 1961. *Industrial dynamics*,

FUTURING project, 2017a. *FUTURING_ D1.2: FUTURING Baseline Vision*,

FUTURING project, 2017b. *FUTURING_D1.3: Description of the Building Blocks and Pillar Actions methodology*,

Gauthier, C. & Gilomen, B., 2015. Business Models for Sustainability Energy Efficiency in Urban Districts. *Organization & Environment*, p.1086026615592931. Available at: http://oae.sagepub.com/content/early/2015/07/02/1086026615592931%5Cnhttp://oae.sagepub.com/content/early/2015/07/02/1086026615592931.abstract.

Giurco, D. et al., 2015. *SHIFTING BUSINESS MODELS FOR A CIRCULAR ECONOMY METALS MANAGEMENT FOR MULTI-PRODUCT-USE CYCLES WEALTH FROM WASTE CLUSTER CITATION Shifting Business Models for a Circular Economy: Metals Management for Multi-Product-Use Cycles*,

Haack, J., 2017. *The Business Model for Sustainability from a System Dynamics Perspective by*. Lund University.

Harrison, J.R. et al., 2007. Simulation modeling in organizational and management research. *Academy of Management Review*, 32(4), pp.1229–1245.

Hjorth, P. & Bagheri, A., 2006. Navigating towards sustainable development: A system dynamics approach. *Futures*, 38(1), pp.74–92.

Joyce, A. & Paquin, R.L., 2016. The triple layered business model canvas: A tool to design more sustainable business models. *Journal of Cleaner Production*, 135, pp.1474–1486. Available at: http://dx.doi.org/10.1016/j.jclepro.2016.06.067.

Kim, 1998. *Introduction to Sustainable Design*,

Kunc, M. & Morecroft, J., 2007. System Dynamics Modelling for Strategic Development. In *Dyson, R and O'Brien, F. (eds.) Supporting Strategy: Frameworks, Methods and Models, New York: Wiley & Sons, (157-189)*.

This project has received funding from the European Union's Horizon 2020 research and innovation Programme under grant agreement N° 730305

Lewandowski, M., 2016. Designing the business models for circular economy-towards the conceptual framework. *Sustainability (Switzerland)*, 8(1), pp.1–28.

Maurya, A., 2010. Running Lean. *Science of Aging Knowledge Environment*, 2002(20), pp.1–278. Available at: http://www.runningleanhq.com/.

Mentink, B., 2014. Circular Business Model Innovation: A process framework and a tool for business model innovation in a circular economy. *Delft University of Technology*. Available at: http://repository.tudelft.nl/assets/uuid:c2554c91-8aaf-4fdd-91b7-4ca08e8ea621/THESIS_REPORT_FINAL_Bas_Mentink.pdf.

Morecroft, J.D.W., 1992. Executive knowledge, models and learning. *European Journal of Operational Research*, 59(1), pp.9–27.

Moreno, M. et al., 2016. A Conceptual Framework for Circular Design. *Sustainability*, 8(9), p.937.

Mouazan, E., 2016. Understanding circular business models : drivers , obstacles and conditions towards a successful transition.

Nußholz, J., 2017. Circular Business Models: Defining a Concept and Framing an Emerging Research Field. *Sustainability*, 9(10), p.1810.

Osterwalder, A. et al., 2014. *Value Proposition Design: How to Create Products and Services Customers Want.*, Hoboken: John Wiley & Sons.

Osterwalder, A. & Pigneur, Y., 2010. *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*, John Wiley & Sons.

Planing, P., 2014. Business Model Innovation in a Circular Economy Reasons for Non-Acceptance of Circular Business Models. *Open Journal of Business Model Innovation*, (April 2015), pp.1–11.

Poutiainen, P.S., 2015. *Designing out waste: an exploratory study of circular business models*.

Ramos Li, 2016. *Business Models for a Circular Economy*,

Rauter, R., Jonker, J. & Baumgartner, R.J., 2017. Going one's own way: drivers in developing business models for sustainability. *Journal of Cleaner Production*, 140, pp.144–154.

Richmond, B., 1991. Systems Thinking.

Roome, N. & Louche, C., 2016. Journeying toward business models for sustainability: A conceptual model found inside the black box of organisational transformation. *Organization & Environment*, 29(1), pp.11–35.

Roos, G., 2014. Business Model Innovation to Create and Capture Resource Value in Future Circular Material Chains. *Resources*, 3(1), pp.248–274.

Ruggieri, A. et al., 2016. A meta-model of inter-organisational cooperation for the transition to a circular economy. *Sustainability (Switzerland)*, 8(11).

Schaltegger, S., Lüdeke-Freund, F. & Hansen, E.G., 2012. Business cases for sustainability: The role of business model innovation for corporate sustainability. *International Journal of Innovation and Sustainable Development*, 6(2), pp.95–119. Available at: https://www.scopus.com/inward/record.uri?eid=2-s2.0-

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84861647808&partnerID=40&md5=ddb3585c51eb5013fd2bdbb801bd7d17.

Sterman, J.D., 2000. *Business dynamics: Systems thinking and modeling for a complex world* Irwin/McGr., Boston. Available at: http://www.lavoisier.fr/notice/frJWOAR6SA23WLOO.html.

Sterman, J.D., 2007. Exploring the next great frontier : system dynamics at fifty. , 23(2), pp.89–93.

Stubbs, W. & Cocklin, C., 2008. Conceptualizing a 'Sustainability Business Model'. *Organization & Environment*, 21(2), pp.103–127.

Suskewicz, M.W.J. and J., 2009. How to Jump-Start the Clean-Tech Economy. *Harvard Business Review*.

Talukder, M.H., 2017. Circular business model innovation–a process framework and a tool towards more circular economy.

The RETRACE project, 2017. *Systemic Design Method Guide for Policymaking: A Circular Europe on the Way* RETRACE pr. Silvia Barbero, ed.,

Uyarra, E. et al., 2014. Barriers to innovation through public procurement: A supplier perspective. *Technovation*, 34(10), pp.631–645.

Wells, P. & Seitz, M., 2005. Business models and closed-loop supply chains: a typology. *Supply Chain Management: An International Journal*, 10(4), pp.249–251.

Whelan, T. & Fink, C., 2016. The Comprehensive Business Case for Sustainability. *Harward Business Review*. Available at: https://hbr.org/2016/10/the-comprehensive-business-case-for-sustainability [Accessed November 14, 2017].

Wilkes, L., 2012. Establishing a Reference Framework . An Overview . , (April), pp.1–8. Available at: http://everware-cbdi.com/erfoverview [Accessed September 28, 2017].

Witjes, S. & Lozano, R., 2016. Towards a more Circular Economy : Proposing a framework linking sustainable public procurement and sustainable business models. *Resources, Conservation & Recycling*, 112, pp.37–44. Available at: http://dx.doi.org/10.1016/j.resconrec.2016.04.015.

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