D5.1 New Business Models and Services for the Water Sector

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

Document history

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Updates from previous versions

After the evaluation of the Deliverable, some comments have arisen asking for more concrete data and the application of the developed methodology to more demo cases and companies. In order to expand the study and respond to the evaluators' comments, new analyses have been included and the conclusions reached in the original document have been expanded.

After a second revision, new comments arose related to information about the info included on the business models developed for the companies (SWOT, market related aspects, sales channels… etc.). Exploitation results and patents were requested as well, but those results have been developed in T5.2, resulting on the development of 2 start-ups (Newater valorising the Sewer Miner solution of CS Athens and Seitiss in collaboration with AquaMinerals to develop water upcycling activities in France). It must be noted that NextGen has not filled any patent during the project.

Description of the changes

The work carried out in the revision of the document has consisted in:

- On one hand, the analysis made to La Trappe's case have been done to three more demo cases (Westland, Athens and Timisoara). Ecocanvas cannot be applied to demo cases because is a tool focused on business models of isolated companies, and not on ecosystems of entities, which is the case of the demo cases. The work developed in this Deliverable was afterwards used to develop the value chains of the different demo cases on D5.2. For that reason, only three new demo cases have been included here. Those new analysis are shown from Section 4.3.2 to Section 4.3.4, and Recommendations are included on Section 4.3.5.
- With the aim of analysing circular business models, the Ecocanvas has been used on eight companies of the water sector related to different demo cases. Section 4.4 includes them as well as discussion of the results.
- Finally, Section 5 has been updated with conclusions from the new sections.

On the second revision, the business models described on Section 4.4.2 to Section 4.4.9. have been expanded to include technical, market and marketing aspects after each of the Ecocanvases.

Third revision

Reviewers comment:

The deliverable has been amended and resubmitted. Even though now 3 more demo cases have been included, the report does not cover all 10 demos. Findings from the demo cases as presented in Table 3 should be clearly addressing the specificities of each demo case and highlight the circularity aspects of each business model including the nexus approach. It is good that additional spinoffs have been included, even though not covering all demos.

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Reply and correction:

Task 5.1 in the DoA states that NextGen will propose new business models and services around circular water systems, for which we will undertake a systematic approach to develop such new business models and services. As such we developed the Ecocanvas approach and applied it at 4 demo cases as presented in D5.1. And we applied the Value Chains approach to all 10 demo cases as presented in D5.2.

The reason that in D5.1 not all 10 demo cases have been covered, is that the Ecocanvas approach cannot be applied to the other demo cases because it is a tool focused on business models of isolated companies and not on ecosystems of entities. Moreover, all 10 demo cases have been covered in D5.2 with the value chains approach.

Analysing demo cases from a business model perspective is complicated or even impossible for two main reasons: a) A business model only makes sense when the entity being analysed is for profit. Most demo cases are WWTPs or public entities that do not have this purpose. b) The business models and the tools available for their analysis are designed for companies that operate in isolation. In most of the demo cases, several entities were working together, which also made it impossible to analyse them from this perspective.

The analysis was therefore limited to those where information related to business models was available: Westland, Athens, La Trappe, Timisoara.

To alleviate this lack of information, what was finally done was to analyse with Ecocanvas (a tool designed to analyse the business model of a company taking into account its sustainable and circular characteristics) nine companies involved in the aforementioned cases, in particular: Raceway Reactor (La Trappe), Aquaminerals (Westland), Biopolus: (La Trappe/Athens), Chemitec (Athens), Aquatim (Timisoara), Adasa (Costa Brava), Alpha Wassertechnik AG (Altenrhein), Netics (Westland).

With this analysis, the business models of some of the entities involved in the analysed demo cases were analysed in depth. And we analysed for-profit companies involved in two of the demo cases that did not have analysable business models (Alternhein and Costa Brava).

Table 3 has been expanded with the circularity and nexus aspects of the demo case specifics.

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Summary

The work described in this report is related to Work Package 5, focused on exploring new business models and support marked creation and, in particular, is linked with Task 5.1, focused on business models and services. The objectives of the deliverable are:

1. Offer a set of tools (business model canvas and indicators) to ease the transition to a circular business model.
2. Offer an overview of Circular Economy in the water sector in Europe.
3. Explore different options of circular business model innovation and circular business models.
4. Explore which services can help in the transition to a circular business model in the water sector.

This report includes a literature review of different available tools related to circular business models, including circular business models strategies, sustainable and circular business models canvas and sets of indicators. Then, an overview of the water regulations in Europe are included. Finally, the work includes a methodology to analyse circularity and/or business models of companies or water treatment sites. Thanks to this methodology, a tool shaped as a questionnaire has been designed and tested in one of the NextGen demo cases.

Conclusions from this work are:

- The literature review (Section 2) has shown that there are already on place several tools (business canvas and indicators) to help designing sustainable business models, but few specifically focused on circular business models. Each available tool is based on different definitions of sustainability, so that the better one will depend on the application.
- Circular Economy, in general, and its application in the water sector, specifically, are key topics at European level (Section 3). Several new regulations are being launched about those topics that will affect the companies' transition to the circular economy.
- The developed tool (Section 4) has been successfully tested in four demo cases (La Trappe, Westland, Athens and Timisoara), and seems to be effective gathering information enough to describe several circularity aspects of an entity/circular site. From a business model point of view, the performance of a water circular system is much easier to reach if the water treatment systems are combined with supporting technologies to recover and treat waste streams. In addition, it has a positive impact from the environmental point of view as well thanks to the decrease of produced waste. The overall results show that the tool is able to give useful information of the circularity of a site at different levels and opportunities to improve it. Nevertheless, more demo cases will be analysed and results presented in Deliverables (D5.2 and D5.3) with the aim of improving it.
- Besides, a collection of Ecocanvas made to companies to the water sector (Section 4.4) has been developed and analysed.

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Glossary

Acronym	Meaning
BM	Business Model
BMC	Business Model Canvas
BMI	Business Model Innovation
CCS	Carbon Capture Storage
CCU	Carbon Capture and Utilizing
CE	Circular Economy
CSP	Circular Service Provider
EBME	Ecology of Business Model Experimentation
ESIF	European Structural & Investment Funds
ETS	Emission Trading Scheme
EU	European Union
LCA	Life Cycle Assessment
MNR	Metabolic Network Reactor
PB	Photobioreactor
PNSB	Purple Non Sulphur Bacteria
RR	Raceway Reactor
TLBMC	Triple Layered Business Model Canvas
WP	Work Package
WWTP	Waste Water Treatment Plant

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1. Introduction

NextGen aims to boost sustainability and bring new market dynamics throughout the water cycle at the 10 demo cases and beyond. Through activities to close the water, energy and materials cycles in 10 demo cases, Work package 1 (WP1) will provide the necessary data to assess the benefits and drawbacks of the technologies (WP2), but also to provide evidence to convince stakeholders on their implementation (WP3), while overcoming the social and governance barriers (WP4) and creating new business models to promote the implementation of those solutions (WP5 & WP6).

This report is about business models in the framework of the NextGen project and corresponds to the second deliverable of WP5. The objectives of the deliverable are:

5. Offer a set of tools (business model canvas and indicators) to ease the transition to a circular business model.
6. Offer an overview of Circular Economy in the water sector in Europe.
7. Explore different options of circular business model innovation and circular business models.
8. Explore which services can help in the transition to a circular business model in the water sector.

Section 2 includes a collection of tools that can help shaping a business model with the circular economy principles through different business model canvases and indicators; Section 3 is focused on the state of circular economy in the water sector in Europe; Section 4 shows an analysis tool developed to analyse the circularity of an entity and its application in four demo cases and the application of the Ecocanvas to eight companies related to the different demo cases; and Section 5 includes the conclusions of the present work.

This deliverable complements the activities of exploitation in NextGen and of business modelling in T5.2. This information was crucial to support the effective exploitation of the project results, which led in particular to the development of 2 startups (Newater valorising the Sewer Miner solution of CS Athens and Seitiss in collaboration with AquaMinerals to develop water upcycling activities in France). It must be noted that NextGen has not filed any patent during the project.

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2. Circular Economy and Business Models

2.1. Circular Economy Concept and Challenges

Usually, the concept of 'economy' leads us to think of systems of trade, finance, investment, business, profit, loss, GDP and other elements that give us a view of the growth (or decline) of a country or region. These concepts are the result of a linear economic system whose functioning was established in the 18th century during the first industrial revolution, an era that witnessed the emergence of the economic thinking underlying today's global economy and mechanized production[1].

However, the world is not the same in the 21st century. There is contrasting information that shows the first consequences of the shortage of certain resources, pollution and the damage done to soil, water, air and biodiversity. This entails not only environmental consequences, but also social ones. Overpopulation, poverty, epidemics, diseases, wars, unemployment and food shortages are consequences of past decisions –or the lack of them- on resource management. This economic system, based on mass production and consumption, can be largely described as linear: virgin materials are taken from nature, used to make products, which are then used and eventually disposed of, with the consequent decline of natural resources as well as environmental and social impact. However, the economic system must be planned to take into account both living beings and the persistence of economic benefit. This is precisely the purpose of the Circular Economy (CE)[2].

Beyond the current linear model, the CE aims to redefine growth by focusing on positive benefits for society and the environment. This implies the gradual decoupling of economic activity and growth from the consumption of finite resources and the elimination of the concept of "waste".

The Ellen MacArthur Foundation has identified four building blocks that will help fostering a more circular economy[3,4]:

- **Circular product design and production:** A key feature of a circular economy is to be restorative and regenerative by design. The recovery of materials and products is not

[1] Leonas, K.K., *The use of recycle fibres in fashion and home products,* S.S. Muthu (Ed.), Textiles and Clothing Sustainability, Springer, Singapore (2017), pp. 55-78.
[2] Gardetti, M.A., *Introduction and the concept of circular economy*, Circular Economy in Textiles and Apparel, (Elsevier), 2019, 1-11.
[3] Ellen MacArthur Foundation, *Towards the Circular Economy – Economic and business rationales for accelerate transition,* (Sun, McKinsey & Co.), 2012.
[4] Accessed online: https://www.ellenmacarthurfoundation.org/circular-economy/concept/building-blocks (13 September 2020)

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only addressed at end of use but is enabled at the design level. Companies will need to build core competences in circular design to facilitate product reuse, recycling and cascading.

- **New business models:** Business models that move from ownership to performance-based payment models are instrumental in translating products designed for reuse into attractive value propositions. By prioritising access over ownership, this models drive a shift from consumer to users.
- **Reverse cycle:** A value preserving material backbone is a core requirement for the transition to a circular economy. To create value from materials and products after use, they need to be collected and brought back. Reverse logistics and treatment methods allow those materials to get back in the market.
- **Enablers and favourable system conditions:** While businesses can largely drive these first three building blocks, several enabling conditions can greatly help the transition:
    - Collaboration
    - Rethinking incentives
    - Providing a suitable set of international environmental rules
    - Leading by example and driving up scale fast
    - Access to financing

This document will focus on the building block related to business models, introducing the latest advances and how they can be implemented in the water sector.

2.2. Business Models and Circular Economy

As shown in the previous section, a circular economy system requires the design and implementation of business models that are based on using as little resources for as long as possible, while extracting as much value as possible in the process. Furthermore, it requires production processes that are constructed in such a way that the residuals from these processes, possibly after regenerating them, can be reused in the same process or used in the biological or technical cycle. Organisations that are willing to adopt the circular economy model need to implement new types of business models by rethinking value propositions and developing value chains that offer feasible cost efficiency, production effectiveness, and business performance[5,6].

A business model describes the rationale of how an organization creates, delivers and captures value, in economic, social, cultural and other contexts[7]. Achieving greater

[5] Rashid, A., Asif, F.M.A., Krajnik, P., Nicolescu, C.M., 2013. *Resource conservative manufacturing: an essential change in business and technology paradigm for sustainable manufacturing*, J. Clean. Prod. 57, 166-177. https://doi.org/10.1016/j.jclepro.2013.06.012.
[6] Schulte, U.G., 2013, *New business models for a radical change in resource efficiency*, Environ. Innovat. Soc. Transit. 9, 43-47. https://doi.org/10.1016/j.eist.2013.09.006.
[7] Osterwalder, A., Pigneur, Y., 2010, *Business Model Generation*, John Wiley & Sons, Hoboken.

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sustainability or circularity requires changes in the way companies generate value, understand and do business. This transition requires a rethinking of the traditional business models (BM, Business Model) that allows the decoupling of value creation and resource consumption. Therefore, innovation in business models (BMI, from Business Model Innovation) towards sustainability and circularity is fundamental for these companies.

The BMI is a modification of the BM in response to internal and external incentives and consists of a dynamic process that can happen in different intensities, depending on the degree of novelty included or the scope of changes. Among the different existing BMI models, two will be commented: the BMI oriented to sustainability and the BMI oriented to circularity[8].

Sustainability-oriented BMI

The sustainability-oriented BMI incorporates sustainability principles as guidelines for the design of business models, incorporating complexity to the conventional BMI process. In addition to pursuing the generation of superior value for the client to achieve competitive advantage and capture economic value, it seeks to contribute positively to the environment and society[9,10].

The extent to which sustainable principles will be incorporated into the business model and generate results with impact will depend on the ambition of the decision makers. The three possible strategies for incorporating sustainability into the BMI are[11]:

- Defensive: focus on risk/cost reduction to keep the business as usual
- Accommodative: focus on improving the BMI to reduce impacts.
- Proactive: focus on a totally new design of the value logic.

Proactive strategies usually have a greater impact because they involve incorporating the values of sustainability into the internal logic of the company, by rethinking the value proposition and the systems of creation, and through dissemination and capture, to maximize social and environmental benefits, not just economic ones.

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[8] Pieroni, M.P.P., McAloone, T.C., Pigosso, D.C.A., *Business model innovation for circular economy and sustainability: A review of approaches,* Journal of Cleaner Production, 2019, 215, 198-216.

[9] Lüdeke-Freund, F., *Towards a conceptual framework of business models for sustainability,* Knowledge Collaboration & Learning for Sustainable Innovation, ERSCP-EMSU Conference, Delft, The Netherlands, 2010, 1-28.

[10] Stubbs, W., Cocklin, C., *Conceptualizing a sustainability business model*, Organization & Environment, 2008, 21, 103-127.

[11] Schaltegger, S., Freund, F.L., Hansen, E.G., *Business cases for sustainability: the role of business model innovation for corporate sustainability,* International Journal of Innovation and Sustainable Development, 2012, 6, 95.

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The sustainability-oriented BMI needs new and different areas of analysis[12]:

- Organizational: focused on individual companies and their own value-generating activities
- Inter-organizational: focused on the interrelations with other actors to co-create and share value.
- Social: focused on interrelations with other organizations to produce shared social value.

CE-oriented BMI

The BMI oriented to the circular economy incorporates the principles and practices of the circular economy to the design of the business model. It aims to enhance resource efficiency and effectiveness and close resource and energy cycles by changing the way economic value and product interpretation are addressed[13].

Circular BMI can then be defined as the conceptualisation and implementation of circular business models, which comprises the creation of circular startups, the diversification into circular business models, and the acquisition of circular business models for the transformation of a business model into a circular one. This can affect the entire business model or one or more of its elements, the interrelations between the elements, and the value network[14].

Four different types of circular business model innovation strategies can be identified in the literature[15,16]:

- *Circular business model transformation* describes the modification of an existing business model. While the initial business model can be both conventional of circular, after applying the circular business transformation, the resulting business model will incorporate circular economy features.
- *Circular start-ups* refer to the creation of new business models that incorporate circular economy strategies outside of an existing company.
- *Circular business model diversification* describes the development of new business models that incorporate circular economy strategies from within an existing

[12] Boons, F., Lüdeke-Freund, F., *Business models for sustainable innovation: state-of-the-art and steps towards a research agenda*, Journal of Cleaner Production, 2013, 45, 9-19.
[13] Bocken, N.M.P, de Pauw, I., Bakker, C., van der Grinten, B., *Product design and business model strategies for a circular economy,* Journal of Industrial and Production Engineering, 2016, 33, 308-320.

[14] Geissdoerfer, M., Pieroni, M.P.P., Pigosso, D.C.A., Soufani, K., *Circular business models: a review,* Journal of Cleaner Production, 277 (2020) 123741
[15] Geissdoerfer, M., Morioka, S.N., de Carvalho, M.M., Evans, S., 2018, *Business models and supply chains for the circular economy*, J. Clean. Prod. 190, 712-721. http://linkinghub.elsevier.com/retrieve/pii/S0959652618311867.
[16] Geissdoerfer, M., Vladimirova, D., Evans, S., 2018, *Sustainable business model innovation: a review*, J. Clean. Prod. 198, 401-416, https://doi.org/10.1016/j.jclepro.2018.06.240

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organisation. The current business model of the parent organisation stays in place and the new business models are either integrated into the organisation as new businesses or spun-off as subsidiaries.

- *Circular business model acquisition* describes merger and acquisition activities that target business models that incorporate circular economy strategies.

Those strategies can be also combined by the same organisation depending on its objectives.

Circular Business Models

Circular business models can be defined as business models that are cycling, extending, intensifying, and/or dematerialising material and energy loops to reduce the resource inputs into and the waste and emission leakage out of an organisational system. This comprises recycling measures (cycling), use phase extensions (extending) a more intense use phase (intensifying), and the substitution of products by service and software solutions (dematerialising)[17].

The second half of the definition describes four generic strategies for circular business models identified in the literature[18,19,20]:

- Cycling means that materials and energy are recycled within the system, through reuse, remanufacturing, refurbishing, and recycling.
- Extending resource loops implies that the use phase of the product is extended, through long-lasting and timeless design, marketing that encourages long use phases, maintenance and repair.
- Intensifying resource loops implies that the use phase of the product is intensified through solutions such as sharing economy or public transport.
- Dematerialising resource loops describes the provision of product utility without hardware through substitution with service and software solutions.

[17] Geissdoerfer, M., Pieroni, M.P.P., Pigosso, D.C.A., Soufani, K., *Circular business models: a review,* Journal of Cleaner Production, 277 (2020) 123741,
[18] Bocken, N.M.P, de Pauw, I., Bakker, C., van der Grinten, B., 2016, *Product design and business model strategies for a circular economy*, J. Ind. Eng. 33 (5), 308-320. https://doi.org/10.1080/21681015.2016.1172124.
[19] Geissdoerfer, M., Morioka, S.N., de Carvalho, M.M., Evans, S., 2018, *Business models and supply chains for the circular economy*, J. Clean. Prod. 190, 712-721. http://linkinghub.elsevier.com/retrieve/pii/S0959652618311867.
[20] Geissdoerfer, M., Vladimirova, D., Evans, S., 2018, *Sustainable business model innovation: a review*, J. Clean. Prod. 198, 401-416, https://doi.org/10.1016/j.jclepro.2018.06.240.

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2.3. Tools to design and measure circular business models

2.3.1. Business Model Canvas

Business model canvas (BMC) is a strategic management and lean start up template created by Osterwalder and Pigneur in 2010[21] for developing new or already existing business models. This canvas helps finding out the business model of a company exploring nine building blocks: Customer segments, Value proposition, Channels, Customer relationships, Revenue Streams, Resources, Activities, Partners and Cost structure (See Figure 1).

Since its creation, this canvas has been extensively used to define business models by entrepreneurs around the world. However, as it can be seen from Figure 2, the BMC only takes into account aspects related to the economic performance of the company. In recent years the growing concern about climate change and its consequences have brought the necessity of re-defining the global economy.

This fact has led to new versions of the BMC that allow to include sustainable and circular aspects within the definition of the business model of a company. In this section some of those new BMC are introduced.

[21] Osterwalder, A., Pigneur, Y., 2010, *Business Model Generation*, John Wiley & Sons, Hoboken.

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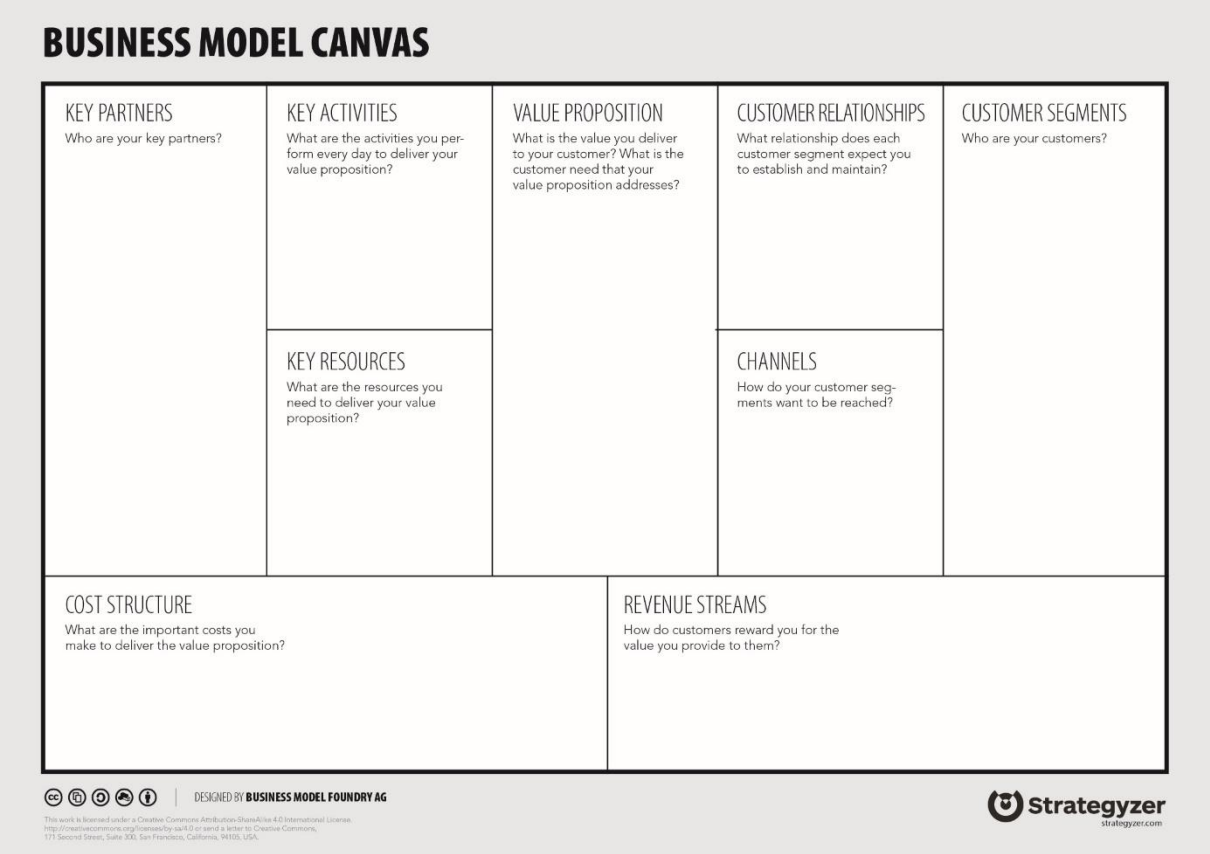

Figure 1: Business Model Canvas[22]

Value mapping tool for sustainable business modelling

The Value Mapping Tool for sustainable business modelling proposed by N.M.P. Bocken et al[23] was conceived to help companies create value propositions to support sustainable business modelling. The tool adopts a qualitative approach to value analysis and has the following specific aims:

- Understand the positive and negative aspects of the value proposition of the value network (i.e. the network of stakeholders involved in creation, delivery and receipt of value associated with provision of a product/service);
- Identify conflicting values (i.e. where one stakeholder benefit creates a negative for another stakeholder), so that action can be taken to tackle these;
- Identify opportunities for business model redesign and realignment of interests to reduce negative outcomes and improve the overall outcome for the stakeholders in the value network – especially for society and the environment.

The value mapping tool is shown in Figure 2, including:

[22] Accessed online: https://www.designabetterbusiness.tools/tools/blank-canvas (15/10/2020)
[23] Bocken, N.M.P., Short, S., Rana, P., Evans, S., *A value mapping tool for sustainable business modelling*, Corporate Governance, 2013, Vol. 13, (5) 482-497, http://dx.doi.org/10.1108/CG-06-2013-0078.

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- Four representations of value to facilitate a systematic value assessment (concentric circles). Identifying them separately encourages a more thorough exploration of the current business model, and assists in identifying areas requiring change or improvement.
- Stakeholder segments to facilitate a multiple stakeholder view of value. The tool seeks to expand the range of stakeholders or recipients of value, including the environment and society. Each segment represents a stakeholder group.
- A network centric rather than firm centric perspective to encourage the optimisation of value in a network (i.e. considering all actors involved in the design, production and distribution of a product or service). The firm is represented as "employees and shareholders" to facilitate the network perspective.

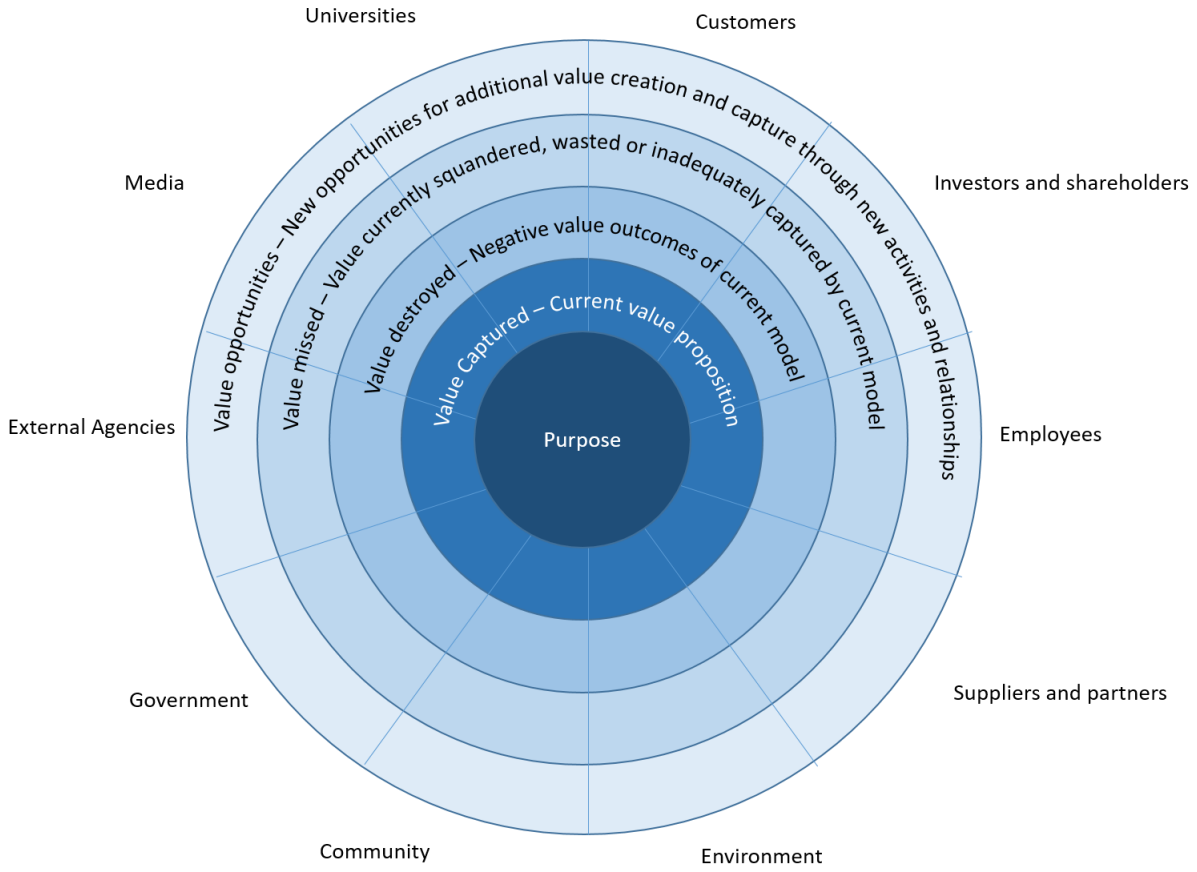

Figure 2: Value Mapping Tool

Triple Layered Business Model Canvas (TLBMC)

The Triple Layered Business Model Canvas[24] proposed by A. Joyce and R. L. Paquin is a tool for exploring sustainability-oriented business model innovation. It extends the original business model canvas by adding two layers: an environmental layer based on a lifecycle perspective

[24] Joyce, A., Paquin, R.P, *The triple layered business model canvas: A tool to design more sustainable business models*, Journal of Cleaner Production, 135 (2016) 1474-1486, http://dx.doi.org/10.1016/j.jclepro.2016.06.067.

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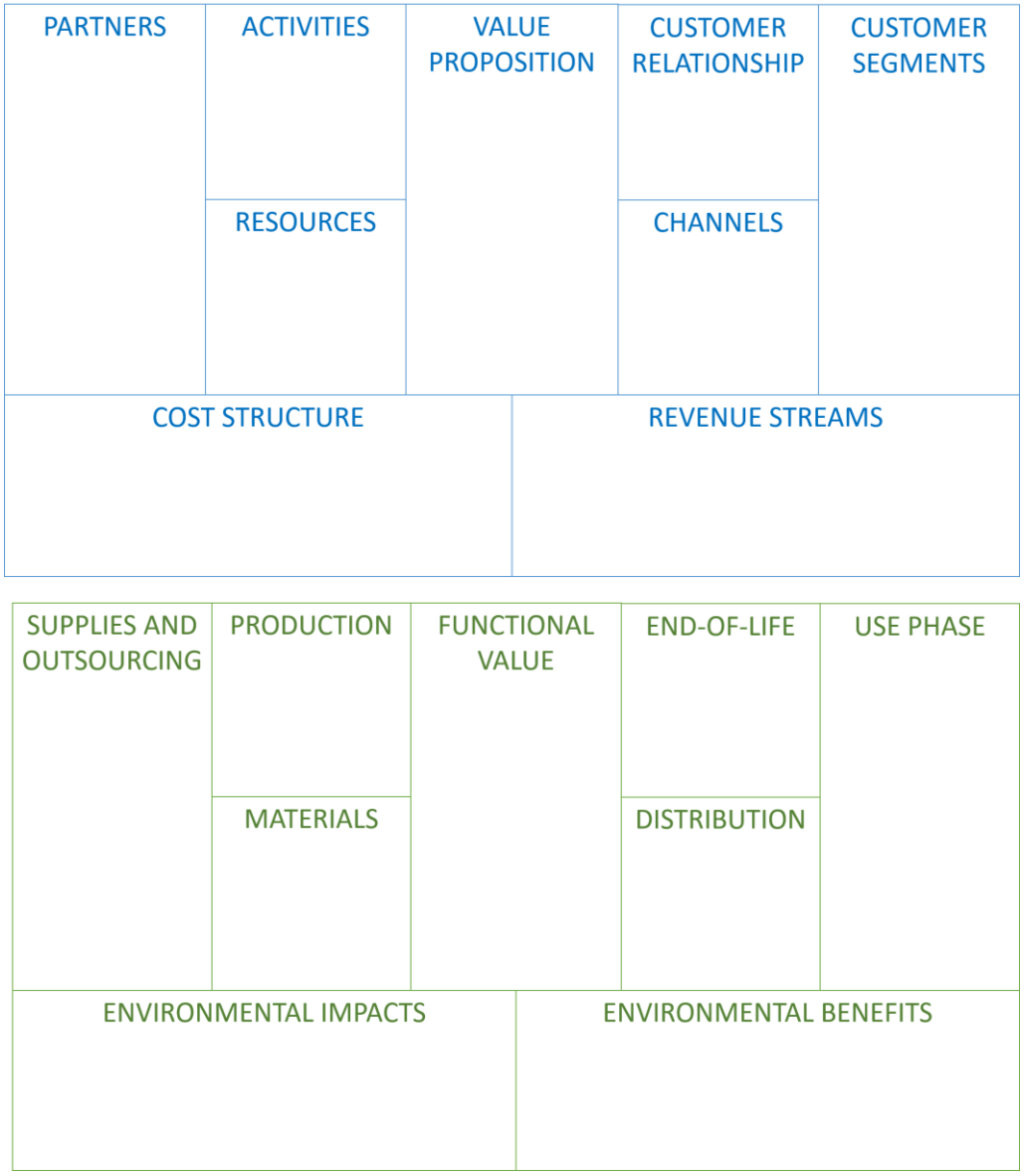
and a social layer based on a stakeholder perspective. When taken together, the three layers of the business model make more explicit how an organisation generates multiple types of value – economic, environmental and social. Visually representing a business model through this canvas tool supports developing and communicating a more holistic and integrated view of a business model; which also supports creatively innovating towards more sustainable business models. The TLBMC canvas is shown in Figure 3.



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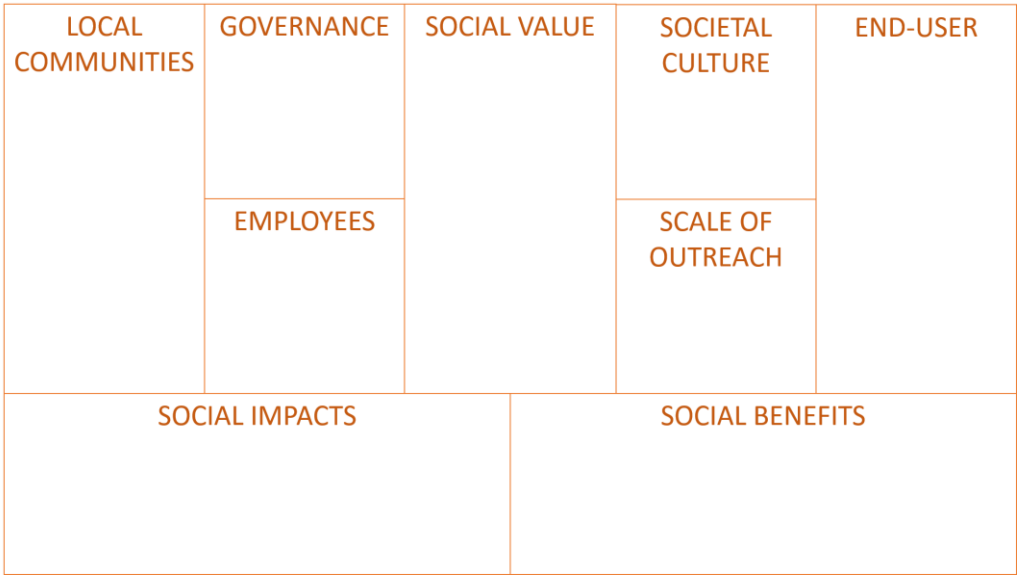

Figure 3: The Triple Layered Business Model Canvas

As it can be seen from the previous figure, the first layer of the TLBMC is the same proposed by Osterwalder an Pigneur. The second one is the environmental layer, that builds on a life cycle perspective of environmental impact, and stems from research and practice on Life Cycle Assessments (LCA), which is a formal approach for measuring a product's or service's environmental impacts across all stages of its life[25]. This layer includes the following elements: functional value, materials, production, supplies and outsourcing, distribution, use phase, end-of-life, environmental impacts, and environmental benefits.

The third layer is the social layer, which builds on a stakeholder management approach to explore an organization's social impact[26]. A stakeholder management approach seeks to balance the interests of an organization's stakeholders rather than simply seeking maximum gain for the organization itself. This layer includes the following elements: social value, employees, governance, communities, societal culture, scale of outreach, end-users, social impacts, and social benefits.

Each layer supports a horizontal coherence, or an integrated approach to exploring an organization's economic, environmental or social impact. Combined, the three layers provide a vertical coherence through connecting the components of each layer to their analogous in the other layers, further elucidating key actions and connections and their impacts across layers. Integrating the economic, environmental, and social layers supports a more robust and holistic view of an organization's business model through its actions and relationships, which can support a more systems-level perspective of sustainability-oriented innovation[27].

[25] Svoboda, S., 1995, *Note on Life Cycle Analysis in Pollution Prevention in Corporate Strategy,* National Pollution Prevention Center for Higher Education, Univ. of Michigan, Report: LCA Note.
[26] Freeman, R.E., 1984, Stakeholder Management: a Strategic Approach. Pitman, Boston.
[27] Zott, C., Amit, R., Massa, L., 2011, *The business model: recent developments and future research,* J. Manag. 37 (4), 1019-1042.

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Business Model Mapping Tool

Another approach to support business innovation is the use of visual tools to reduce complexity and reveal tacit structures to help understand and communicate the business model, generate and develop new business model ideas, and remove obstacles to innovation. One of such a tools specifically designed for circular business is the one designed by Julia L.K. Nussholz, which offers a standardised representation of the elements and possible cycles of circular business models to prolong the useful life of products and parts, and close material loops[28]. The tool is shown in Figure 4.

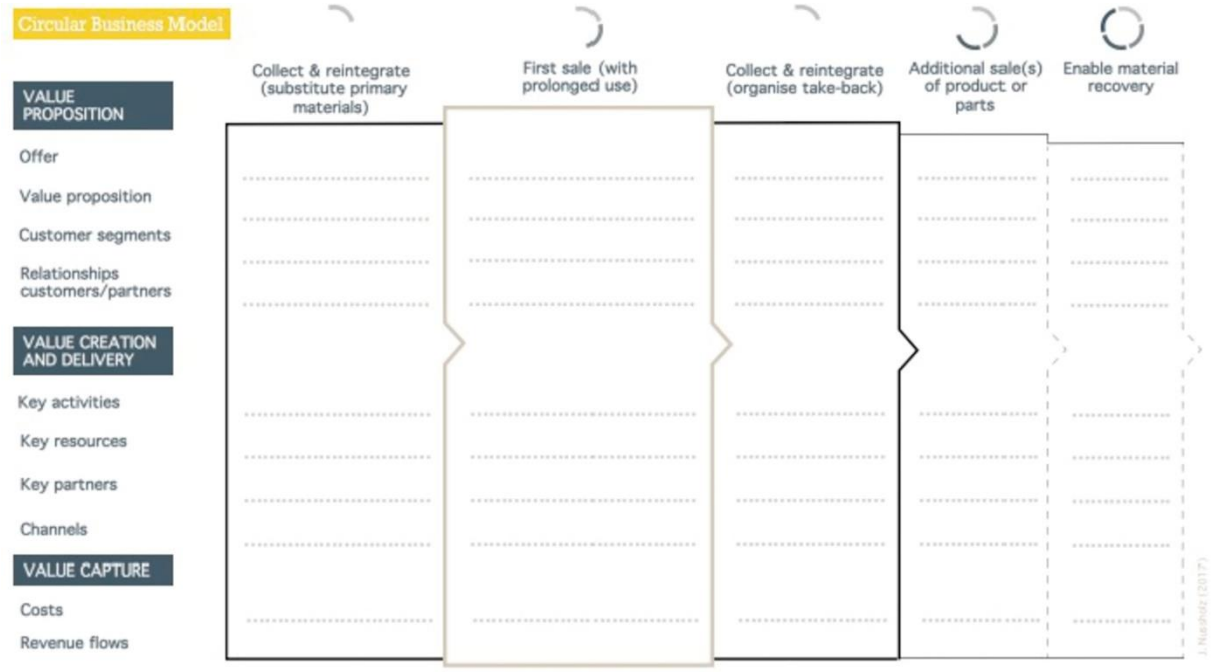

Figure 4. Circular business model mapping tool

It is based on the business model value dimensions and elements included in Osterwalder's and Pigneur canvas (shown in the first column of figure 4):

Table 1: Value dimensions and business model elements of the business model mapping tool

Value dimension	Question to answer	Business model element
Value proposition	What value is proposed and to whom?	Offer Value proposition Customer segments Customer/partner relationships
Value creation and delivery	How is vale created and delivered?	Key activities Key resources/capabilities Key partners Channels

[28] Nussholz, J.L.K., 2018, *A circular business model mapping tool for creating vaule from polongued product lifetime and closed material loops*, Journal of Cleaner Production, 197, 185-194.

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Value capture	How is value captured?	Costs Revenue flows

So, those three value dimensions and their business model elements are integrated with four lifecycle interventions:

- **Collect and reintegrate:** To close resource loops and extend the life of products, parts or materials, they need to be collected and reintegrated into the value chain. Generally, reintegrating secondary production (i.e. products, parts, materials) should be preferred over using virgin resources. After the first sale of a product, a company 0can in some cases organise take-back of their products or parts to enable additional sale(s) or material recovery.
- **First sale (enabling prolonged useful life):** Bringing an offer to the market, a company should enable a long useful life of the product for the user. Manufacturing companies can design for longevity, repair or remanufacturing of their products and offer repair or upgrading services. Companies in the aftermarket can resell a product or its part, e.g. through operating refurbishment, repair or remanufacturing.
- **Additional sale(s) of the product or part to other uses:** To further prolong the useful life of products, a company can enable additional use phase (s) to other uses beyond the first sale. This can be enabled through arranging refurbishment, repair or remanufacturing. The application of the product and the value proposition and customer segments may change in the additional use phase(s). In some cases, only parts of the product are suitable for reintroduction to the market.
- **Material recovery:** To prevent leakages of materials, a company needs to enable closed material loops (e.g. recycling) and avoid downcyling when the end-of-life is irreversibly reached. Product and business models should be designed to facilitate optimal recovery routes of materials.

Ecologies of business models

The methodology to analyse ecologies of business models was proposed by N. Bocken et al.[29] in 2019 with the aim to understand the impact of a business model in environment, society, economy and other key stakeholders. It is based on the idea that business models would need to be understood in their wider context:

- The shaping of individual business models takes place in an institutional context, which provides rules that are conductive to certain forms of providing products and services.
- Such shaping occurs in the context of other business models
- Some of which compete with the new business model, while others are complementary, or even provide vital inputs for the new business model.

[29] Bocken, N., Boons, F., Baldassarre, B., *Sustainable business model experimentation by understanding ecologies of business models*, Journal of Cleaner Production, 208 (2019) 1498-1512.

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- The ecological impact of a business model is difficult to assess as this impact is shaped by the interaction with other business models.
- This eventually determines the material, energy and labour flows associated with the provision of products and services.
- To understand how the provisioning of goods and services impacts on the natural ecosystem, a closer look is taken at a localized business ecosystem rather than an individual business model.

The methodology is summarised in the Ecology of Business Models Experimentation (EBME) map (see Figure 5). The experimentation process starts with an input, which could be a new sustainable business idea or a current business model to be improved. The steps to follow are:

- Step 1: The first step is about defining the sustainability aims of the business. Such aims can be defined by exploring, managing and reconfiguring dependencies through business experimentation. Dependencies can be:
    - Modified: reduce dependency on less sustainable business models
    - Destroyed: Seek to destroy unsustainable business models by outcompeting them on their key resources.
    - Create: Maximise contribution to favourable institutional infrastructure for more sustainable business models.
- Step 2: The second step is about identifying the types of dependencies in place from existing infrastructure, products/services and resources.
- Step 3: The third step entails giving a closer look at the dependencies that were identified and determine their nature (neutrality, competition, symbiosis/mutualism).
- Step 4: While the first three steps are about analysing business model dependencies, the fourth and final step is about business model design and it is done by exploring how positive can be increased and negative value reduced, around the four business model dimensions from the value mapping tool, namely value created, captured, missed, destroyed, and new value opportunities. The different forms of value are related to multiple stakeholders at the same time, also including society and the environment. This final design step is geared towards the generation of new business models based on partnerships and collaborations that foster shared value dimensions for multiple stakeholders across multiple business models.

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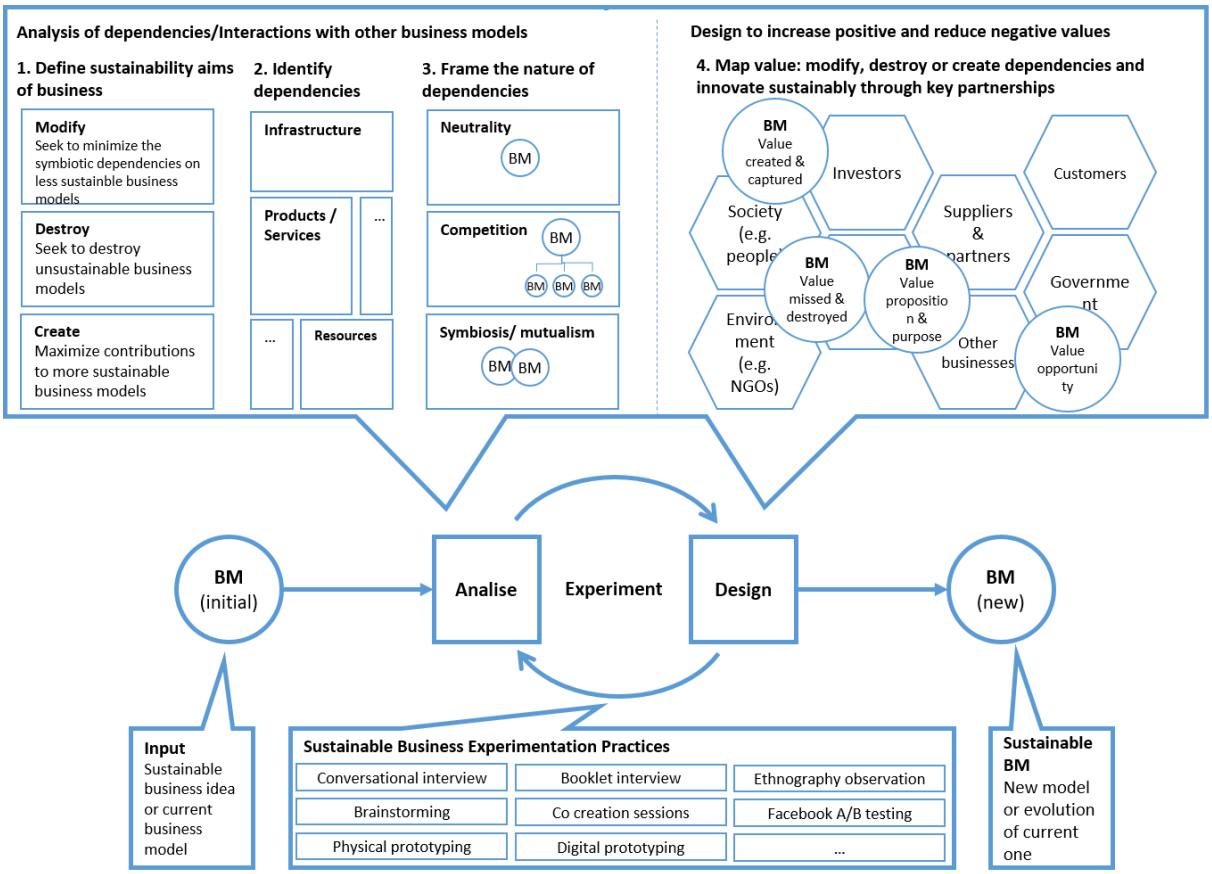

Figure 5: The Ecology of Business Models Experimentation (EBME)

Ecocanvas

All the previous tools are designed to design sustainable business models, but are not focused specifically in circular business models. Ecocanvas[30] is a tool backed by a methodology for enabling businesses to coherently formulate unique circular value propositions based on a lifecycle perspective. The tool is valuable for rethinking and personalizing sustainability and circular economy by more practically tackling the three dimensions of sustainable development (economic, environmental and social), while being adaptable to the organization's context.

The Ecocanvas (see Figure 6) was created adding three extra blocks to the traditional BMC. Those new blocks comprise three forces:

- Economic and legal: Current and future economic challenges such as regulations, market innovations, and macroeconomic issues can represent a risk for the company. These challenges affect the market rules and operating system, which lead to a

[30] Daou, A., Mallat, C., Chammas, G., Cerantola, N., Kayed, S., Saliba, N.A., *The Ecocanvas as a business model canvas for a circular economy,* Journal of Cleaner Production, 258 (2020) 120938, https://doi.org/10.1016/j.jclepro.2020.120938.

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transformation of the whole business model, starting from the connection between Cost of Structure and Revenue Streams to finally influence the rest of the blocks.

- Environmental: Current and future environmental challenges such as water scarcity, climate change, pollution, and environmental threats can directly affect businesses' supply chain, and production activities or logistics. This increase in environmental challenges leads to a rethinking of a company's business strategy, which influences the following blocks: Key resources, Key partners and Structure of Costs.
- Social forces: Current and future societal and technological challenges, such as digital technology, manufacturing, and cultural shifts, will shape customers perceived values, beliefs, and behaviours over time. This leads to important changes in Stakeholders Relationships, Channels and Sales, and consequently to the Revenue Streams.

These three blocks are used to map and classify forces that might be challenging in the business model. Mapping the foresights is a process that aims at (1) identifying key driving forces that change an organization's environment, (2) determining the positive and negative impacts of potential futures, and (3) taking measures and fostering creativity and eco-innovation that will improve an organization's long term competitiveness. Furthermore, in each of the environmental and social blocks, a section related to their respective impact is included. This additional part is provided in order to evaluate all the potential impacts that the business model would generate when operating.

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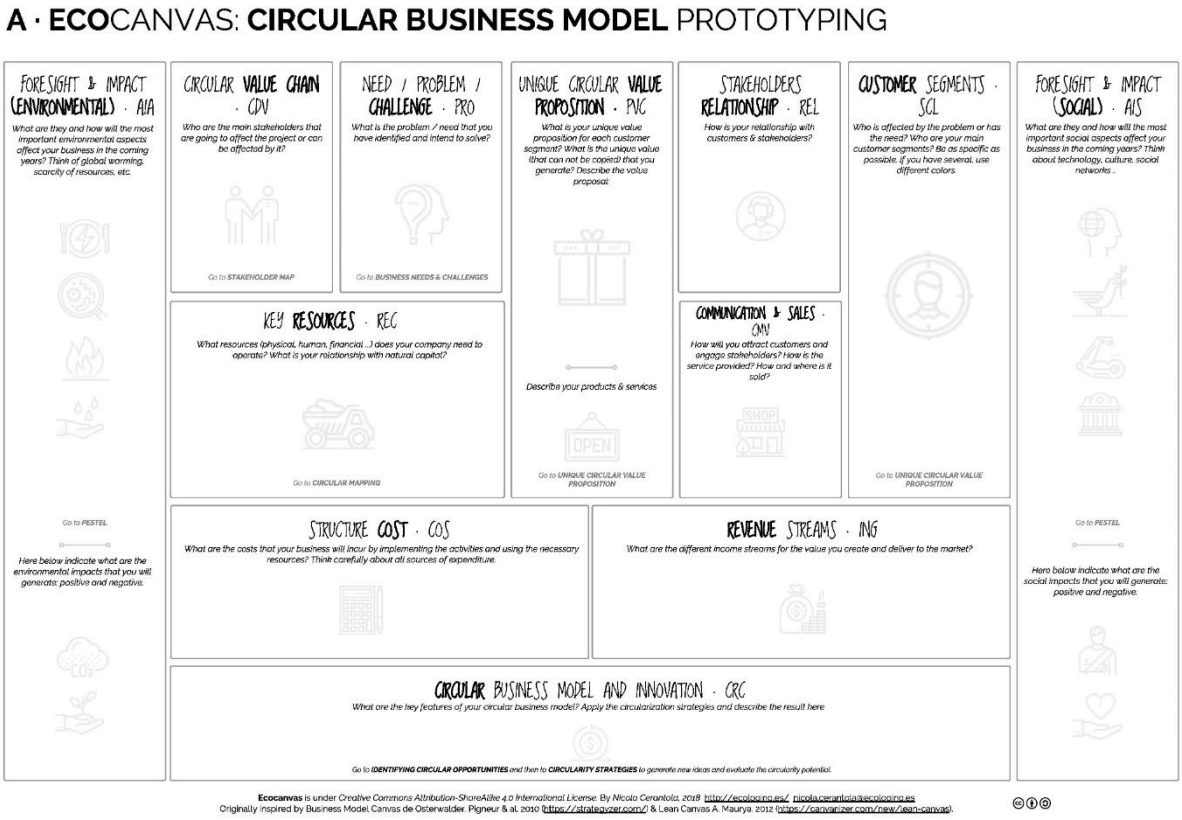

Figure 6: Ecocanvas: Circular Business Model[31]

2.3.2. Circular Economy Indicators

The previous tools help figuring out how to make a business more or less sustainable and circular but doesn't provide a measure of how circular it is. Measuring circularity is not an easy task, CE is an umbrella concept incorporating different meanings and this fact has resulted in the development of different sets of indicators that respond to the various existing definitions[32].

Saidani et al.[33] developed a classification of circular economy indicators inspired by existing taxonomies of eco-design tools and sustainability indicators aiming to assess, improve, monitor and communicate on the CE performance.

This taxonomy includes ten categories to classify, differentiate and orient the use of proper C-indicators:

[31] Accessed online: https://ecologing.es/ (20/10/2020)

[32] Moraga, G., Huysveld, S., Mathieus, F., Blengini, G.A., Alaerts, L., Van Acker, K., de Meester, S., Dewulf, J., *Circular Economy indicators: What do they measure?* Resources, Conservation & Recycling 146 (2019) 452-461. https://doi.org/10.1016/j.resconrec.2019.03.045.

[33] Saidani, M., Yannou, B., Leroy, Y., Cluzel, F., Kendall, A., *A taxonomy of circular economy indicators*, Journal of Cleaner Production 207 (2019) 542-559. https://doi.org/10.1016/j.jclepro.2018.10.014.

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1. Levels: micro, meso, macro
2. Loops: maintain, reuse/remanufacture, recycle
3. Performance: intrinsic, impacts
4. Perspectives: actual, potential
5. Usages: improvement, benchmarking, communication…
6. Transversality: generic, sector-specific
7. Dimension: single, multiple
8. Units: quantitative, qualitative
9. Format: web-based tool, excel, formulas…
10. Sources: academic, companies, agencies

Those ten categories were used to develop "The C-Indicators Advisor"[34], an Excel based, macro enable tool, which is linked to a database of 55 sets of C-indicators classified according the proposed taxonomy. The goal of that selection tool is to support the users in identifying and selecting the most appropriate circularity indicators in line with their requirements.

More recently, the Ellen MacArthur Foundation has introduced Circulytics[35], a circularity measurement tool for companies. This tool has been designed to support a company's transition towards the circular economy, regardless of sector, complexity, and size. The final goal is to revel a what extent a company has achieved circularity across its entire operation. The tool is based on a wide set of indicators and is freely available. However, the tool still seems to be a bit limited to truly capture the systemic nature of circular economy. For that reason, some authors have pointed out the interest on extending product- and organization-level frameworks to embrace biological cycles, material, technologies, and social structures form an institutional perspective[36].

[34] Accessed online: http://www.circulareconomyindicators.com/advisor.php (26/10/2020)
[35] Accessed online: https://www.ellenmacarthurfoundation.org/resources/apply/circulytics-measuring-circularity (22/11/2020).
[36] Fehrer, J. A., Wieland H., (2020) *A systemic logic for circular business models*¸ Journal of business research, https://doi.org/10.1016/j.jbusres.2020.02.010.

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3. Circular Economy and the Water sector

3.1 Introduction

In December 2nd, 2015, the European Commission published the "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions" entitled "Closing the circle: An EU Action Plan for the Circular Economy"[37]. This document highlights the virtues of the Circular Economy at all levels and establishes the need to develop an appropriate regulatory framework to enable its implementation, as well as establishing an action plan with a 2020 horizon with clear proposals to be developed.

This document highlights how water scarcity has worsened in some parts of EU and how it was having a negative impact on both environment and economy. The focus was there on boosting water-efficiency measures and the reuse of treated wastewater in safe and cost-effective conditions.

In December 11th, 2019, the European Union published the Green Deal[38], whose goal is to make Europe climate neutral by 2050 boosting the economy through green technology, creating sustainable industry and transport, and cutting pollution. Figure 8 shows the elements of the European Green Deal, one of which is “Mobilising industry for a clean and circular economy”, area where they plan to invest at least 1 trillion over the course of ten years. The roadmap set for this element is the following (See Table 2):

Table 2: Industrial strategy for a clean and circular economy

Action	Indicative timetable
EU Industrial Strategy	March 2020
Circular Economy Action Plan, including a sustainable products initiative and particular focus on resource intense sectors such as textiles, construction, electronics and plastics.	March 2020
Initiatives to stimulate lead markets for climate neutral and circular products in energy intensive industrial sectors	From 2020
Proposal to support zero carbon steel-making processes by 2030	2020
Legislation on batteries in support of the Strategic Action Plan on Batteries and the circular economy	October 2020

[37] Accessed online: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0640&from=EN (03/11/2020).
[38] Accessed online: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu_en (05/11/2020)

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Propose legislative waste reforms	From 2020

Figure 7: The European Green Deal

Following the roadmap shown in Table 2, in March 11th, 2020, the EU Industrial Strategy[39] and a circular economy action plan[40] were published. The EU Industrial Strategy outlines three drivers of industrial transformation: global competition, climate neutrality, and a digital future. The strategy is underpinned by a set of inter-connected and reinforced elements: (1) certainty for industry and a deeper and more digital single market, (2) upholding a global level playing field, (3) a shift to climate neutrality, (4) building a more circular economy, (5) embedding industrial innovation, (6) skilling and re-skilling, and (7) investment and financing the transition.

On the other hand, the Circular Economy Action Plan, presents new initiatives along the entire life cycle of products in order to modernise and transform the European's economy while protecting the environment. It is driven by the ambition to make sustainable products that last and to enable citizens to take full part in the circular economy. The document identifies seven key product value chains: Electronics and ICT, Batteries and vehicles, Packaging, Plastics, Textiles, Construction and buildings, and Food water and nutrients. Building on the work done since 2015, the new Plan focuses on design and production for a circular economy, with the aim of ensuring that the resources used are kept within the EU economy for as long as possible.

[39] Accessed online: https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en (05/11/2020)
[40] Accessed online: https://ec.europa.eu/commission/presscorner/detail/en/FS_20_437 (05/11/2020)

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The policies mentioned above show the commitment that the European Union has with the adoption of the concept of the Circular Economy. The specific measures and initiatives proposed in the field of water are indicated in the following section.

3.2 The Water Sector in Europe from the CE perspective

The water sector distinguishes three focus points in the transition to the circular economy:

- **Water.** Water itself is an important resource for private individuals, industry and nature. Scarcity of water in an increasing part of Europe in combination with increasing costs (financially end environmentally) of water treatment, makes it evident to create more circular chains.
- **Energy.** Water is an important carrier of energy and can make an important contribution in the energy-transition. For instance, geothermal energy or using heat/cold from the surface, drinking water, or waste water infrastructure (aquathermy). Municipal wastewater contains a lot of biodegradable components, with digesting of the municipal wastewater sludge biogas can be extracted. In the Netherlands , about 1/5 of the biogas is produced at municipal wastewater treatment plants[41].
- **Materials and nutrients**. The water sector generally treats water, using energy and chemicals. The process itself leads to residuals, ranging from gases, concentrates or solids wastes. The resources as well as the wastes are playing a role towards more circular sourcing and disposal, with the ideal situation that the residuals are treated and reused within the treatment process.

3.3. Good practices

3.3.1 Introduction

The water sector has excellent starting credentials to play an important role in the transition to the circular economy. Often prompted by cost reductions and/or sustainability goals, various water companies already have taken steps over the last 10 years or so that can now be considered as good practices. Since there are numerous examples, in this chapter the most replicable, scalable and/or appealing are given.

[41] Accessed online: https://www.cbs.nl/nl-nl/nieuws/2018/19/rioolwaterzuivering-steeds-effectiever-en-duurzamer (16/11/2020).

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The examples are given for water (3.3.2), energy (3.3.3) and materials & nutrients (3.3.4). Making these cases a success requires specific knowledge on various terrains (legal, commercial, certificates, etc.). This knowledge is often not available within the sector, organizing this sectorial and regional is an interesting option.

3.3.2 Water

Water itself is probably the most circular element on earth. The natural hydrological cycle brings it all over the planet and plays an important role on the temperature distribution, weather and availably/supply of fresh water for plants animals and humans. However, due to climate change and other human interferences, this natural cycle is interrupted. The availability of enough fresh water becomes an increasing problem in various parts of Europe.

Water retention

Due to human intervention, the water flow –after rainfall- is accelerated in the hydrological cycle. For instance, the cut of forests and the building of houses and roads with accessory sewage has led to an accelerated transport of water to the rivers and sea. In wet periods a sensible thing to do, but the decreased retention, for instance by infiltration of water into the soil, leads to water scarcity in dryer periods.

Various options for the retention of water are stimulated by (local) governments (subsidies, building permits, etc.):

- Green roofs, rainwater is caught in bathtub-like constructions and a substrate math with e.g. sedum is growing on it;
- The grey- and black water are decoupled in households. Greywater is reused, for instance in the garden, the black water is treated at the sewage plant;
- Simple rain barrels;
- ‘Tiles out- plants in’ in gardens.

Use of municipal wastewater effluent

Treated water is mostly discharged into surface waters like rivers. Depending on the effluent quality and type is use, it might locally be reused. In some cases, an extra polishing step is needed and the effluent needs to be transported with extra piping.

An appealing example of this water reuse comes from Sealand. DOW Chemical operates a large plant near the city of Terneuzen. It uses a significant volume of fresh water. Unfortunately, near this location the ground and surface water is brackish to salt. Desalination is an option, but expensive and environmental unfriendly. In a mutual project with the local water authority, the effluent of the municipal wastewater treatment plant is post-treated into demi water. After the usual treatment process, the water is treated in a helofytenfilter and biological membrane bioreactor.

This reactor is working since 2013 and now uses all the effluent. It produces ~500 m^3/hr and the production costs are < 0,1 €/m3.

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3.3.3 Energy

The water sector can play an important role in producing sustainable energy: energy production from the 'wastes' retrieved in the water treatment process, but also where water itself is used an energy-carrier.

Digestion

Digesters have become commonplace at municipal waste water treatment plants across Europe. When a plant has enough size (and therefore sludge) and/or is supported by national stimulation measures, the business cases are often positive. The biogas has a positive sales value and the volume of the sludge is reduced (and thus lower hauling costs). In the future this economic value might further increase due to CO_2-pricing. This can be significant, instead of CH_4- and CO_2-emmisons from the sludge into the air, the carbon is utilized. Depending on the future standardisation of CO_2-pricing, this might lead to additional value.

The biogas is in most cases at the site burned and converted into electricity and warmth. The electricity is partly used at the site and put on the grid. The warmth is often used for the digestion process.

A new trend is that the biogas is onsite processed into green gas and carbon dioxide. The purified CO_2 is used in greenhouses, the green gas is injected in the grid or cooled and compressed into fuel for transport-vehicles.

Methane from groundwater

Methane arises in groundwater when organic material is broken down in absence of oxygen. It dissolves in the water and is only released when pumped up and comes into atmospheric conditions. This methane-containing groundwater can therefore be found in areas where the subsurface contains a lot of organic materials, for instance peat.

Dutch-based drinking water company removes methane from one of their production sites 'Spannenburg'. Their main reasons are because of the environmental (methane is one of the strongest greenhouse gasses) impact and that methane is a source for bacteria in their infrastructure. In the Netherlands drinking water is not chlorinated, the drinking water companies therefore avoid any risk on bacterial growth.

The methane is burned and used for electricity production.

Cold from the drinking water network

The 'cold' of the drinking water infrastructure can also be used for cooling purposes. The groundwater temperature varies from 10-14° C and surface water has a lot more variation varying from ~0° C to over 30° C in warm summers. Given the substantial impact that temperature may have on water quality, the World Health Organization recommends a maximum value of 25° C. This recommendation is adopted in most countries.

The fact that during most of the year the water is colder than this limit gives water companies the opportunity to use the cold of the water in the infrastructure. In the city of Amsterdam,

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the water utility 'Waternet' uses the cold of their drinking water to cool the city's blood bank. Because the utility wants to be absolutely certain that the water after use at the blood bank doesn't exceed the 25° C, it targets a temperature after use at the blood bank of 15° C. This means that this heat- (or actually cold-) exchanger is operational during the colder months.

3.3.4 Materials and nutrients

At this moment, various value chains have been developed on the recovery and use of materials and nutrients. In this chapter a selection of appealing chains is described.

Struvite

In municipal waste water plants crystallisation of struvite ($Mg(NH4)PO4{\cdot}6H2O$, see Figure 8) is an often observed reaction. This is nuisance for operators, this uncontrolled crystallisation leads to blockage of pipes and thus interruptions of the treatment process. Deblocking is expensive, as well as prevention measures.

Figure 8: Struvite precipitation in pipes (photo: STOWA)

Struvite can also be produced in a controlled part of the treatment process. In this struvite reactor digested sludge is brought into contact with oxygen and additional magnesium. Under these circumstances, struvite starts to crystallize, often in the form of little colourless particles.

The high N-, Mg and particular P-content makes this crystal interesting for the use as fertilizer. Struvite is a slow-dissolving crystal, making it interesting for slow-realising use (e.g. fruit trees) of for further processing into more specific fertilizers. Depending on the regional situation and possibilities, the struvite is used directly on farmland, mixed into rational fertilizer or used as a specially developed fertilizer (corn production).

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Cellulose

In Europe, an average inhabitant uses approximately 13 kilograms of toilet paper. This toilet paper, that mostly consists of cellulose, is flushed through the toilet and then removed in municipal waste water treatment plants. In a traditional plant this cellulose –or its degradation product- ends up in the sludge with the other removed materials. Recovering this cellulose is interesting for several reasons. First, the cellulose itself has an intrinsic value, provided that it is purified. Second, recovering and (re-)using this cellulose has an important environmental effect since is replaces virgin cellulose. This virgin cellulose comes from trees. For the plant itself the advantage of recovery lies in the fact that this saves on energy and chemicals since the cellulose doesn't have to be demolished in the biological purification process in the plant, an energy consuming process.

With specially for this purpose developed fine sieve technology fibres can be removed from municipal wastewater. The sludge consists of ~70% cellulose. This sludge can be applied directly in low end applications like incineration of digestion. The full potential is achieved when this sludge is processed, giving a dry, sterilized and '100%' pure cellulose. This product is applied in the asphalt industry, embankment protection and 3D-printing.

The technology provider Cirtec has installed this technology in (amongst other places) at a treatment plant in Geesterembacht (Nl) and Truccazzano (It).

Calcite from softening

Softening is a normal step in de drinking water production, the hardness of the source determines when this is necessary or not. Centrally lowering the hardness of the water extend life expectancy of household equipment, saves cleaning chemicals and saves energy. All because it avoids lime scaling.

This softening leads to a reasonable volume of calcite at the production locations. The calcite is in the form of little (1 mm) pellets or sludge. This calcite finds its way within various economics sectors in the EU:

- Agriculture/nature and gardening as lime fertilizer;
- Sand-replacement in concrete;
- Feed (GMP+-certificate required, grinding/sieving required);
- Crawl space insulation;
- 3D-printing (grinding/sieving required);
- Glass manufacturing;
- Cosmetics (grinding/sieving required);
- Carpet tile industry (grinding/sieving required);
- Composites like shower trays or tiles.

The above mentioned applications can in most cases be considered as applications in the biological or technical cycle. A real circular example comes from The Netherlands and Germany. Here, the calcite from the softening process is grinded, sterilized and sieved to new

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seeding material. This seeding material is an essential ingredient in the softening reactor. The drinking water industry has high standards on the materials they use in the drinking water production. The development of this circular seeding material has therefore helped greatly in opening pathways to other sectors with high quality standards. From the same calcite-processing plants where this seeding material is produced, also the feed- and cosmetics industry is supplied.

3.3.5 Sectorial collective approach on CE

The development and operationalization of circular chains for water, energy and materials requires specialized knowledge on multiple terrains. After all, a water company will encounter amongst others legal-, quality-, commercial-, supply chain- and research issues. Specialized knowledge is often not or not well enough present at the water companies.

Some water companies tackle this problem partly by creating **purchasing organisations**. These organisations collectively and professionally tender their waste management. The advantage is that the purchasing is professional and by working together their volume increases, making it an interesting order for the market. This volume might also be interesting to demand additional –in this context circular- requirements.

However, these purchasing organisations on a whole haven't been successful in creating durable circular value chains. One reason is that creating a circular chain requires a lot of time, time that the market doesn't have in a tendering process. These orders are often for a certain period of time, while circular chains have a mid- to long term focus due to the initial costs. But maybe the most important reason is that this type of cooperation is client-contractor, while a solid circular value chain is based on a more tantamount position of the parties involved.

Another approach is **the collective establishment of an asset** where materials are processed. For instance, a waste-to-energy incineration plant. In this case multiple water companies establish a plant and are shareholder in it. This option is capital intensive, but sharing the investment makes the burden smaller. By putting the (waste-) volume together, this asset is used effectively, lowering the operational costs. The plant is run by a professional organisation; the water companies can focus on their core business. Because these water companies are shareholder important variables are secured, like compliance, pricing and security of disposal.

The counter side of these collective assets is that the participants are obligated to supply this asset, often for decades. At the beginning this asset is most likely state of the art, but as times passes new technology might provide more suitable (e.g. pricing, environmental impact) solutions. The owners can't supply these new chains without financially scarifying their own assets. Also innovation itself is inhibited, simply because there is no use in investing in R&D because the residuals are not available for this potential

A rarest, but considered successful approach is that of a collective '**shared service centr**e'. This shared service centre specialises in all the competences that are needed initiating and operating a circular value chains. Competences that are normally not present at water

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companies but are essential to be successful in these new value chains. This shared service centre develops new chains and operationalize them on behalf of its participants. The water companies are shareholder in this shared service centre, giving them the possibility to establish policy and supervise the shared service centre.

The advantage of this approach is that a wide knowledge of value chains is centralised in one company. It has barely assets, the entrepreneurial risks are therefore small. This cooperation leads to innovation-, buying- and sales power. Based on the available volume and desires of its participant it closes contracts with the marked. By optimising maturities, it can anticipate on new developments and therefore 'continuously' innovate.

The challenge in creating this shared service centre is that the participants have to agree on a common policy and transfer the autonomy in determining where their materials go, even though this is not known up-front. A company that meets this profile of a shared service centre is Dutch-based AquaMinerals.

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4. NextGen contribution

4.1 Introduction

The work developed in the framework of this deliverable is focused on obtaining practical information about how to develop new circular business models in the water sector as well as identifying different services that can help adopting such circular models.

In first place, a literature review was made about existing circular strategies, tools and indicators to identify, characterize and measure circularity (see Section 2). Then, as it is described in the following section, a methodology was designed to explore the circularity of ecosystems of entities at different levels that was then applied to one of the NextGen democases.

Based on this methodology, a tool based on a questionnaire has been developed to serve as a guideline to gather information about the business model and the circularity of an entity or groups of entieies. This questionnaire is a modification of some of the already existing business model canvas with the aim of making the business analysis more simple and more focused on the circularity of the company.

This tool works like a business model canvas, since it includes a list of topics to think about that should be taken into consideration when designing or shaping a circular business model in the water sector.

Democases are not companies but ecosystems of companies that collaborates to reach a common goal. That makes business canvases not useful to analyse their situation, since they are designed to describe an isolated company's business model. In those cases, questionnaires and methodologies such as the ones described in this document can be of use to give a first overview about how those interactions contributes to build new business models. The present work proposes a methodology that can be applied to entities or groups or entities to analyse the circularity..

This document sets the principles of this analysis and tests it in some examples and has been extensively deployed to all demo cases in D5.2 to study the value chains involved in each of them.

To deepen the analysis of real circular business models in the water sector, the Ecocanvas methodology presented on Section 2.3.1. has been applied to some companies related to different demo cases.

In Section 4.2. the developed methodology to analyse ecosystems of companies is presented. Section 4.3. shows examples of the application of this methodology to some of the demo cases. Section 4.4. shows examples of application of the Ecocanvas to companies related to the different demo cases.

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4.2 Methodology

As mentioned above, a tool has been designed to analyse the circularity of entities or groups of entities. Three elements were used to design that tool, keeping in mind that it should be comprehensive enough to provide the needed information and, at the same time, it should be simple enough to be feasible. Those three elements were:

- Circularity at different scales
- Business Model Canvas
- Circular strategies

Those three elements are described below.

Circularity at different scales

As demonstrated above, measuring circularity is not easy because there are different definitions depending on the focus of the analysis. Besides, circularity can happen at different scales and it is important to take into account all of them to really identify the true circular nature of an organization. For instance, a company can internally recycle materials or water, but bring to landfill by-products that could be used by other companies. Other example could be a company that uses a service instead of product model but is not taking into account how to properly dispose their assets after their end-of-life. For that reason, the present work proposes a model where four different circularity levels are considered (See figure 9):

- Nano: Product/process level. This level takes into consideration the circularity at product and process level and tries to identify if there are closed loops in terms of water, energy or materials within the company. Besides, in case of having more than one process line, this level considers if there are interactions and connections among them.
- Micro: Organisation as a whole. This level analyses how the concept of circularity is being applied at company level, including strategy, employees, resources, communication…
- Meso: Interrelations between close entities. In this level, the relation of a company with its close environment is explored. Industrial symbiosis is an example of this level, trying to close loops about water, energy and materials with other companies and entities that are in the surroundings of the analysed one.
- Macro: Interrelations at bigger scale (municipal, regional, national, international). This level is an extension of the scale of the previous one, taking into consideration opportunities to share resources and strategies with entities placed farther away.

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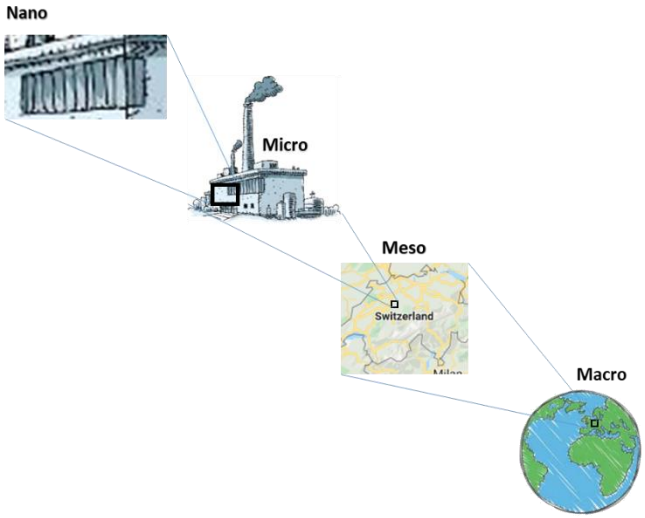

Figure 9: Multi scale analysis framework

Each one of the scales includes the previous one, so exploring each level in an aggregated way can give a better idea about how circular a company is, exploring the company's features from the Nano to the Macro level and balancing its positive and negative aspects regarding circularity in each level.

Business Model Canvas

Business Model Canvas are widely used tools to define the business model of a company. As described in Section 2.3.1, although traditional BMC are only focused in the economic aspects of a company, in the last years many new BMCs have been developed including aspects related to sustainability and circularity. After analysing different business model canvases, two BMCs where selected as starting point for the present work:

- the Triple Layered Business Model Canvas (TLBMC) was selected as starting point for the present work, since it comprises the three main pillars of sustainability: economic, environmental and social. When taken together, the three layers of the business model make more explicit how an organization generates multiple types of values.
- The Ecocanvas, since is specifically focused on circular companies and includes some topics not considered in the TLBMC.

Circularity strategies

The third element included in the tool is focused in the kind of circular business model strategy that a company is using and how it was implemented. In section 2.2 we mentioned that the strategies for circular BMI are:

- Circular business model transformation
- Circular startups
- Circular business model diversification
- Circular business model acquisition

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Or combinations of them. On the other hand, the different circular strategies for BM are:

- Cycling
- Extending
- Intensifying
- Dematerialising

So, the developed tool should be able to identify which of those were used.

Designing of the tool

Once selected and analysed the previous described elements, a tool shaped as a questionnaire was designed. First, the different circularity levels were set as categories to be analysed in an independent way. Levels meso and macro were merged in the same category for practical reasons. Second, the information requested in the three layers of the TLBMC where classified in the circularity levels and then completed with the circular features included in the Ecocanvas. Third, the micro and meso level were enriched with some questions focused on identifying the strategies for circular BMI and BM. Finally, a "general information" section was added to get a general overview of the company. Figure 10 shows a scheme of the followed process.

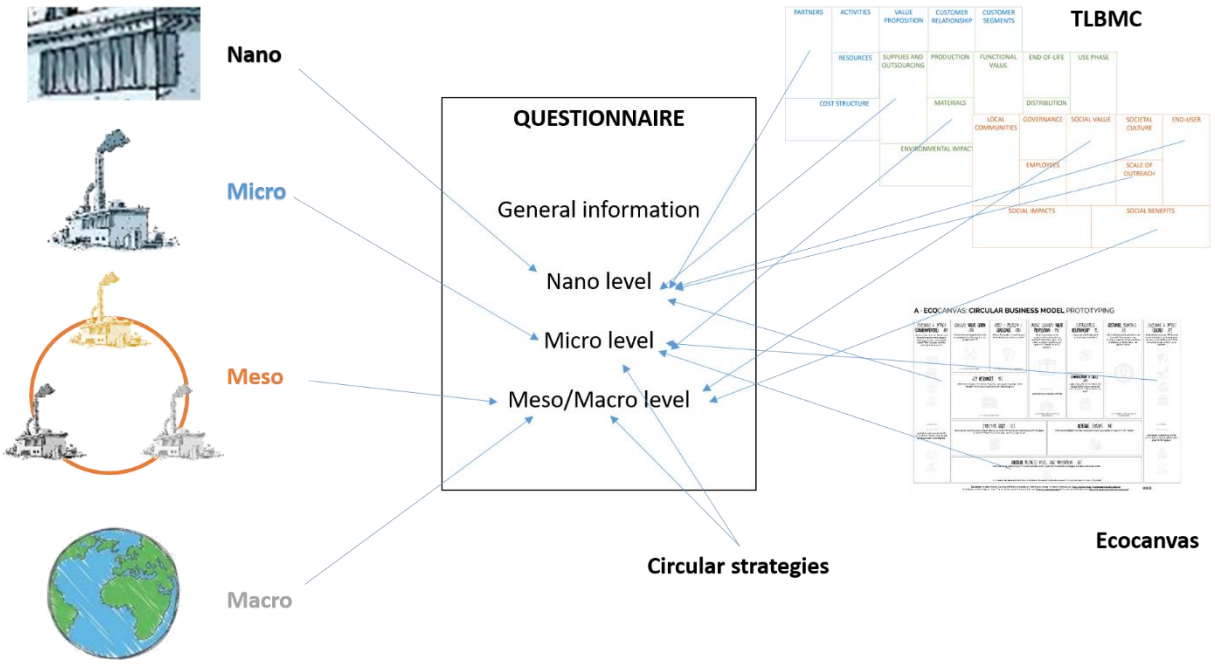

Figure 10: Questionnaire designing process

Description of the tool

As mentioned previously, the developed questionnaire includes the following sections:

- General information: the goal of this section is to get a general overview of the company, including information such as name, size, scope and a brief description of its activity.

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- Nano level: The goal of this section is to analyse the product/process level of the company. The section includes questions about the water treatment system, the consumables it needs, the energy it consumes and the possibility of having a secondary process to treat the outputs of the water treatment system. A company will be considered circular at Nano level in the following situations:
    - When consumables and/or energy are recovered and used back in the processes.
    - When there are more than one process taking place, consumables, energy and/ or by-products are recovered in at least on them and used in at least another one.
- Micro level: The goal of this section is to analyse the company as a whole. Aspects such as strategy, communication, employees and stakeholders are included here. At this level, a company will be considered circular in the following situations:
    - Circularity is clearly part of the strategy of the company
    - Circular elements such as green funding, training about circularity for employees or specific circular activities are in place.
- Meso/macro level: Depending on the scope of the company, just the meso or macro level or both of them are studied. Aspects such as suppliers, clients, industrial symbiosis, policymakers, society or environmental impact are asked about in this section. Circularity in this case is identified if:
    - The company takes part in industrial symbiosis networks, through sharing energy, water or materials.
    - The company puts in place strategies focused in their clients focused on recovering, repairing, refurbishing, recycling…
    - The company takes into consideration circular aspects regarding the value chain.
    - The company is aware about its impact in society and environment.

The developed questionnaire is included in Annex I. Since companies can significantly differ from one to another, not all the questions make sense in all the cases. The questionnaire is conceived as a comprehensive list of items that will have to be used or not depending on the case. Besides, it was adapted to companies focused on treating water and specifically tries to figure out if the NextGen project has brought innovation conducting to increase its circularity.

After the questionnaire is completed, the information is analysed to obtain the following information:

- A **description about how circularity happens at the different levels** (nano, micro, meso/macro).

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- **Technical circularity:** technical circularity is a combination of the information gathered in the nano and meso/macro levels. It includes the circular performance in terms of material, energy and water reuse within the company and in its relation with other companies. Figure 11 shows an example of the information to be gathered, taking over a company that has a primary process that treats the water and a secondary one that process the output of the water treatment process. Ideally, in both processes, consumables and energy are recovered and reused within the company, and even shared with other companies.

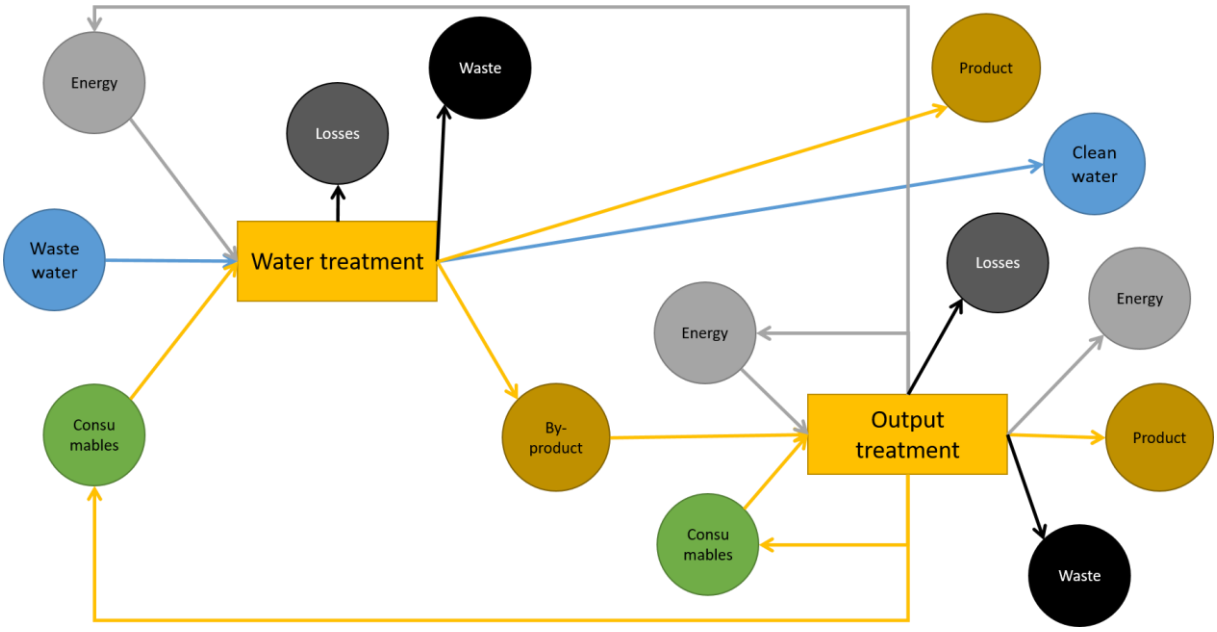

Figure 11: Technical circularity scheme

- **Circular business model innovation and circular business model:** Following the circular BMI described on section 2.2, if the BM of an entity have changed, the focus is to identify which is the strategy followed thanks to information gather through levels micro and meso/macro. Besides, the current circular BM will be identified from the same levels.

4.3. Demo cases

The methodology described above was originally applied in detail to La Trappe's case (See Section 4.3.1. below). This deep analysis served as starting point for the work developed in D5.2. After the revision of D5.1., some demo cases have been added to this preliminary analysis. In those new cases, the technical circularity was skipped because the resulting schemes were included in D5.2 for all of them.

4.3.1. La Trappe (NL)

There are four entities involved in this demo case. La Trappe and the waterboard De Dommel have signed an agreement to jointly direct the activities focused on creating a circular

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environment there. Then, the private companies Biopolus and SEMiLLA IPStar works as circular consultants and technology providers.

The goal of this case study is to figure out if the list of questions included in the tool are enough to rebuild the circularity and the circular business model strategy of the demo case. The work done in this sense consisted of making interviews with different people from the staff of the above mentioned entities to ask the questions included on the tool depending on their role.

In particular, information for section A (General information (See Anex I) was obtained from information already available online about La Trappe; questions included on section B (Nano Level) were asked to a member of La Trappe/De Dommel board and technicians from Biopolus and SEMiLLA IPStar, and questions included on sections C (Micro Level) and D (Meso/Macro level) were asked to a member of La Trappe/De Dommel board.

The gathered information is shown in the following section.

4.3.1.1. Description of the Site and background

The Koningshoeven BioMakery is fully integrated into the historical monument of the Koningshoeven Trappist Abbey and Brewery. The facility treats industrial wastewater from the brewery and municipal wastewater from the Abbey and Visitor center.

The main economic activity of La Trappe Abbey is the production of beer, although they also produce other products such as chocolate, cheese and bread. The site's wastewater treatment operation, in terms of circularity, was totally linear until 2018, when a wastewater treatment facility using a Metabolic Network Reactor technology, developed by Biopolus, was constructed to treat the water from the abbey and the brewery thanks to a project developed by La Trappe and the waterboard De Dommel. Until then, the wastewater was being discharged into the sewer and treated offsite at the regional wastewater treatment plant (WWTP).

The facility treats the water for safe discharge to the local canal, maintaining the local water cycle. The facility also includes a heat exchanger that recovers heat from the raw wastewater to heat the green house(s). By keeping the water local, and recovering heat from the wastewater, the La Trappe Biomakery introduced basic elements of circularity before the start of NextGen. Also, before the start of NextGen, a feasibility study was conducted assessing the potential to expand circularity around the MNR technology using space technologies developed within the micro-ecological life support system alternative (MELiSSA) of ESA. This feasibility study was performed by SEMiLLA IPStar, a private company created within the MELiSSA consortium with the mandate to implement those technologies in terrestrial applications for civil society.

Biopolus' MNR is a modular and adaptable platform technology designed with the intention of incorporating supplemental processes and technologies to achieve higher levels of circularity. Through the NextGen project, supplement modules (technologies) provided by SEMiLLA IPStar are being tested for compatibility to the MNR system. The ultimate goal is to

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improve site circularity and to develop these technologies so that can be later used at other sites.

4.3.1.2. Circularity at different levels

Nano level

The water stream that is being treated currently is the industrial one coming from the brewery, whose quality varies depending on the activities in the brewery and other factories. There are two systems in place: The Metabolic Network Reactor (MNR), working at full scale, and the purple non sulfur bacteria (PNSB) raceway reactor (RR), at pilot scale.

The MNR technology is Biopolus' patented 3rd generation Integrated Fixed-film Activated Sludge (IFAS) water treatment technology. The underlying principle behind the MNR technology is a well-known natural phenomenon, where microbial biofilm develops on the roots of aquatic plants. The technology is characterized by a large quantity of biomass that is attached to submerged "carriers" – either to the natural root system of specially selected plants, or to artificial roots, developed by Biopolus, for this specific purpose.

The full treatment process takes place in an array of MNR reactors. This separation makes it possible to fine-tune the environmental conditions in each section, allowing for the development of separate, specialized ecologies to mature in the different tanks. As the water flows from reactor to reactor, it is continually cleaned, as various species break down the different contaminants. The path and volumetric distribution of wastewater between the reactors is controlled by process management software and can dynamically adapt to the changing loads, thereby optimizing the process (See figure 12).

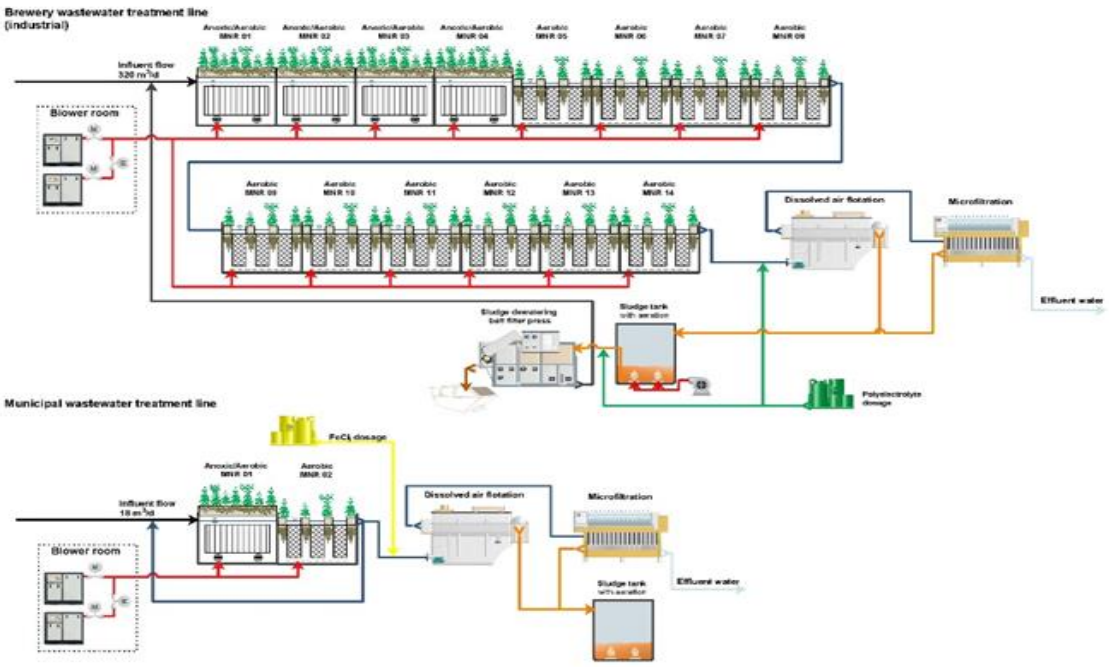

Figure 12: MNR Scheme

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In terms of consumables, the main ones used by the MNR are sulphuric acid (pH adjustment), Iron (III) chloride (coagulant) and a polymer (flocculant). The energy it uses comes from solar panels installed nearby at the abbey. A heat exchanger recovers thermal energy from the sewer line, which is used to heat the greenhouse, which houses bioreactors (with plants). The system produces clean water that is released into the local canal, while the sludge is removed from the site and brought to Marineterrein, in Amsterdam, to produce compost.

Concurrently, SEMiLLA IPStar is testing the application of various space technologies at la Trappe. The goal is to integrate these technologies with the MNR system. The raceway reactor (RR) allows the photoheterotrophic production of purple non-sulphur bacteria (PNSB) on waste streams as a microbial protein source for animal feed or plant fertilizer. This technology can recover carbon, nitrogen and phosphorous from a waste water stream and treat the water in the same process. Conventionally, PNBS are cultivated under anaerobic photoheterotrophic conditions in closed photobioreactors (PBR). For transferring the space technology an economically more interesting case can be made for cultivation of PNSB in open raceway reactors. Raceway reactors are open systems with a depth of 20 cm, a surface to volume ratio of 5 m^2m^{-3} and are agitated through a paddle-wheel (See Figure 13).

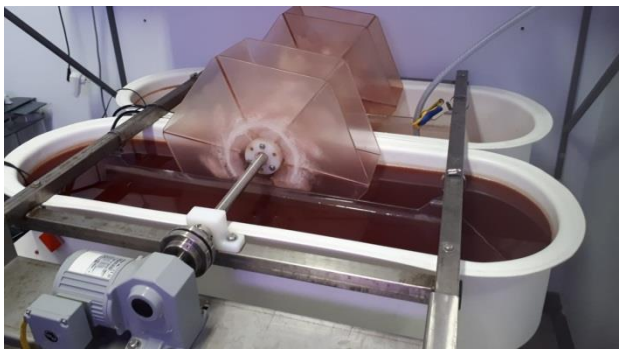

Figure 13: Raceway reactor

Currently, part of the output from the raceway reactor (water and biomass) is being discharged in the MNR reactor and part is being harvested for research. The influence of the part discharged on the MNR doesn't affect its performance since it represents less than the 1% of the total input of the MNR.

Originally, the idea was placing the raceway reactor after the MNR but some experiments showed that the raceway reactor needs an influent with a higher concentration than the one obtained after the MNR. Currently a scenario is investigated whereby the RR can take off a high load from the wastewater, therefore helping the MNR in obtaining higher efficiency and predictability.

In addition, one more MELiSSA technology will be added in January 2021 to the water processing system. The installation of the system was delayed due to COVID, since transport and installation was not possible due to COVID restrictions. The technology is the MELiSSA Membrane technology concerning a multi-step membrane filtration system.

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The NextGen project also considers the treatment of the municipal wastewater coming from the Abbey and the visitor center (including the beer and cheese tasting restaurant). However, due to the pandemic, the visitor center and the restaurant were closed, and the municipal line to the facility was shut down. The wastewater stream became so minimal that it could not be treated. Currently, the municipal stream is going to an offsite wastewater treatment plant. Once operations return to normal, the municipal line will be recommissioned and the facility will treat the site's municipal wastewater as well.

Micro level

Strategy

Circular Economy is quite important for the board in charge of the development of the NextGen project at La Trappe. This board is composed of the Abbey and the waterboard De Dommel, both which are in charge of making decisions regarding actions made at the site. For the Abbey, the final goal is to become a circular site. For the waterboard De Dommel, the site is a Living Lab where it's being explored how water management can happen in the future in an scenario of water scarcity.

NextGen activity is part of a circular economy strategy for the region, which goes beyond the project. In fact, currently there is also a project in place, which is focused on making the site energy neutral by 2024.

Communication

Many activities regarding communication have been developed around the NextGen project in La Trappe. The greenhouse including the MNR is nearby the Abbey's restaurant and can be visited. Besides, the site includes informative panels explaining the technologies that are in place and the goals of the NextGen project. Other dissemination activities, such as the creation of a short film that can be found in YouTube[42], have been developed.

Employees

The monks have been engaged in the project from the very beginning of the project, cooperating with the technicians and researchers from Biopolus and SEMiLLA to install, run and monitor the different systems.

Resources

As mentioned before, the MNR was installed before the NextGen project thanks to the partnership between the Abbey and the waterboard De Dommel. Different applications have been submitted to obtain funding to develop the actions requested to make the site more circular.

Meso/Macro level

Stakeholders

[42] Available online: https://www.youtube.com/watch?v=_rsxNrrC-Ws (last access 11/12/2020)

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The project is regulated by an agreement and managed by a board composed of the Abbey and the waterboard De Dommel. Both have a general vision about the goals and activities at the site, and they make joint decisions regarding which technologies will be tested at the site.

In addition, two technological partners are providing the technical solutions:

- Biopolus: Acting as the platform technology provider and circular consultant, provider of the MNR technology.
- SEMiLLA IPStar: Technology provider of technologies such as the RR and the membrane, and circular consultant.

Distribution

The produced clean water is currently being discharged to a canal, so there is no need to transport it. The sludge produced in the MNR system is transported to Amsterdam to be processed to produce compost.

Use phase

The water discharged to the canal is being used for irrigation by the Abbey's nursery and the surrounding local farms.

Industrial symbiosis

Although there is no industrial symbiosis network as such, some links with other entities are in place. The first example is the treated water that is being used for irrigation by surrounding farms and another one is the sludge processed to make compost.

Policymakers

De Dommel, as the local policymaker on water issues, is part of the project itself. In addition, the municipality of Tilburg (home to the Abbey), is also involved, mainly due to the sludge, which is considered a regulated waste that is transported offsite.

Society

La Trappe is making a big effort to show its progress to circularity. The installed systems can be visited by those attending the Abbey and the circular solutions and intentions are shown in the Abbey webpage, contributing to spread the concept of circular economy and to generate social impact.

Environmental impact

The project is already making a great positive environmental impact. The discharging of the treated water into the canal helps maintain the local water cycle, reducing the negative effects of the dry climate on the area. One benefit is that farmers can use this water to irrigate their lands, reducing the need to pump ground water for irrigation. Another benefit is that the surrounding local biodiversity can be bolstered by maintaining the water level in the canal.

In the future, the system is expected to generate clean water with quality high enough to be used for bottle washing in the brewery. This would result in a 50% decrease of the water used

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by the brewery, reducing the need to pump groundwater, thereby helping to maintain an adequate ground water level.

Conclusions

At *Nano level*, the introduction of different technologies has helped to start closing loops within the Abbey. Reaching a high circularity is still work in progress, but the right steps are being done in this sense.

Circular economy is really at the core of the activities that take place in La Trappe, with a high engagement of employees, a strong communication effort and the right resources on place. This makes the *Micro level* quite high in circularity too, since circular economy is in the core of the strategy of the entity and the will of the decision-making team, what have a reflect on the kind of activities that take place there.

Several efforts are taking place at *Meso and Macro* levels as well. The right stakeholders are in place and are contributing to increase site circularity. Interesting relationships are being developed with the environment from an economic and environmental point of view thanks to the relationship with the nearby farms and to the activities resulting in ecosystem regeneration.

La Trappe is really evolving towards a circular economy system and the NextGen project is highly contributing to that. Its circularity is expected to be quite high at the end of the project.

4.3.1.3. Technical circularity

The technical circularity of La Trappe has evolved a lot along the years from a linear model to another one that is increasingly circular.

Before NextGen, some circularity was introduced thanks to the installation of the MNR system to treat water (See Figure 14).

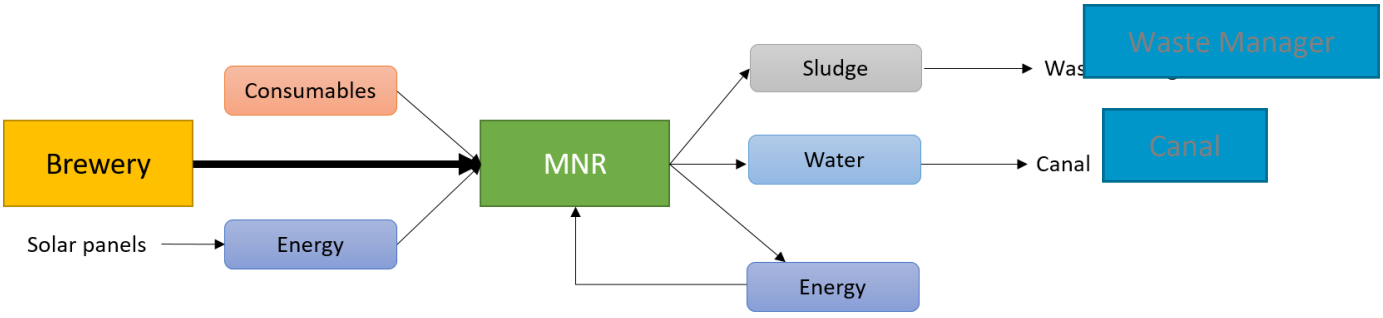

Figure 14: Situation pre-NextGen

As shown in the previous figure, before the NextGen project, the MNR was treating the effluent from the Brewery using some consumables and energy from solar panels. The MNR was producing clean water that was directed in the canal (to maintain the local water cycle), the sludge was transported offsite by a waste manager and, and thermal energy was recovered from the influent wastewater and directed to the MNR to warm the greenhouse.

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Currently, and as mentioned above, the MNR has improved its performance (through on-going adjustments to the system) while the raceway reactor is being tested to recover nutrients from the effluent from the brewery (see figure 15).

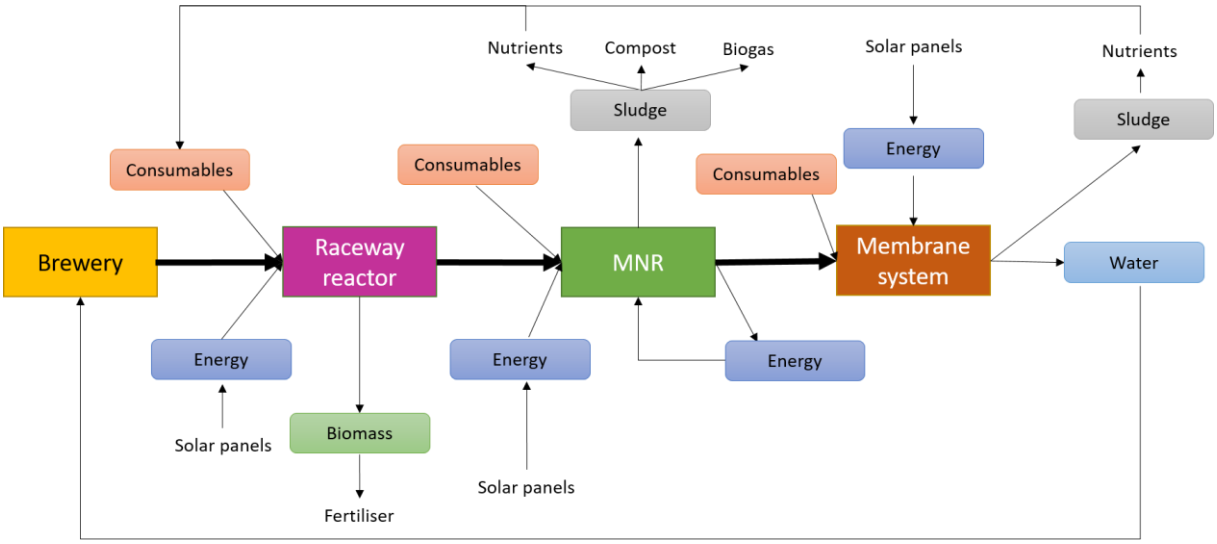

Figure 15: Current situation

The brewery line is being treated by the MNR while a little portion is being used to test the raceway reactor. The water and sludge obtained from the raceway reactor are being discharged into the MNR. The sludge removed from site is now being made into compost by the offsite Marineterrein.

Next year the membrane system will be installed and tested on the brewery line, expecting to get both high quality water as well as biomass and sludge that can be used to recover nutrients to be used to produce outputs such as fertilizers in the future. Ideally, the final system will look like Figure 16:

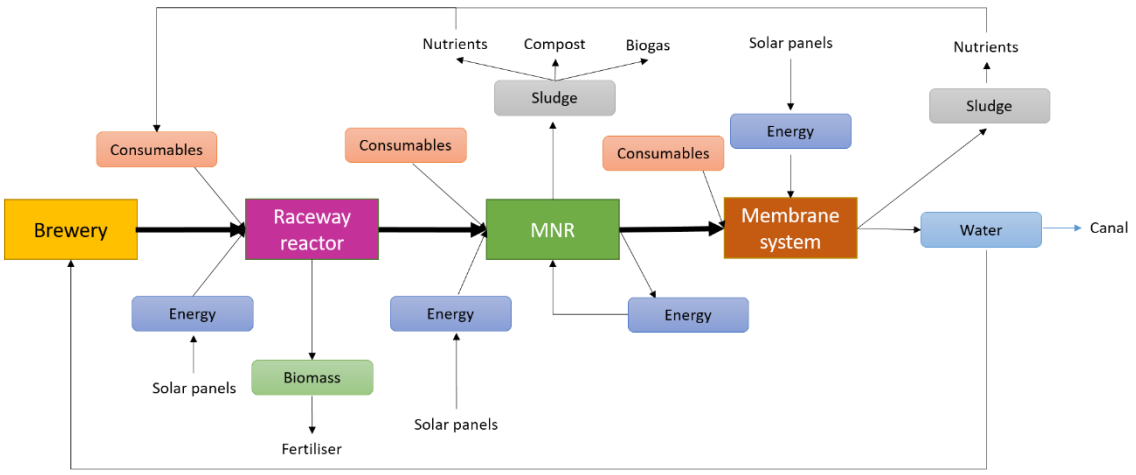

Figure 16: La Trappe Circular System

This scheme includes the chain of technologies (raceway reactor, MNR and Membrane) and possible use of the waste of each of them to close loops within the Brewery. The raceway

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reactor produces biomass that could be used to produce fertilizer to be sell or used in La Trappe's gardens. The sludge from the MNR and the membrane system could be used to recover nutrients to feed the raceway reactor and to produce compost and/or biogas. Finally, the water produced at the end of the process could be used to clean the bottles in the brewery or to be discharged on the canal.

4.3.1.4. Business model innovation and business model

Along the last years, the business model of La Trappe has evolved from a total linear business model to one that is continuously increasing its circularity. The business model innovation strategy followed in this case has been a *circular business model transformation*, since the former business model was modified through the incorporation of new technologies for water treatment and new ways of using some of the produced wastes.Nevertheless, in order to finalize the investment, they have worked out the business case based on a linear business model approach. They calculated the ROI and TOC (between 8 and 10 years which is acceptable by the Abbey).

Among the four possible circular business model strategies (cycling, extending, intensifying and dematerializing), the one followed in la Trappe is *cycling*, since the different technologies installed at La Trappe are focused on the recycling and reuse of water. In addition, they are working in make valuable products out of wastewater streams (for instance, whey stream from the cheesemakery, waterstream from the whirlpool at the bakery, waterstream from the beer borstel…).

4.3.2. Westland (NL)

4.3.2.1. Description of the Site and background

This case study contains several testing grounds in the Westland region. The Westland region is a highly densely populated region in the Netherlands, where also lots of water flows exist (river mouth of the rhine branches and lots of local flows). Combined with the presence of not only water treatment plants and wastewater treatment plants, but also lots of greenhouses, great opportunities arise for generating water and related residual flows.

The Westland demo case consists of two material chains:

1. Alum sludge from drinking water treatment. When treating surface water for drinking water production, in most cases the first treatment step is removing the suspended solids. These solids are mainly organics and small silica particles like clay. In this process step alum coagulant is dosed to the raw surface water and 'bind' (based on weak polarity of both the coagulant as well as the suspended solids) the suspended solids. When the particle becomes bigger and heavier, it will sink in settling basins that are designed for that purpose. The resulting sludge was before the 'NextGen solution' used in, for instance, sounds barriers or soil cover of wastes at dumps. In de demo case, the alum sludge is treated and used in shaped building materials such as bricks.
2. Municipal wastewater sludge. This sludge comes from the biological treatment of municipal wastewater. It is traditionally dewatered to 23% and send to incinerators for

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further waste processing. In the (intended) NextGen demo case, the sludge is dried (>95% dry matter) and used as fuel in the cement industry. Furthermore, a significant part of the remaining non-caloric components (like Ca, Mg) in the sludge are of added value in the cement clinker and there saving on raw materials.

In the case of the alum sludge, the water company of Evides is the owner and therefore disposer of the sludge. With other water companies they developed, 'through' their shared service centre AquaMinerals, a new pathway for this sludge. An innovative procurement procedure challenged the market to come up with ideas for a better material route for the alum sludge. The winners were then supported in their route to develop this pathway and climb the TRL (Technology Readiness Level). Eventually the company of Netics won this 'contest' and developed a brick made from this sludge. A full-scale manufacturer stills needs to be found. The water companies (like Evides) are open to act as a launching customer.

In the case of the wastewater sludge, the water authority of Delfland acts as the disposer. They have a participation in a mono combustion plant where the dewatered sludge is incinerated. Due to the water content, this process is more or less energy neutral. The combustion plant is responsible for their energy management, resource management and disposal of the ashes. In the new route, Delfland will dry their sludge up to 95% dry matter or more. Then they will send this dried sludge to a plant with an energy-need, the trading being handled by one of their participations in collective entities (this might be the combustion plant they already deal with today). The plant is a cement-clinker plant, where not only the energy will be used, but also some relevant elements for the clinker recipe.

4.3.2.2. Circularity at different levels

Nano level

For the alum sludge, the source of the water is surface water, for the biosolids it is the municipal wastewater. The alum sludge comes from the coagulation process where the suspended solids are removed from the surface water. The water itself will undergo multiple treatment steps and will be used as potable water. The biosolids come from a rather traditional biological municipal wastewater treatment plant. The treated water will be discharged in surface water.

The alum sludge consists of alum, organic materials and an inert fraction (clay, silts). It settles in big ponds where it is spread out over large surfaces in order to dry it with the natural resources wind and sun. Every 1-2 years, these ponds are scooped out and the sludge is disposed of by the water company.

The municipal wastewater sludge has a water content of 23% when dewatered and > 95 % when it is dried. The dry matter fraction contains a lot of organic material, but also heavy metals, microplastics, hormones and medicine residuals. For this reason, the sludge is incinerated, and all the harmful components are destroyed, or (like the metals) end up in the ash. The current route is more or less energy neutral; the proposed route will ***cost*** energy on

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site for the drying process. However, this energy used will be (over-)compensated by the energy use of the dried sludge that has a caloric value compared to wood.

Micro level

Strategy

For both cases the ambition to become (more) circular has been the driving force. The force here being the water company and water authority. It is actually for both entities easier to keep things as they are. After all, the alum sludge volume is relatively small and has a relative minor impact on the performance of the water company. And for the water authority counts that they are participant of an existing plant that might end up with less feedstock.

Both organisations follow the national ambition to reduce the use of raw materials by 50% in 2030 and become fully circular by 2050.

Communication

The water company, water authority and AquaMinerals regularly communicate about their circular ambitions. Both on a strategy level, as well as on operational and tangible issues. The organisations are public / not-for-profit and therefore don't have a marketing strategy. They communication is more stakeholder oriented, the 'general public' as the most important party.

Employees

The organisation organises workshops an meetings on the theme of circularity. The employees closed to this theme follow courses (at PAO, SWO).

Meso/Macro level

Distribution

Both sludges are transported by truck to the processing plant. These are relatively standard trucks but are watertight (because of the remaining water) and in the case of the wastewater sludge closed because of odour control.

Use phase

The alum sludge from the drinking water production was previously used as low interest building material, for instance in sounds barriers alongside motorways. In the new situation the sludge is used to produce shaped building materials such as bricks. The recipe is still being optimised, but the alum sludge content is ~2/3. There is no significant other energy use in this new pathway.

The sludge from municipal wastewater treatment is traditionally incinerated. With a dry matter content of 23%, this process is more or less energy neutral. In the new pathway, the sludge is dried (costing energy) and then used for its energy and resource content in the cement industry (giving energy and saving on resources).

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Policymakers

For both cases policy makers from the water organisations are evidently involved. There is no direct involvement of public policy makers, but in the cases they deal with general policy areas that are developing. For example:

- Carbon Pricing
- End-of-waste status
- Ambition 50% reduction of use of resources and in 2050 100% circular

Society

Both the drinking water company as well as the water authority have strong goals on social aspects. For instance:

- Interaction with society on water savings
- Interaction with youth giving guest-lessons at schools
- Managing their nature reserves eco-friendly and communicating about it
- Personnel policy: local and diverse

Environmental impact

The footprint before the Next-solution for the alum sludge was 1,52 ton CO2-eq, based on a supply of 886 tons annually. The impact after the Next-solution is 1,18 CO2-eq. The absolute numbers are relatively small due to the relatively small amount of sludge. The difference in both chains is also limited, mainly because in both cases, the sludge replaces low impact (-carbon) virgin materials (sand, silt, clay).

The footprint for the material chain of the municipal wastewater sludge in the previous situation is 26.789 tons CO2-eq. This impact is calculated from the dewatering onsite until the incineration of the dewatered sludge (thus also including transportation) and is based on a supply of 100.000 tons of sludge (78.000 tons of dewatered sludge). The impact of the chain when drying onsite and using the dried sludge at a cement plant is – 7.852 CO2-eq. This is also based on a supply of 100.000 tons, leading to 18.100 tons of dried sludge. The impact of the drying is also included in this calculation.

Conclusions

The *Nano scale* is mainly present in the municipal water case in the treatment of the sludge, since the heat produced by the incineration is used to dry the sludge before the incineration. So, an energy loop has been closed at this level.

At *Micro scale*, the most relevant action was the strategic decision made by the water authority and the water company to make things in a different way. In the case of the alum water, a competition was made to find new ideas to transform a waste into a new product. In the case of the municipal water, the result was using the materials in the cement industry, despite the higher cost.

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The main scale in this demo case is *Meso/Macro*, mainly due to its size (the whole Westland region) and, therefore, the scale of the impact of the activities. In the case of the alum sludge, the loop is closed thanks to the creation of a new company that processes it to create a new product (bricks from alum sludge). In the case of the municipal water, is again another company who dries and incinerate the sludge. The scope of the impact in terms of materials (transformation of waste into new products, keeping them on the loop), energy (use of the heat produced on the sludge's incineration used to dry the sludge) and water (surface and municipal) covers the whole region.

4.3.2.3. Business model innovation and business model

In both cases (surface and municipal water), the increase on the circularity happened thanks to the inclusion of new companies in the ecosystems, so there was no business model innovation since the strategy was to find complementary business models. In Section 4.4.9. the Netics case will be developed in more detail, explaining how the company will develop the new activity.

Regarding the business model, the main one is *cycling* because all the efforts are focused on keeping materials, water and energy on the loop instead of being disposed as waste.

4.3.3. Athens (GR)

4.3.3.1. Description of the Site and background

The Athens Urban Tree Nursery is part of Goudi Park, an area which lies in the heart of Athens. It is a mixed-use area, comprising of urban green and urban agricultural spaces, as well as administration and residential uses. The area is in the process of redevelopment and the regeneration will boost the local economy and improve the life of the 4 million citizens in the Attica region. The nursery belongs to the municipality of Athens, it comprises of 4 ha of vegetation and supplies all the urban parks and green spaces of Athens with plant material. It uses potable water from Athens' Water Supply and Sewerage Company (EYDAP) for its irrigation. Furthermore, the nursery is the staging area all of the pruning waste from all of the Athens urban green spaces. The green waste is not treated, only stored on site. Over time a part of the green waste is transferred to the Athens landfill. The nursery uses fertilizers supplied by the local market.

The key stakeholders are:

- Athens Plant Nursery:

The Athens Plant Nursery belongs to the Athens municipality. The Nursery covers approximately 96 acres, 40 of which are used in the production, development, and maintenance of the plants. The remaining area is used for general purposes such as administration buildings and the offices of the Municipality of Athens. The Nursery supplies all the urban parks and green spaces of Athens with plant material. The pruning waste of the urban parks is accumulated at the Nursery. Some of this waste is sent to the Athens landfill.

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The Nursery purchases potable water from the Athens' Water Supply and Sewerage Company (EYDAP).

- Athens landfill:

The Athens landfill is in Fyli approximately 25 km from the Nursery. A part of the green waste from the Nursery is transferred to the Athens landfill. The disposal costs of the pruning waste to the landfill are 1,9 €/m3.

- Athens's Water Supply and Sewerage Company (EYDAP):

The water company is semi-private and semi-public and it supplies the Nursery with potable water for irrigation. The cost of the potable water for the Nursery is 1,17 €/m3.

4.3.3.2. Circularity at different levels

Nano level

The summers in Athens are hot and dry. Recent studies show increasing tendency towards drier conditions, with increased variability of extreme rainfall events. Overall precipitation is expected to decrease as longer dry spells and reduced rainfall intensity has been observed. Temperatures are projected to increase in the Athens area in the order of 7-8°C by 2100[43].

With the longer, hotter, drier summers, green areas are more important than ever to reduce the urban heat island effect. Lush green parks also create a positive environment for both the citizens and the local wildlife. Access to blue green urban spaces has positive effects on the mental and physical health of urban citizens. The green spaces also help provide homes for wildlife.

However, green areas require both water and nutrients to remain healthy and vibrant. Athens currently lacks adequate nutrient rich soil, and the reduced rainfall and drier conditions mean more irrigation to keep green areas lush.

The pilot test developed through NextGen takes place at the Athens Urban Tree Nursery, where wastewater is extracted from the municipal sewer line via a pumping station into a storage tank. The wastewater is then treated using a modular hybrid unit, which uses Membrane Bioreactor (MBR) technology for wastewater treatment and Ultraviolet radiation (UV) for water disinfection. The pilot system produces approximately 25 m3/day irrigation water that can be used to irrigate the local tree nursery.

The wastewater treatment sludge will be collected, dewatered and mixed with treated pruning wastes from the nursery. The raw materials (400 L/ week of sludge and 300 L/ week of green waste) will be continuously mixed in a Rapid Composting Bioreactor, where the closed and aerated system will speed up the degradation process to create an eco-friendly compost in approximately 2 weeks. Roughly 200 kg of high-quality compost will be available biweekly for use.

[43] : https://www.climatechangepost.com/greece/climate-change/

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In addition to water and nutrient recovery, a thermal recovery unit will also be installed at the pilot site to recover approximately 10kWh thermal energy from the treated wastewater. This heat will be used to boost the Rapid Composting Bioreactor, for added system efficiency.

The overall goal is to create healthy and vibrant green spaces in the city of Athens. The pilot test will show that by upcycling two available waste streams: wastewater (& sludge) and green waste, Athens can have a sustainable solution for irrigation water and nutrient rich compost.

Micro level

Strategy

The NextGen solution takes three biological waste streams (wastewater, sludge, and green waste) and upcycles them using three different technological solutions to create valuable sustainably sourced resources. The solution was created using circular economy principles as strategy, where the individual streams and technologies interconnect and rely on each other.

In addition, the solution is in line with the Athens Resilient Strategy[44] for a circular approach to water services by 2030, that focuses in four pillars (open city, green city, proactive city, and vibrant city), 65 actions and 53 supportive actions.

Communication

There are regular online meetings between the stakeholders to discuss on-going activities, adjust strategy, and to discuss results. The results of the NextGen pilot will be evaluated and published. In addition, local stakeholders are informed of pilot test occurrences during CoP meetings.

In the regular Greek partner meetings, we have in the agenda the circular economy aspect to be considered, and in general the project has embedded this approach well in the design and implementation of the pilot case.

The circularity is planned to be communicated in the marketing strategy of the project; however, there is the intention to share the circularity approach until the end of the project.

Employees

The pilot project relies on several stakeholders that work together within the NextGen project. Each stakeholder has their own training policy. For example, at Biopolus, several staff members have taken part in the Ellen MacArthur executive education course on the Circular Economy. The company also has a designated circular economy specialist on staff.

Training is performed in the persons, employees from the Municipality of Athens that are operating the configuration locally. They are trained to be using the PCL system and address any unexpected event happens during the operation of the units. Also, training is planned to

[44] https://resilientcitiesnetwork.org/downloadable_resources/Network/Athens-Resilience-Strategy-English.pdf

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be performed when the compost production unit is operational and stable, so that they will be running and operating the whole site configuration.

The employees that are about to be hired by the Municipality of Athens, will be trained to be focusing on circular economy activities.

Meso/Macro level

Stakeholders

Besides the stakeholders mentioned above, the following are important at meso level:

- NTUA – National Technical University of Athens. The NTUA manages the NextGen solution, and monitors the performance of the systems through the collection and analysis of data for system optimization and for potential further expansion.
- Biopolus Institute. Biopolus is providing the Rapid Composting Unit and the Heat Recovery Unit. They are responsible for commissioning and testing the systems, and for fine-tuning the process based on pilot testing results. Biopolus will train local municipality workers to run the systems.
- Chemitec. Chemitec is providing the sewer mining equipment, and is responsible for commissioning, and for fine-tuning the equipment based on operational results. Chemitec is also responsible for training the municipality workers to run the sewer mining equipment.

Distribution

The produced water is used for irrigation in the dry period during the summer and when irrigation is not needed (in the wet period), the water is used for aquifer recharge.

The produced compost after sampling and analysis is performed and if the quality characteristics are acceptable, the compost is planned to be used on site for the plants of the Nursery.

Use phase

The produced water will be used for the irrigation of the nursery and other green spaces in Athens.

Regarding the energy recovered on the energy recovery unit, local houses could benefit from the heat produced by the Nursery and reduce its energy cost.

The compost produced by the Rapid Composting Unit will be used on other places of Athens/Greece.

Policymakers

With regards to the policymakers, there is a connection between the Decentralised Administration – Water Directorate, with which some initial discussion in the 1st Community

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of Practice have taken place, regarding the circular economy solutions and potential adaptation of such solutions in the planning of the particular authority.

Society

As project partners (NTUA, Chemitec, Biopolus, EYDAP, City of Athens), we have no particular connections with the society, however through the NextGen Serious Game and the AR application, we expect to have much more visibility and public outreach of the pilot and the technologies practiced there.

The availability of good compost and irrigation water in times of draught, means the municipality of the Athens can maintain and even upgrade their green spaces. The citizens directly benefit from lush green spaces in their city, which means they are likely support this circular sustainable solution. Citizen support creates a stronger case for funding the initial investment of the NextGen solution.

Buildings on the surroundings will benefit from the energy produced on the energy recovery unit, lowering their energy costs.

Environmental impact

The positive effects on the environment are the following:

- The sewer mining unit will help recovering value from waste, revalorising material that would be disposed otherwise.
- The use of the treated water instead of potable water for irrigation will contribute saving potable water and reducing its scarcity.
- Another positive environmental impact is the fact of using green waste to obtain the fertilizer, material that would end on the landfill otherwise.
- The production of fertilizer contributes to giving back nutrients to the soil where it is used.
- The natural water reserves in and around Athens can regenerate, thanks to the reduction of water needed for irrigation. In the meantime, healthier and more numerous green spaces mean wildlife can return and flourish in the city.
- Finally, the energy production contributes as well reducing the needed energy from the power grid.

Conclusions

With water scarcity becoming more prevalent, new circular water management systems need to be developed. Water reuse is an innovative way to address water scarcity, whereby wastewater is treated to the desired reuse levels, reducing the need for virgin water extraction. The use of sewer mining to treat and reuse water locally allows for efficient use of water resources. The added benefit of the heat recovery system harvests thermal energy, which can also be used locally to heat or cool buildings. By including the rapid composting bioreactor, the sludge derived from wastewater treatment can be mixed with green waste to create valuable compost. The prospect of creating value from waste is desirable (EU circular

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economy directive) and can be replicated in cities worldwide. It is especially relevant in cities where water scarcity is a major concern.

The demo case is developing its circularity mainly at *Nano* level because the MNR, the Rapid Composting Bioreactor and the thermal recovery unit are placed in the Nursery and the water, materials and energy are used there. In addition, there is a strong *Meso* activity because the created loops involve stakeholders at city level. Regarding water, the treated wastewater comes from the urban network and once treated is used both in the nursery and in other green spaces of the city. Compost is made thanks to the sludge from the sewer mining unit and the green waste incoming from the city; and will be used at city level and even at bigger scales in the future.

4.3.3.3. Business model innovation and business model

As the pilot study is not yet fully working, the full costs and the positive economic impact is difficult to extrapolate out. It is clear that there will be value created, but the overall economic value is not yet clear. The economic value will depend largely on the assigned value of water, the natural resource that the NextGen solution is focused on saving, recycling. The environmental impact of the solution is quite extensive, and as such, the economic value of the solution will change/increase as water shortages and climate impacts change the economic value of natural resources, and as the cost of environmental benefits are weighed in.

The Athens NextGen solution uses sewer mining and circular technologies to create valuable resources from wastes. The investment costs of the machinery and the operational costs of running the machines must be offset by the value of the products created. The products created (irrigation water, compost, and thermal energy) can be sold to the actors.

However, the values associated with the extensive environmental benefits and the social impacts should also be considered when deciding on whether or not to proceed with the solution.

The full business potential is not yet clear but adding in the environmental and social benefits creates a strong case for the solution. As water shortages and climate change becomes more pressing, the economic values of the resources will also increase. Environmental mandates may make the solution a necessity in the future. Government subsidies, tax credits, and environmental R&D campaigns may fund the initial cost of the investment, making a strong business case for operating the solution and selling the products.

A new branch can be created within the Athens Water Supply and Sewerage Company (EYDAP SA) that works specifically with sewer mining for water recycling, so the circular business model innovation will be *circular business model diversification*. The company can place these localized entities in areas of high irrigation needs and water scarcity spots. The sludge can be transported to the nursery, where larger rapid composting bioreactors can be used to create even more compost for use throughout Athens green spaces. There are lots of possibilities

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that may come from the Athens NextGen solution, each option should be reviewed to see where there is a greater environmental need and where potential economic benefits exist.

The production of compost from green waste and sludge can be expanded exponentially to create large amounts of valuable compost. This is especially true in the Athens case. The Athens wastewater treatment plant produces approximately 2 000 - 3 000 m3 of wastewater sludge a day. The green spaces produce 40 000 – 50 000 tons of green waste yearly. Large scale rapid composting unit(s) can be installed to mix and treat the readily available WW sludge with the readily available green waste to create large quantities of peat. The large quantities of compost can be used to revitalize the Athens topsoil, helping to replenish the urban biological cycle. The excess compost can be sold throughout the Athens region and/ or Greece. This type of biological cycle boost, through compost production, can be copied in other cities, to help replace nutrients in the topsoil existing green areas and to help create new green areas.

Due to the effort to clean and reuse the water, and the production of compost from waste, the predominant circular business will be *cycling.*

4.3.4. Timisoara (RO)

4.3.4.1. Description of the Site and background

AQUATIM SA is the public owned Regional Water Company (Water Utility) for Timiș county and currently provides services in Timișoara (capital of the county), Buziaș, Deta, Făget, Jimbolia and Sânnicolau Mare cities and many other county villages. In total there are 144 settlements (2020) with a serviced population of approximate 539,500 inhabitants.

The Timișoara Municipality water system is the oldest implemented and the largest system operated by AQUATIM SA. The water system has undergone significant transitions in the last decades with expanding new drinking water and wastewater treatment plants, as well as good results in leakage reductions in the distribution systems.

Currently there is no wastewater reuse solution. After biological treatment the wastewater is discharged in the Bega river, while the sludge, after dewatered and dehydration (at certain extend) is discharge in the landfill.

Within the NextGen Water project, the aim of Timisoara case study is to install and test an innovative treatment solution for the sludge with production of oil, gas and biochar which can be exploited energetically as fuel or soil enhancing agent or sorbent on regional market.

Another important objective of the project is to explore the potential reuse of effluent from the AQUATIM SA WWTP in Timișora and Lovrin for urban, industrial and agricultural applications.

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The Timișoara waste water treatment plant is designed at this moment for 440,000 p.e. The new WWTP (under extending and refurbishment nowadays) is designed to operate (in 2021) within the following parameters:

- Average daily flow rate = 2,400 l/s
- Maximum daily flow rate = 3,000 l/s
- BOD = 22,000 kg/day
- Suspended solids = 28,000 kg/day
- Ammonia = 5.400 kg/day
- Phosphates = 1.600 kg/day

The water coming from the city wastewater collection system enters the WWTP through 4 main sewers and goes through the mechanical and advanced biological treatment facilities, prior to be discharged into the Bega river. The mechanical treatment phase includes four coarse and fine screens, equipped with cleaning, waste compaction and storage systems. When the sewage stream exceeds the designed capacity limit, the excess is taken by four first flush storage tanks. When this limit is also exceeded, the stream is screened by an automated cleaned rack and then pumped into the Bega river, by seven Flygt pumps, at a rate of 3,500 l/s.

The biological treatment phase includes the nitrification-denitrification process and the chemical treatment for the removal of phosphor. The tank has a capacity of 106,600 cubic metres and is divided into four sections. Each section assures the nitrification and denitrification and is provided with external and internal recirculation. The removal of phosphor is achieved by chemical treatment, using the ferrous sulphate as coagulation agent and a dosing and injection system. The biomass is separated in eight secondary circular settlers, with diameters of 40-48 m.

The excess sludge is stored in tanks, thickened and dewatered with polyelectrolytes. The plant is equipped with a dosing system for the polyelectrolyte and the sludge is dewatered and thickened to approximately 20-22% DS on three Bellmer filters. After solar drying the stabilized sludge is disposed to a landfill.

The rehabilitation of the WWTP in Timisoara minimized the environmental impact (water, air, and soil pollution) and helped improving the health and safety of the neighbouring population and the plant personnel. An important step to lining up with the more demanding environmental quality and safety standards of the EU was thus achieved.

The main stakeholders of the Timisoara case study are the following:

- AQUATIM SA – management of the water supply as well as the wastewater and the sludge in Timiș county.
- Intercommunity Development Agency (IDA) Water-Sanitation Timiș –local body approving development and investment county plans

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- Aquademica Foundation – a local NGO promoting the wastewater reuse and the sludge innovative management towards a circular economy principles implementation at AQUATIM SA and promote this concept to science community and citizens
- Urban, industrial and agricultural partners (pig farming, detergents production, beer production, etc.) – implement pilot projects for wastewater reuse as well as the biochar
- Academia and R&D sector – test and perform analyses and provide scientific data that could support the circular economy approach.
- Community of Practice (CoP) – a local group of specialists constituted in 2021, aiming to communicate and disseminate the information about the importance and the need to achieve a circular water reuse and sludge management for reduction of the environmental impact and emissions. The CoP aim also to initiate pilot or assist in developing real scale projects and to share results with other stakeholders and citizens in Timis county.
- The Sanitary and Veterinary State office for the Timis County- in charge with issuing authorizations for all local stakeholders in using and discharging water.
- The County Division of Public Health-in charge with monitoring the human health products consumption (including water).
- The Environmental Protection Agency- monitoring the quality of water (supply and waste water) over the whole area covered by AQUATIM SA services.

4.3.4.2. Circularity at different levels

Nano level

The Timișoara waste water treatment plant and the AQUATIM SA utility are not using circular innovative technologies at this level.

Micro level

Strategy

According with the World Bank45 water sector diagnosis, Romania is almost a country with water deficit and quite large difference between river basins. Banat river basin (where Timiș county is included) although is not yet at risk has already experienced periods of droughts or heavy precipitation with impact especially in the agricultural sector. Therefore, it is important to prepare in advance and reduce the freshwater consumption by reusing the wastewater as well as better managing the sludge.

Currently, there is no circular water use in place and the sludge is discharged in the landfill. The pilot project that will be implemented within NextGen project for the sludge treatment, will support with its results the current investment plan to install large scale equipment for the sludge management for the Timișoara WWTP (that is the largest sludge producer within

[45] https://openknowledge.worldbank.org/handle/10986/29928

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Timiș county). An important step after pilot implementation is the creating at small scale at the first water-industry symbiosis case.

Communication

AQUATIM SA is having own communication department in charge with communication and dissemination information about their services and about the water quality delivered. Also, through the Aquademica Foundation (a local registered NGO having AQUATIM SA and a German Municipality as main partners) organises since 2020 the Aqua Circular International Conference46 to share knowledge and promote the circular water use and innovation technologies. As AQUATIM SA is part of the Romanian Water Association47, the information about the conference is communicated to all water companies from Romania. The information is delivered in a national magazine named ROMAQUA48.

Employees

Since the conference about water circular economy started to be organised, most of the employees are aware of the topic and all are invited to join the conference. 2021-year conference had a dedicated webinar about wastewater reuse with good practices examples from other NextGen Water project study cases as well as other similar projects (as AquaSPICE49 and ULTIMATE).

Meso/Macro level

Stakeholders Distribution

AQUATIM SA services include the water supply and the wastewater management. No other products than sludge is produced currently. Water supply is secured by groundwater resources within the county and from groundwater and surface water only in Timișoara. As for example, the source of water for Timișoara citizens and companies is the Bega River (76% from total) and from groundwater wells (24% from total).The water from both sources is mixed together in the water supply network of the Timișoara city. Timișoara Municipality being the largest freshwater consumer there is larger percentage of surface water use in order to protect the groundwater that is used also as backup solution in case of droughts. AQUATIM SA exploits 283 wells, 28 treatment units for the potable water, 2300 km distribution networks and more 81,000 km connecting pipes.

The average potable water consumption in Timișoara city is 108 l water/capita/day.

The wastewater after treatment is discharged in the Bega river while de sludge after dewatering is discharged in the landfill.

[46] https://aquademica.ro/
[47] https://ara.ro/
[48] https://www.araromaqua.ro/
[49] www.aquaspice.eu

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There are no available data about the consumption of agricutlture, industry or other consumers.

Use phase

Currently the wastewater is discharged in the Bega river after biological treatment and the sludge is discharged in the landfill.

Policymakers

AQUATIM SA is a public owned company (S.A. =joint-stock company) to which the management of water supply and wastewater has been delegated from the IDA Water-Sanitation Timiș. IDA it is a local NGO special created by several Timis of municipalities and communes that have agreed to join the association, therefore the local councils and the county council that are the regional and local policymakers are aware of AQUATIM SA activities as for example the Aqua Circular Conference where the mayor of Timișora participated in 2021.

At regional level, the Regional Development West Agency50 (ADR Vest, rom.) it is in charge with the implementation of infrastructure (inclusive water) programs from European funding (now still working on Financial exercise 2014-2020).

At the county level, the Timisoara Prefecture51 it is the local arm of Romanian national government in the Timiș county.

Society

Aquademica Foundation and AQUATIM SA organises various events both for citizens and children elaborates various guides and has a good social media presence52 . In Timiș county it interacts with citizens and at country level shares its knowledge and goals in ARA meetings and events.

In the beginning of 2021, a local Community of practice (CoP) has been set up, with the goal of involving other specialists or non-specialists in debating the current water topics in Timisoara, including sectors like energy, water quality, food, health, etc.)

Environmental impact

AQUATIM SA has not calculated its footprint but it is interested to protect and regenerate the environment. The intake area for the surface water for Timișoara has a sanitary protection area in accordance with the legislation. In time, in the area, a micro-delta has been formed, that started to be used by local fauna and flora. Currently there are activities taken by West

[50] www.adrvest.ro
[51] www.prefecturatimis.ro
[52] https://www.facebook.com/aquademica.ro/ ; https://www.linkedin.com/company/aquademica-foundation/ ; https://twitter.com/AquademicaF

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Timișoara University and Aquademica Foundation to obtain the official approval for a ''environmental protection for area''53.

Conclusions

The Timisoara demo case currently works mainly at Meso level. There is no activities at Nano level, and the strategy have been set at Meso level thanks to the entity IDA. The future implementation of the pilot project in NextGen project will contribute to a better sludge management and to transform the current linear model into a circular one. The investment plan of AQUATIM SA is to implement at large scale (for Timișoara WWTP) a treatment for the sludge that will allow its energetic use within the WWTP Timișoara lowering its current environmental footprint due to the sludge disposal in the landfill.

The Aqua Circular conference is contributing to promotion of the concept of circular economy for the water sector and through the meetings and events organized within NextGen Water and AquaSPICE projects in the region and at national level the concept of treated wastewater reuse become more acceptable for all stakeholders – businesses, authorities, citizens.

The climate change impact on precipitation pattern and the more severe and long droughts periods are happening now and AQUATIM SA as well as the other water companies from Romania should pay more attention to their water, energy and environment footprints and protect existing water resources by reuse of the treated wastewater.

4.3.4.3. Business model innovation and business model

The current business model is mostly linear but in the recent years AQUATIM SA started to collaborate in various projects with the Academia sector or in EU funded projects as is NextGen Water project, that have slowly brought innovation into the usual process. Besides setting up the Aquademica Foundation that organizes trainings, conferences and dissemination activities the next step is to setup a research department. This is a new business model for a water company from Romania where companies struggle to implement the current projects about water supply and wastewater management systems. The innovation process at AQAUTIM SA will receive a boost from the pilot project implementation as the plan is to install a treatment for the sludge management for the whole Timișoara WWTP introducing in AQUATIM SA the circular economy model.

4.3.5. Recommendations

The following table summarizes the findings from the demo cases:

[53] https://www.facebook.com/LuncaUrbanaBega/

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Table 3: Findings from demo cases

Demo case	Nano level	Micro level	Meso/Macro level	Circular Business Model innovation	Circular Business Model	Relevant Nexus Sectors	Circularity aspects
La Trappe	Combination of technologies (MNR and RR) to treat water from the brewery and the restaurant that will be used to clean bottles in the future The sludge will be used to produce fertilizer	Strong circular strategy aligned with regions High involvement of employees	Strong relationship with stakeholders, policymakers involved Positive environmental and social impact	Circular business model transformation	Cycling	Industry, Space, Governmental (municipal),	Wastewater that otherwise would be discharged into surface water is valorized and used for production of microbial protein for various (health) applications and slow release fertilizer that can be used for example to produce hops that can be used in the brewing process. In the long term, the treated water will be reused to clean bottles, reducing the water needs of the brewery.
Westland	In the surface water case, the treated water is used as potable water. In the municipal wastewater, energy is recovered from the dried sludge and used as fuel in the cement industry	Strong circular commitment of stakeholders Strong communication efforts to the public and employees	Different entities involved to increase the circularity Policymakers from water organization are involved, but not public ones Positive environmental and social impact	Circularity happens because of the association of different entities	Cycling	Horticulture, Heavy Port industry, chemical sector	Optimization of innovative technologies to improve water – energy nexus by recovering energy from dried sludge Reduction of the sludge that ends up in the landfill Also, alum sludge is treated and used in production of building materials such as bricks.

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Athens	Internal production of water, nutrients and energy thanks to the new facilities	The strategy is based in CE principles and aligned with the Athens's Resilient Strategy. Fluid communication about circular economy activity with the public and policymakers.	Although the systems are located in the Nursery, its impact is expected to be city and region wide. Positive environmental and societal impact.	Business case to be developed. Expectations to create a branch of the Athens Water Supply and Sewerage Company	Cycling	Industry, Water sector, Agriculture	Water and nutrient recovery from wastewater for maintaining green areas in the city of Athens to fight higher temperatures resulting from global warming. Reuse of wastewater for urban green irrigation, urban agriculture, and various non-potable applications such as fire protection and washing of municipality vehicles. A thermal recovery unit to produce approximately 10kWh thermal energy from the treated wastewater to boost the Rapid Composting Bioreactor is a clear example of making use of the water-energy nexus
Timisoara	Nano level has not been developed yet	Strategy set thanks to IDA initiative to move from a linear to a circular model	System works at city level Policymakers are the promoters of the initiative that is still in a very early stage	Not developed yet	Cycling	Agriculture, Governmental (municipal), Water and Industry	The focus of the demonstrated pyrolysis technology which uses thermo-catalytic reforming is to convert aerobically stabilized sewage sludge into biochar, oil, and gas. These resulting products can be used as fuel or as agents to enhance soil quality or as sorbents.

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Demo cases are in general ecosystems of entities that must collaborate to increase the global circularity. Due to the nature of the water sector, the impact of the application of the circular economy principles in this kind of sites has a bigger scope than the site itself, reaching the whole city or even the region.

The COVID situation has negatively impacted the new initiatives, lowering or even stopping the implementation of the technologies and pilots, making it difficult collecting actual data for analysis.

The importance of the Nano level depends on the nature of the site, sometimes make sense to close internal loops and sometimes not, but in every case interaction with external entities happened. Closing loops within the sites have been mainly used to test technologies to be afterwards extended outside the boundaries of the site.

At Micro level, the most important aspect was the strategy, many times aligned with regional or national strategies. Policymakers are key in this sense, because they can act as promoters, facilitators or even become a barrier to implement circular initiatives in this sector. They can help to provide funding, to find the right partners or modify/adapt regulations for the use of reused water and its sludge.

Meso/Macro level is the main one. Loops in the water sector needs to include several entities that helps using the treated water and making the most from the sludge. It's very interesting how through the treatment of sludge different sectors can be included in the value chain. Some examples are the production of fertilizer from a brewery (La Trappe) or the production of bricks from a WTP (Westland).

Regarding business model innovation, it is something that is still being analysed. Most of the times circularity is reached thanks to the inclusion of a new entity that is able to get a product from the sludge. A very interesting case in this sense is the Westland case, where they find a solution for the alum sludge thank to a competition. Making events such as contests or hackathons to find out how to take advantage from waste is a very interesting way of innovating and increasing the circularity of a site.

Finally, the main circular business model for all the cases was cycling, since the main goal is to keep materials, water and/or energy on the loop.

Some other recommendations are:

Circular consultancy services

Circular consultancy services can both help a company to increase its consultancy or to help the creation of a new circular company from the very beginning. The circular economy is a multi-perspective concept whose application is notably enriched when many points of view are considered.

Generally, a company focused on a single sector does not have this global vision, so a company that offers consulting services that complement this vision of circularity can be of great help to increase its global circularity when deciding when and how to innovate its business model.

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So, a Circular Service Provider (CSP) is a company with knowledge in the field of circularity, specifically in the development of a circular and sustainable system. These companies mainly focus on sustainability solutions that can close the urban water, energy, organic waste and food loops safety, while also decreasing the overall operational costs and/or generating profits. It is the circularity service provider that offers circularity as a solution. The CSP works to integrate technologies, products and services to find the most effective circular solution. In this aspect the CSP is providing a circularity service. Part of this service is to find ways in which the performance economy plays a key role in technology providers' business model.

Business models like the one from Aquaminerals (see next Section) that acks like brokers between waste producers an companies that can treat those waste to transform them in valuable products are really interesting to be replicated.

Portfolios of innovative technologies to treat waste

One of the conclusions of the performed analysis is that there can be several ways to treat and process waste, leading to different end products. These alternative methods have varying technology requirements, upfront costs, operational costs, energy requirements, and variability in automation versus manual operation. The methods also result in highly variable products, with different levels of valorisation. In order to effectively increase circularity, you must be able to find the appropriate solution for treating the waste (sludge, biomass…) for a specific water treatment system at particular site. The same technology can or cannot make sense, depending on different conditions (energy cost, characteristics of the waste to treat, environment where the obtained product is going to be used, etc.). Therefore, it would be very useful to have in a place a portfolio of innovative waste treatment technologies, which not only summarizes the various technologies, but also discusses the optimal conditions for their application. Also included can be a list of potential buyers or clients for the valorised end products. This portfolio could become a reference guide for water sector companies and/or CSP providers to help make the water sector companies transition to a circular business model.

Geolocalized maps of waste – resources – potential clients

Another way of becoming circular is treating waste as a byproduct (secondary raw material) that is going to be processed by another company (industrial symbiosis). This method of circularity requires knowledge of the waste itself and also requires quite a bit of management. First, it is necessary to either find a company that can process and/or use the waste or you may need to advertise your waste as a valuable secondary raw material so that companies interested in your waste can easily find you to purchase/ accept your waste. It may be that there are no such companies in your area and you may have to go far to find relevant companies, or you may have to encourage entrepreneurs to create new companies for this purpose. A visualization of wastes produced and the waste resources needed can help the potentially symbiotic partners find each other.

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This may be done, by creating geolocalized maps, which can be openly available online, where this kind of information (companies, its activity, needed resources and waste produced) are all located in one place. Such platforms are already available, where companies can share resources and byproducts (at even national level). One example of such a platform was created by the "Interplatform Group of Circular Economy" (Grupo Interplataformas de Economía Circular[54]). Here, any company can register and have access to the tool to see posted information about the buying and selling of byproducts (secondary raw materials).

4.4. Ecocanvas collection

4.4.1. Introduction

In the previous section some examples of ecosystems of entities have been showed. As mentioned before, sometimes it makes no sense speaking about business models in this situation. In order to get some insights of how circular business models work in the water sector, this section analyses eight examples of entities related to it.

The analyzed entities are related to different demo cases and located on different countries. Some of them are already consolidated organization or companies and some are just created spin-offs or spin-off projects that are currently under development. The following table summarizes them:

Table 4: List of companies analysed with the Ecocanvas

Name	Demo case	Country	Status
Raceway Reactor	La Trappe	Netherlands	Project
Aquaminerals	Westland	Netherlands	Consolidated
Biopolus	La Trappe/Athens	Hungary	Consolidated
Chemitec	Athens	Greece	Consolidated
Aquatim	Timisoara	Romania	Project
Adasa	Costa Brava	Spain	Consolidated
Alpha Wassertechnik AG	Altenrhein	Switzerland	Consolidated
Netics*	Westland	Netherlands	Project

*Netics is a consolidated company, but the example analyzed in this work is about a spinoff they are planning to create.

The companies listed above were analyzed using the Ecocanvas described in Section 2.3.1. As described there, the Ecocanvas is based on the traditional business model canvas developed

[54] https://www.giec.es/acceso_herramienta.asp

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by Osterwalder where three new cells were added to capture social, environmental and circular aspects from a company (See Figure 6).

For each of the entities, an interview was conducted to complete the Ecocanvas. The following sections shows the results of these interviews (Sections from 4.4.2 to 4.4.9), including a summary of the main findings in Section 4.4.10.

4.4.2. Raceway Reactor by SEMiLLA IPStar

The raceway reactor (RR) has been developed by SEMiLLA IPStar and tested on La Trappe's demo case. The raceway reactor treats wastewater using purple bacteria in order to obtain both clean water and biomass. Two business models have been explored. The main business concept (RR as WWT) involves two different parties (See Figure 17), One that requires water treatment using the decentralized raceway reactor and recovers investments by selling the biomass, and another party that makes use of the biomass. SEMiLLA in this case would be the provider for both customers in the value chain from waste to resource.

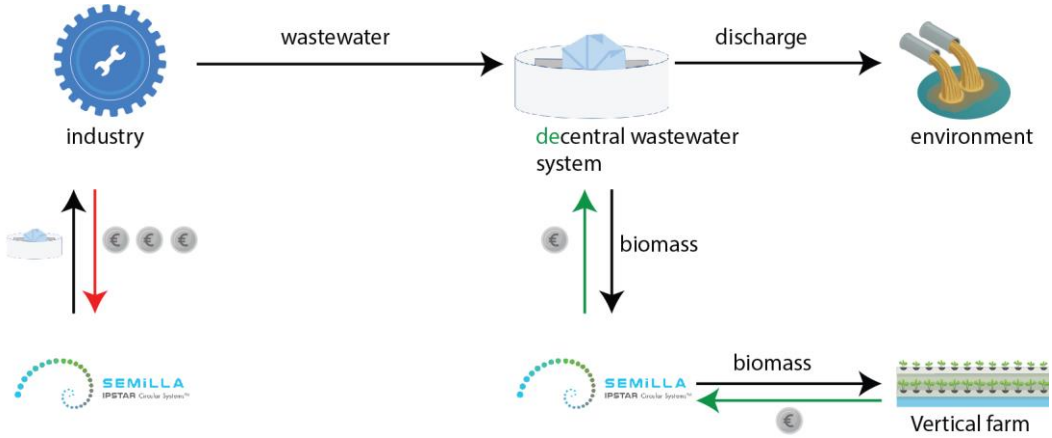

Figure 17: RR business case concept

Another business concept (RR as PNBS biomass producer) has been developed in collaboration with end users such as GrowX[55], a company specializes in the development of vertical farms. In this case, the circular vertical farm uses organic waste streams from urban environments (such as supermarkets, restaurants, and farms) as input in a biodigester to produce biogas as an energy source for the vertical farm. The waste stream of this process could be used as input to the purple bacteria reactor, recovering important nutrients as biomass that could be used as fertilizer in the farm. In this case, SEMiLLA would have a single customer, the Vertical farm, which aims to treat the water and recover nutrients.

The Ecocanvas will be developed for both options, the RR as WWT and the RR as PNSB biomass producer, to provide a better understanding of how the business model works and how it affects the environment and society.

[55] https://www.growx.co/

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Customer segments

Table 5: Market segmentation

Primary customer segments	Secondary customer segments
Breweries Waterboards Vertical farms	Agrifood (open field) Life sciences Research institutes Municipalities Building complex

Unique circular value proposition

The two value propositions are:

WWT

Table 6: WWT value proposition

Value proposition	Description
Biological wastewater treatment	Breweries typically pay a fee for discharging their wastewater to the central sewage system. By treating the water on-site, breweries can avoid this fee and also reduce their CO2 footprint. The treated water can be discharged back into the environment, rather than sent to a central sewage treatment facility. This not only reduces costs for the brewery, but also helps to conserve resources and minimize environmental impact.
Less energy use	The most common wastewater treatment system on site are physic-chemical systems which have a higher energy demand than the raceway reactor.
Sustainability	On-site wastewater treatment can improve the sustainability of organizations by reducing the amount of waste and pollution they produce, and by conserving resources. Additionally, by-products of the treatment process can be used to improve circularity and strengthen the business case of the user. For example, if the by-product can be used as a raw material for another industry, it creates a new revenue stream for the organization, making the business case more robust. Additionally, by-products can be used as a fertilizer, reducing the need for synthetic fertilizers, which in turn reduces the environmental impact of the organization.
Tailor fit	Wastewater characteristics can vary greatly depending on the organization or industry

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	producing it. The raceway reactor system can be designed to optimize the technical efficiency by taking into account the specific characteristics of the wastewater. This allows the system to effectively treat the wastewater and recover valuable resources, such as clean water and biomass. Additionally, the raceway reactor system can be tailored to the needs of the specific organization or industry, further improving its efficiency and effectiveness.
Creates revenue	Investing in decentralized wastewater systems can come with high capital and operational costs (CAPEX and OPEX), but the Purple Bacteria Raceway Reactor technology can offset these costs by creating revenue from the sale of biomass as a slow-release fertilizer. The system uses purple bacteria to treat the wastewater and recover valuable resources, such as clean water and biomass. By selling the biomass, the system can generate revenue that can help to pay for the initial costs of the system. This can make the investment in a decentralized wastewater system more cost-effective and economically viable for organizations.

PNSB biomass

Table 7: PNSB Value proposition

Value proposition	Description
Fertiliser	The biomass contains macro and micro elements necessary for plan cultivation
Biostimulant	The biomass can also act as a biomass against different pathogens of diseases and increase the nutritional factor of the plants
Circular products	By using fertiliser as nutrient recovered from waste streams, it creates circular, low CO_2 footprint products that appeals to the buyers.
Organic label	Using an organic fertiliser can allow the certification for organic products, increasing the cost of the retail cost of the plants.
Short supply chains	Having fertiliser obtained locally on the waste streams, create a resilient food system.

Communications and sales

WWT

Table 8: WWT Channels

Channels	Description

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SEMiLLA/MELiSSA network	Workshops, conferences, events advertising the technology and thus reach to different markets in other countries through the partners of the MELiSSA project.
Key partners	As key partners in the consortium the organisations can link new customers to SEMiLLA by directing the inquires on the topic from potential customers to SEMiLLA.
International fairs (water, food)	Showcasing the system in international fairs will increase the reach to the relevant markets
Sales persons	Actively searching for customers by contacting similar actors in the same industries (eg. Breweries, vertical farms). This contact can be done by phone, visits on site, and invitations to ongoing projects.
Marketing campaign	Directed marketing campaign B2B, on dedicates website, and social platforms, press releases.

PNSB biomass

Table 9: PNSB channels

Channels	Description
Website	The fertiliser products will be sold directly online through a webshop and delivered on site through couriers/post. This version can be also sold to private customers (B2C).
Marketing campaign	Directed marketing campaign B2B, on dedicates website, and social platforms, press releases.

Customer and stakeholder relationships

WWT

Table 10: Customer relationships

Customer relationships	Description
Analysis/consultancy	The first relationship with a potential customer is by analysing the wastewater stream and thus propose tailor fit design to meet their objectives and maximise circularity. This is a way to lock up the customer.
Training	Train the personnel of the customer on operating the system and offer advice along the way.
Maintenance services	Regular maintenance and optimisation work can help strengthen the relationship with the customer on long term.
Process byproduct (biomass)	By collecting and processing the biomass in is stablished a long term relationship with the customer and a dependency to SEMiLLA.

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PNSB biomass

Table 11: PNSB customer relationships

Customer relationship	Description
Consultancy, advice	Besides direct sales, the customer can be engaged in a long term relationship by offering advice for application rate and optimisation of nutrient use efficiency.
R&D	Engage with the customer in setting R&D on site of the user for finding new opportunities for the biomass use (e.g. different crops)

Revenue streams

WWT

Table 12:WWT revenue streams

Revenue streams	Description
Direct sale	The main revenue stream for the company would be selling directly the container solution to end users. This includes selling pre and post treatment solutions tailored fitted to the customer.
Operational training	The end user will be trained for operation of the system. This training will also be done regularly on checking the efficiency of technology and advice, consult based on the requirements, against a fee/hour.
Maintenance service	Regular maintenance services can be performed in order to check and keep the system at the highest efficiency. This activity can also be trained to the end user personnel and advised on demand.

PNSB biomass

Table 13:PNSB revenue streams

Revenue streams	Description
Direct sale	The fertiliser can be packed on different quantities with all information of application labelled on the package. The fertiliser can be solid in bulk to agro-food industry and in small quantities to private consumers.
Consultancy, advice, analysis	The company can give consultancy and advice services to businesses or private consumers on application of the fertiliser and nutrient use efficiency strategies. SEMiLLA can also offer consultancy services by guiding R&D projects in finding novel ways of valorisation of the

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	fertiliser (for e.g. with different candidate crops).

Need/Problem/Challenge

WWT

Table 14: Needs

Customer segment	Customer problem/needs
Brewery	Water reuse (low opex cost) Wastewater discharge (fee for discharge level) Recover nutrients for own crop production (limited)
Waterboard	Decentral modular systems for off-loading the central system Innovation in water treatment and wastewater recovery systems
Vertical farms	Water reuse Recycle nutrient solutions Fertiliser Substrate with fertiliser Circularity for increasing market value for the products Organic products (organic fertiliser)
Agrifood (open field)	Fertiliser producers Protein production Substrate
Life sciences	High value product Low cholesterol biomass
Research institutes	Microbiology, bio-engineering, pilot lab equipment
Municipalities	Lower operational costs, more resilient system, circular solutions Implement decentral waste reutilization systems for sustainable strategy New developments that need to have high degree of circularity Policy regulation
Building complex	Clean water recovery Water reuse/discharge level Fertiliser production for greening area

Key resources

The key resources needed to operate for both business models are:

- Raceway reactor
- Bacteria inoculum
- Human resources with the expertise to make the tailor fit solutions, consultancy services and advice

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Circular Value Chain

The value chain again similar in both cases. It is shown in the following figure:

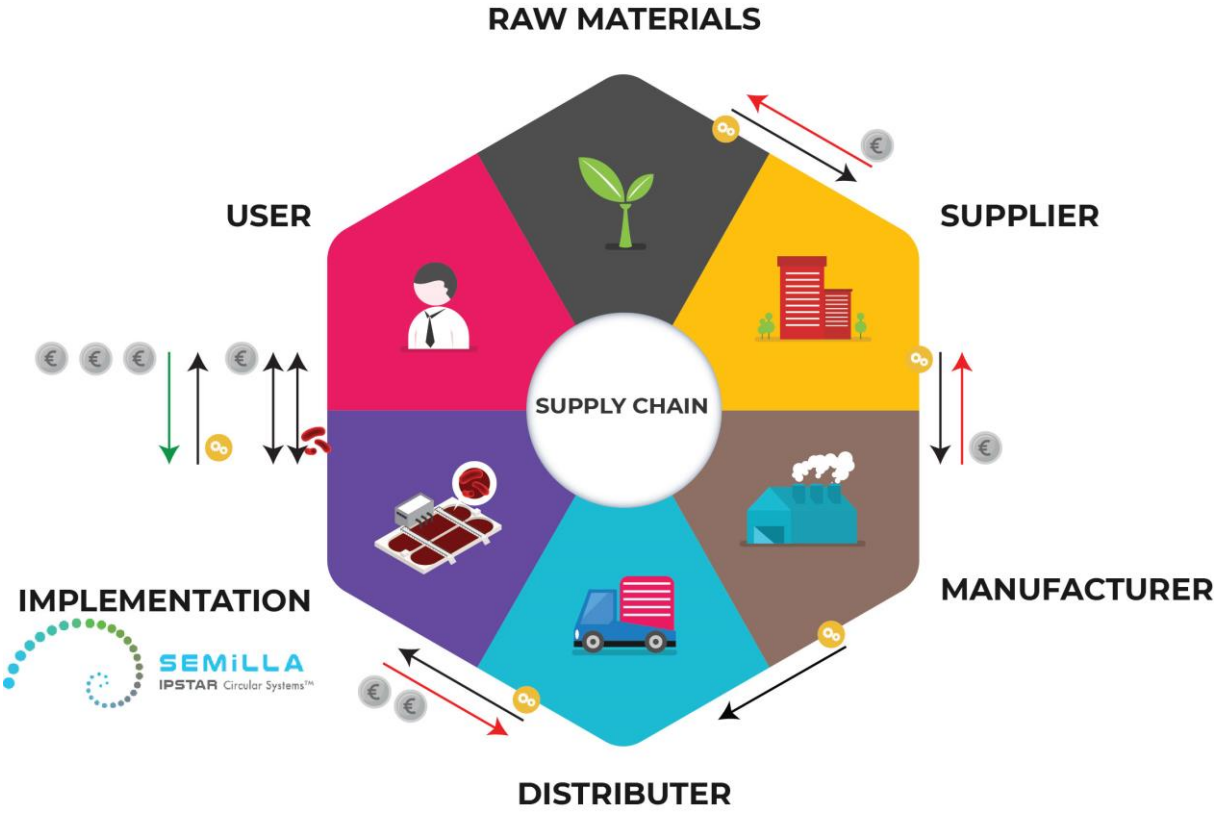

Figure 18: Raceway reactor value chain

In the WWT option, the reactor will be placed in a company that needs the water to be treated. Then the biomass will be recovered by SEMiLLA and then sold to other companies.

In the PNSB option, the fertiliser once produced will be sold to farmers or private consumer.

Cost structure

The business case is very much dependable on the specific context of the installation. The wastewater quality, requirements of the end user, the infrastructure and scale are all important variables in the design of the system. Therefore, a price/product is not a straightforward to be set in other cases.

There are two different concepts for the business case. First, one is having two end users, one for the water treatment and another for the biomass as fertilizer use. The second concept is in the case of circular vertical farms where the end user is the same for both water treatment, and biomass as fertilizer use. Moreover, the scale-up 40 feet shipping container can be sold as a product or service and the costs and benefits for the client and SEMiLLA are significantly different in each case.

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The cost structure was calculated on a design principle for a 40 feet shipping container. The pre-treatment and post-treatment for the wastewater treatment are not considered as they are highly dependable on each specific case.

The processing of the biomass is considered by using nano-filtration, centrifuge and spray drier. The capex and opex of the biomass processing were separately considered. It is notable that the biomass application as dry matter or sludge is still under investigation and could have a great impact on the business case.

The verification tests results render a technical efficiency of the scale up scenario at 2.4 m^3 per day. Taking in account the maximum efficiency obtained in the lab, the results show that the same system could process up to 5 m^3 per day. Therefore, the following cost structure for a 40 feet shipping container is calculated.

Table 15: CAPEX and OPEX wastewater treatment scale-up version and post treatment systems.

	CAPEX		OPEX	
	Min 2.4 m^3 d^{-1}	Max 5 m^3 d^{-1}	Min 2.4 m^3 d^{-1}	Max 5 m^3 d^{-1}
	1000 * euro $unit^{-1}$		1000 * euro $year^{-1}$	
40 feet shipping container V 8 m^3	165.16	110.85	69.69	69.68
	1000 * euro $unit^{-1}$		1000 * euro $year^{-1}$	
NF	31		0.37	
Centrifuge	6.72		0.27	
Spray drier	460		0.008	

Assuming a biomass concentration of 0.48 Tss m^{-3}, and a recovery of 100% in the NF, 97% in the centrifuge and 95% in the spray dried, a quantity of 276 to 575 kg of dried biomass can be produced per year. This quantity controlled for 100% Nitrogen requirement would result in a threshold from 377 to 785 tons of lettuce produced per year.

The cost of the biomass as fertiliser is not yet competitive in the market as it will be at least the fold higher than traditional synthetic fertiliser options. The added value as recycled, short supply chain and biostimulant characteristics could make the product competitive. Moreover, in the case of the circular vertical farming concept, the fertiliser obtained is a by-product that has the potential to supply -at least in part- the required plant nutrition. Therefore, the price per fertiliser is positive as obtained from the WWT unit.

Foresight and Impact – Environmental

The environmental impact of this business model is positively high. On one hand, the raceway reactor is an innovative wastewater treatment system that has high potential and provides treated water that can have many uses. On the other hand, the produced biomass can be used to produce fertiliser. Thus, the proposed business model reduces water scarcity and the disposal of waste on landfill, at the same time producing biomass and fertilizer that can be used to produce food on vertical farms.

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Foresight and Impact – Social

From the social point of view, circular systems contribute to boost circular practices through the dissemination of the concept. On the other hand, the option of teaching how to maintain the system can be translated into the creation of new job positions.

Circular business model and innovation

The mean circular business model strategy is cycling, since the business model is based on the treatment of wastewater that can be reused afterwards, as well as the production of biomass from waste. Dematerialising is as well present when offering the system through renting to the customers instead of selling the reactor.

The two Ecocanvases related to the two shown options are summarised below:

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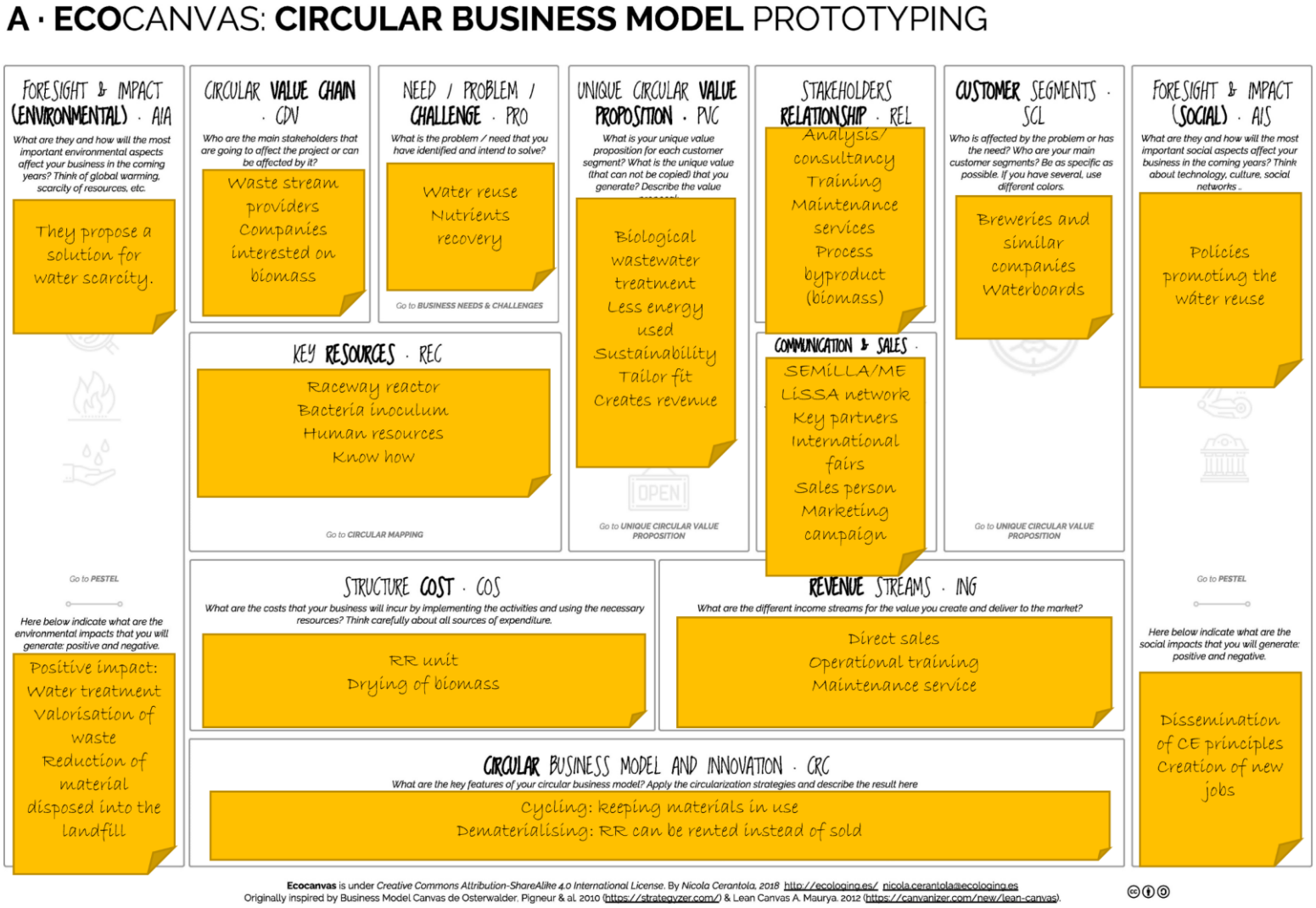

Figure 19: Ecocanvas Raceway Reactor – WWT

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Technical aspects

When using the RR as WWT, the product would be a customized system that allows water treatment that besides produces biomass because of the water treatment process. This biomass will be afterwards recovered by SEMiLLA and sold to other companies. Two services can be offered as well to the companies that acquires the RR: training for operation of the system and/or maintenance against a fee/hour.

So, the main source of revenue will be selling the RR to end users and may include the hourly fee due to the training and/or the maintenance. In addition, revenues will be obtained from the selling of the produced biomass.

Regarding the cost structure, the main costs come from the creation of the RR. This cost may change from one situation to another depending on the required quality of water. The biomass needs to be dried before being sold, which implies a high energy consumption and, therefore, is another important source of costs.

Table 16: RR as WWT SWOT.

Strengths	Weaknesses
Low energy water treatment system. The system is producing biomass that can be sold to increase benefits. The system can be scaled and adapted to different wastewater compositions. Offers a decentralized solution for wastewater	The PNBS needs nutrients to grow what means that cannot be used only in every kind of stream It is a living system that can be destabilized if the composition of the stream changes
Opportunities	**Threats**
High interest and need for new and innovative wastewater systems both at private and public level Many options of using the produced biomass	The system is still in a very low TRL level and needs more testing

Market aspects

The RR offers a solution that can be used by any company with an intense use of water (the system was tested in the brewery sector). From the wastewater treatment point of view, the identified need covered by this solution is the savings in terms of fee for wastewater discharge and the possibility of reusing the treated. In the case of waterboards and municipalities, such as systems can be used as wastewater decentralized modular systems with lower operational costs.

So, the customer segments would be:

- Water-intensive industry (breweries)
- Waterboards and municipalities

Regarding the market trends, this solution has some advantages:

- Low energy consumption compared with traditional membrane systems

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- The system does not produce sludge, but biomass that is as well a valuable product
- Offers a solution to the public sector to decentralize water treatment
- Allows nutrient recovery, contributing in many ways with the implementation of the circular economy

Water treatment is a hot topic nowadays what means a big market opportunity for solutions such as the RR. However, there are some market barriers mainly due to the novelty of the system and the lack of testing on different water-intensive sectors. The bacteria needs nutrients in the wastewater, which limits the type of flows that can be treated with this system.

Marketing aspects

The unique circular value proposition offered by this solution is the biological wastewater treatment that this solution offers, that reduces the CO2 footprint and the discharge fee of the wastewater. Besides, is a low energy system and increases the sustainability of the companies. The RR is a customizable system that can be optimized to a specific industry and produces an extra revenue thanks to the biomass production.

The main sales channel would be the networks the company already have (SEMiLLA, MELiSSA) and the website. It would be necessary to hire a salesperson that actively search customers and find new sectors where the system can be used. Regarding the strategic partners, on one hand we need those related to the development of the system (providers) and the search of the companies interested on buying the biomass in order to make it become more profitable.

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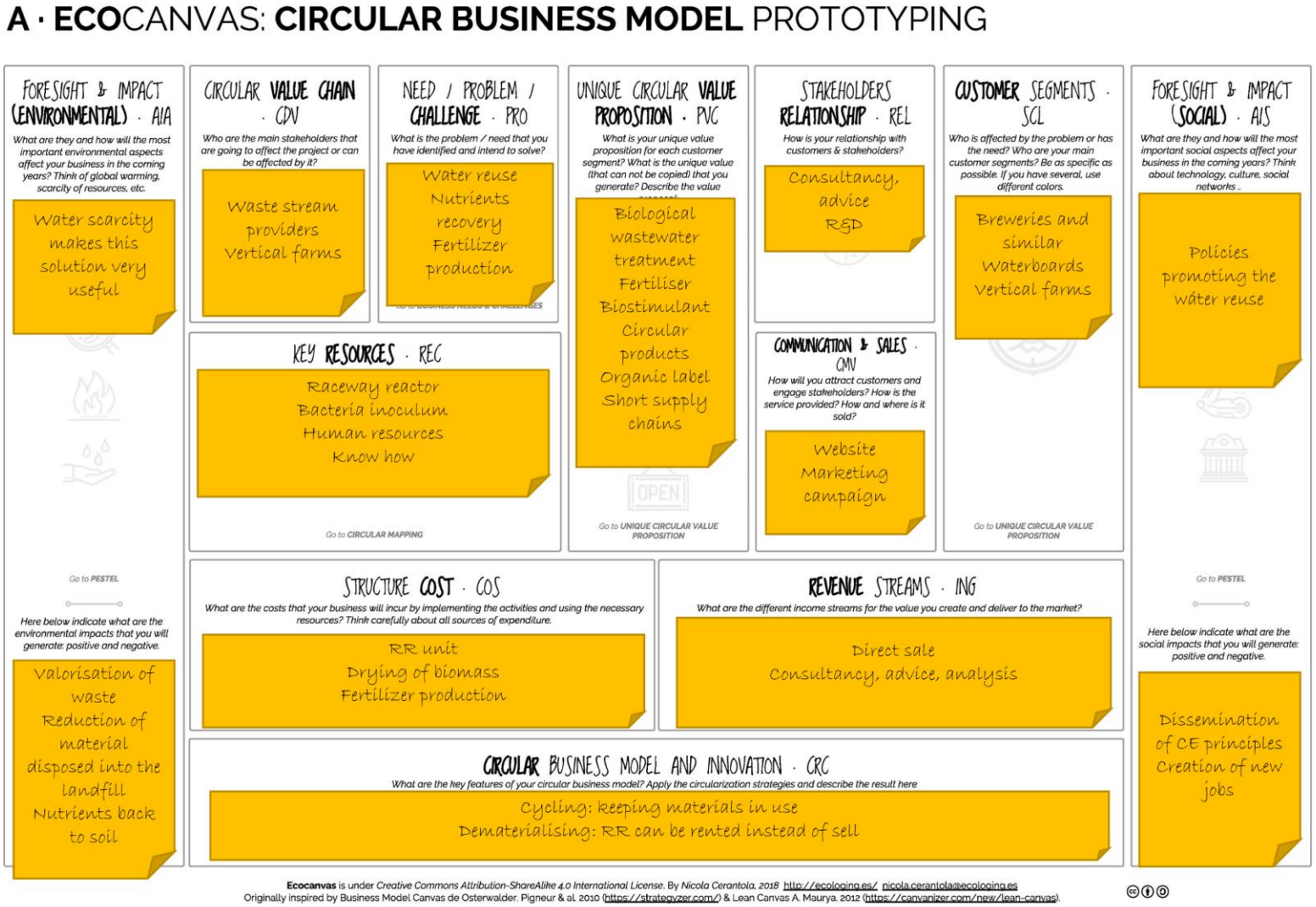

Figure 20: Ecocanvas Raceway Reactor - PNSB

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541

Technical aspects

In the case of RR as PNBS biomass producer, the product is again the wastewater system but the goal is to treat organic waste streams from the city (supermarkets, restaurants, farms…) and use the produced biomass as input in a biodigester to produce biogas as energy source for vertical farms and nutrients that can be used as fertilizer. Again, two services can be offered as well to the companies that acquires the RR: training for operation of the system and/or maintenance against a fee/hour.

So, the main source of revenue will be selling the RR to the vertical farms and the direct sale of the fertilizer produced from the nutrient recovery. In this case the hourly fee due to the training and/or the maintenance can be considered as well.

Regarding the cost structure, the main costs come again from the creation of the RR. After comparing the cost of the production of the fertilizer with already existing systems, it is not competitive yet, so research in this sense should be made to make it profitable.

Table 27: RR as PSNB SWOT.

Strengths	Weaknesses
Low energy water treatment system. Production of biogas. Recovery of nutrients.	Variability of waste streams coming from the city can affect the bacteria. Fertilizers production not competitive yet
Opportunities	**Threats**
High interest and need for new and innovative wastewater systems both at private and public level Vertical farming is a new trend in many countries	Existing alternatives to produce biomass and fertilizers

Market aspects

The RR as biomass producer covers some needs of vertical farms (which are the target customer): water reuse, recycle nutrient solutions, fertilizer production, substrate with fertilizer and circularity for increasing market value for the products.

Regarding the market trends, this solution has some advantages:

- Wastewater treatment from municipalities
- Nutrients recovery
- Circular systems
- Biogas production

Since vertical farming is a market trend, there is a market opportunity for RR as biomass production as support of this new industry. The main market barrier is the cost of the fertilizer production since it is currently over the market prices.

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Marketing aspects

The unique circular value proposition offered by this solution is:

- Fertilizer, since the biomass contains macro and micro elements necessary for plant cultivation.
- Biostimulant. The biomass can also act as a biostimulant against different pathogens of diseases and increase the nutritional factor of the plants.
- Circular products.
- Organic label thanks to the use of organic fertilizer
- Short supply chains, thanks to the use of fertilizer obtained locally.

The main sales channel of the fertilizer would be the website of the company that would be supported by a marketing campaign. Strategic partners are the vertical farms and R&D entities that will give support finding new opportunities for the biomass use.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541

4.4.3. Aquaminerals

AquaMinerals was established in 1995 by and for de drinking water companies. As a shared service centre, its main task was to develop and maintaining sustainable pathways for residuals originating from water treatment. Where in 1995 the majority of the residuals was disposed of, nowadays most materials find their way in functional applications with a positive economic value. Since 2018 water authorities also start joining the collective, giving AquaMinerals also the task to find pathways for materials recovered from municipal wastewater treatment plants.

In short, AquaMinerals is the broker between the market and the public water sector. However, unlike a broker, it invests in research for new pathways and it pays out the full value to the supplier of the residual. This makes it worthwhile for a supplier of residuals to invest improving the quality of the residual and/or the logistics.

Customer segments

AquaMinerals meets the need of the water sector to create firstly continuity in the 'disposal' of residuals. Then AquaMinerals:

- Manages the costs of the pathways (costs as low as possible, revenues as high as possible);
- Develops pathways that are preferable circular and have a low(er) carbon footprint
- Steps into the void between the water sector and the market, with knowledge about quality control, legislation, sales, procurement and supply chain management.

The customers of AquaMinerals are on two side of the value chain:

- The water entities as supplier of the residuals. These are public owned water entities based in Europe. They are also shareholders, codetermine policy, pay the organisation costs and are often involved in valorisation pathways;
- De buyers of the residuals. These buyers can be just about any type of company, they have in common the need of resources and the water sectors' fit their specifications. The buyers are based in Europe.
  Although they don't pay AquaMinerals expenses (the revenues are paid out to the water companies), the sales to the market determines greatly the success of AquaMinerals. The better the sales contracts, the better AquaMinerals is perceived by its participants.

Unique circular value proposition

The unique circular value proposition for the water organisations is that AquaMinerals unburdens them on all issues concerning the material routes of the residuals. With this collective approach the costs are shared and therefore relatively low, combining the materials creates a big(ger) volume and gives their sales- and procurement power making this business model even more interesting.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541

For the customers buying the residuals the unique selling point of AquaMinerals is that they have access via AquaMinerals to a significant and quality-controlled volume of residuals. Without AquaMinerals they would have to deal with multiple water organisations and deal with a variety of qualities, schedules, prices and contact persons.

The AquaMinerals business model is as such not hard to copy, but in a region where this model is in place (like The Netherlands), there is no place for a second one. After all, the sector has already created a collective and will not start another, undermining the first. This model is nevertheless suitable to replicate in other regions in Europe, it requires water companies and/or authorities that are willing to establish a collective organisation and therewith transfer a part of their mandate on the disposal of residuals.

De value chains are also relatively easy to replicate. Water treatment technology in Europe is very comparable and therefore lead to similar material flows. Legislation is in the member states the same, so in most cases what's allowed (and operational) in one country, it is also in the other. The developed applications are quite general, having customers that are likely to be also found in other countries.

One would wonder -because replication is within reach- why this model isn't copied elsewhere in Europe. Of course there's not one answer, but it can be found in:

- Not everywhere the water organisations are public. This means that antitrust legislation might hinder establishing a collective model
- In some countries local authorities work with concessions for a certain period of time. This means that the incentive for a collective model is less interesting. The benefits flow to the local authority, while the water company has to put in efforts
- When the population density is low, the water treatment facilities are likely to be more spread and smaller. Also, the possible users of the materials are likely to be more at a distance. For the collective model this means that combining material streams is less interesting due to the long transportation distances
- The collective yet commercial model requires a balance between (1) cooperating when a collective approach is of added value, but also (2) addressing the individual interests. The Netherlands has a culture that handles with this dilemma. It is called 'polderen', meaning that people live as individuals in a polder, or a low-lying tract of land that formas and artificial hydrological entity, enclosed by embankments known as dikes, but have to act as a strong collective to keep dry feet.

Communications and sales

Participants each have assigned contact persons, at least for operations, research and policy. There are regular meetings with the participants on these themes.

AquaMinerals attracts new customers in a B2B environment. The materials and applications are too specific to use a more general approach. AquaMinerals carries out acquisition on

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intended markets and specific customers. Last few years, and in particular during (and post?) COVID customers found AquaMinerals. The reason might be the increased attention for sustainability and vulnerable value chains.

AquaMinerals organises a biannual symposium for all stakeholders in the value chain. An important aspect of this symposium is networking, presenting of stakeholders (presentation, experience market etc) and foremost creating understanding in the value chain.

Social media are also used. New systems from the site are placed on LinkedIn and Twitter.

Customer and stakeholders relationships

The relationship with the participants can generally be described as familiar. So not 'us and them', but really working together. Of course, there are discussions on the course, the results and progress of the goals, but all participants realize that in the end they must do it together.

The relationship with the customers is evidently much more business-like. Especially in mature, 'fighting' markets the relationship is customer-supplier. However, in less mature markets the relationship is often more open, vulnerable (in a positive way) and cooperative. This can be explained by the interdependency in these new chains where the stakeholders really need to work together and solve possible problems together.

Revenue streams

The largest part of the income is AquaMinerals is the shareholders fee, this is 80-90% of the total income. This fee covers the organisational costs AquaMinerals makes. The financial model is based on the concept that collective activities are paid collectively. The 10-20% income comes from projects that AquaMinerals does for third parties (non-shareholders) and non-collective activities that AquaMinerals does for its shareholders.

Need/Problem/Challenge

For the coming years, AquaMinerals sees the following challenges:

- Upcoming pollutants. The pollutants removed from the water cycle end up (and accumulate) in the residuals. These pollutants form an increasing challenge in finding pathways
- Energy-subsidies and carbon pricing. Due to stimulating policy in order to change the energy-mix, there is an increasing pull for alternative energy-source, like biosolids from water treatment. This will financially undermine the initiatives for resource recovery
- End-of-waste status. Even years after implementing new legislation on this field, in practice most member states have a different explanation on this issue. This means that materials that go across the border(s), need to undergo different procedures (time and money consuming). Furthermore we see that fossil/linear materials are treated different from circular materials, meaning that circular materials need to be tested on much more items and loose even more terrain on competitive advantage.

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Key resources

The major resource for AquaMinerals is its personnel. The team has both a wide and specific knowledge on establishing new pathways as well as maintaining them. An other -non tangible- resource is the collective as such. This means that AquaMinerals is a more powerful player, representing the whole sector.

The natural capital of AquaMinerals is in essence the ground and- surface water itself. The quality of the water determines greatly (1) what needs to be removed from it and (2) the quality of the residuals.

Circular Value Chain

In most circular value chains, all stakeholders play an essential role. One of them stepping out, for whatever reason, breaks the chain and ends the loop. Of course, this doesn't count for alle the stakeholders, under normal circumstances a transportation company can be replaced by another. Most important stakeholders that may affect the circular value chains are:

- The water companies as supplier of the residuals. They influence the volume and quality, for instance by changing the treatment process
- The technology- and service providers. They are the switch between supply and demand. In some cases, they own the IP and can even block certain pathways
- The end user. The end user plays an important role in innovation, specs and pricing
- Legislation. The pathways for the residuals are often new and in a legal unclear terrain. New legislation is being developed, determining greatly if doors will open or close.

Cost structure

The organisations costs of AquaMinerals are 1,95 M€ (2020). This covers all collective costs for developing and maintaining pathways for residuals. These costs also cover the ~300 k€ costs for research and development.

Foresight and Impact – Environmental

AquaMinerals expects positive impact for its operation from the increased attention for the circular economy. This means stimulating policy, market pull by end users that want to become more circular in their business operations. Furthermore, post-COVID prices for resource are increasing, making alternative resource more interesting. COVID learned companies that some of their supply chains are long and vulnerable, making local, reliable sourcing interesting.

The wide attention for alternative energy sources might lead to a strong pull for caloric residuals, competing with pathways of valorisation of these materials. Another challenge for the future are emerging substances, like PFAS. These substances can hinder new pathways greatly.

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Foresight and Impact – Social

The technology will lead to new pathways. Due to various subsides and other types of stimulants, there is a lot of work being done on research and innovation undoubtedly leading to new insights. Also, technology-development in the water treatment process will lead to new residuals and therefore demand for new technologies.

A lot is expected from a general shift in public perspective on the use of residuals. Consumers and therefore manufacturers were reluctant to use non-virgin resources. This paradigm has changed dramatically, nowadays it is almost 'normal' to use alternative resources (thus accepted by the general public) and in some cases it is even demanded by the consumer. Essential is that the suppliers are aware of this trust and therefore responsibility on quality and security of supply.

Circular business model and innovation

AquaMinerals' business model is focussing on the cycling of the resources. It aims at using the residuals in the same process where it came from, thus fully circular. When this is not possible, it will try to apply the residual (processed or not) in other parts of the water cycle. When this can't be achieved, it aims at applying it in the biological- or technical cycle.

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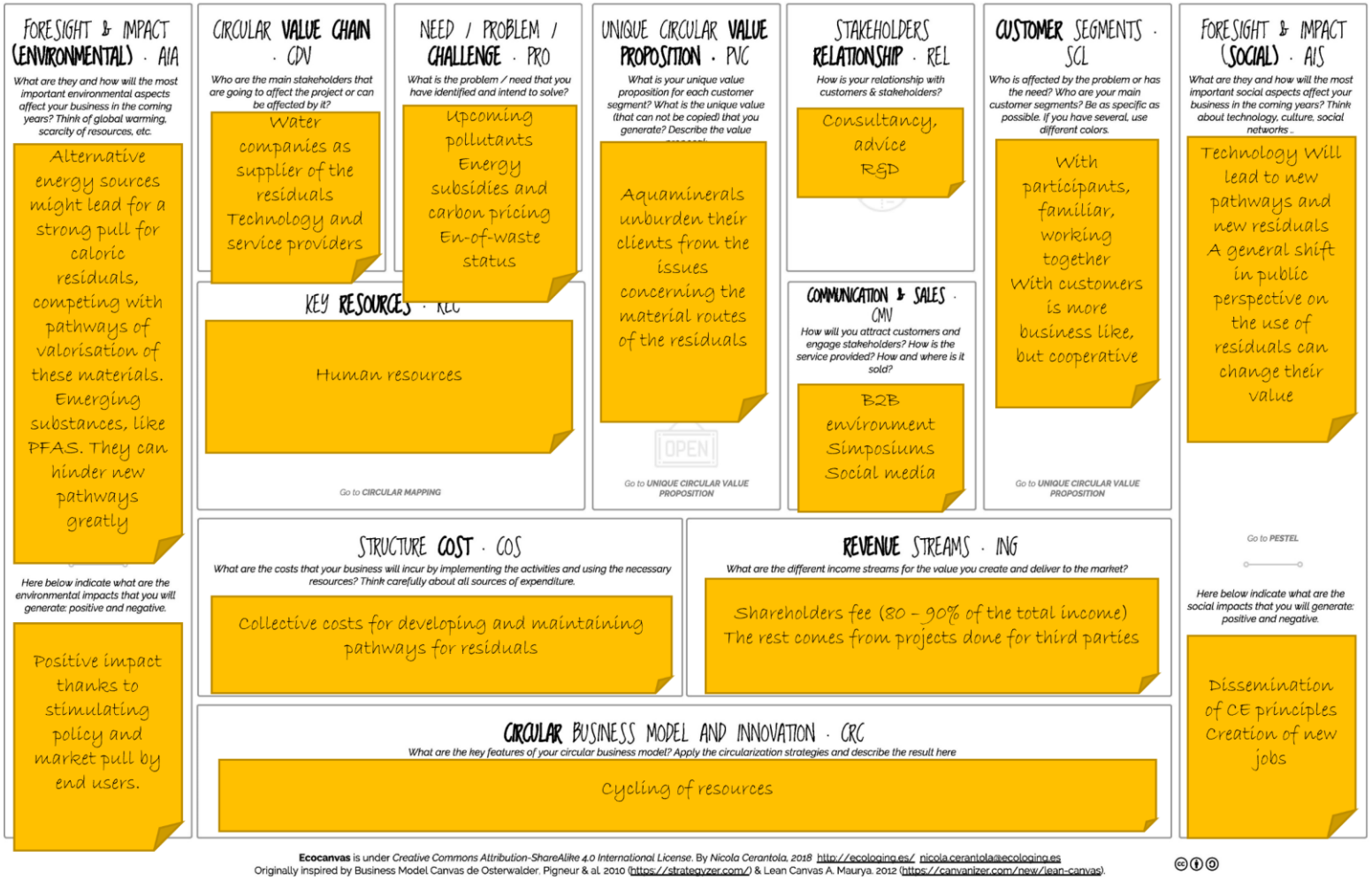

Figure 21: Ecocanvas Aquaminerals

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541

Technical aspects

AquaMinerals offers a broker service between the market and the public water sector through the development of sustainable pathways originating from water treatment of private companies and municipal wastewater plants.

Their main source of revenue is the shareholders fee (about the 80%-90%). The rest of the income comes from projects that AquaMinerals develops for third parties.

Regarding the cost structure, it is related to the developing and maintaining the pathways for residuals and from research and development proyects.

Table 38: AquaMinerals SWOT.

Strengths	Weaknesses
Development of specific solutions for their members. Absence of competence (due to its profile, it makes no sense having another entity with similar goals in the same region). Participation of public and private entities.	Business model easy to copy in different regions of Europe.
Opportunities	**Threats**
Increasing interest on circularity and use of waste as raw materials	Regulation may be a problem when using waste for some applications

Market aspects

Regarding needs and challenges related to the water sector and the related waste production, AquaMinerals offers competitive solutions for the wastewater materials. In addition, the entity invests on research about how to treat the pollutants removed from the water cycle.

Their customers are in the two sides of the value chain: water entities as suppliers of the residuals and buyers of residuals. The former, stakeholders of the entity, pay the costs of the organisation and in many cases are involved in the valorisation pathways. The latter do not pay directly to the organisation, but their degree of satisfaction contributes to improve the perception that Aquaminerals' participants have of the organisation.

Regarding the market trends, AquaMinerals covers the following:

- Wastewater treatment from industry and municipalities
- Some of the solutions are focused on biosolids recovery to be used as alternative energy source.
- Circular systems
- Alternative solutions for produced sludge
- Support to public water treatment entities

Besides, AquaMinerals supports the creation of new companies based on the R&D results.

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Marketing aspects

The unique circular value proposition offered by AquaMinerals is that they unburden their stakeholders on all issues concerning the material routes of the residuals. Costs are shared and therefore relatively low. B2B is the main way of attracting new customers and the strategic partners are their stakeholders. They organize a biannual symposium for all stakeholders in the value chain. Social media are also used.

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4.4.4. Biopolus

The Biopolus Institute is a privately owned non-profit research and development organization based in Budapest, Hungary. It was founded in 2012 as an innovative R&D Centre with a unique combination of water technology, biotechnology and IT. Biopolus is developing a range of its own technologies for addressing some of the typical challenges present when moving towards a circular economy. These developments range from innovative water treatment technologies to urban farming solutions and biological production systems.

Customer segments

To adapt to the ever-changing demands and continuous growth cities need to become smarter. Information technology combined with a decentralized infrastructure can provide this much required flexibility. In order to become economically and ecologically sustainable, cities also need to radically improve their resource utilization by closing their metabolic loops. The nature-based solutions (NBS) provided by Biopolus help urban areas close these loops to become resilient, economically self-sufficient, and more beautiful.

The Biopolus Institute has developed a range of technologies for addressing the sustainability of cities. Biopolus cooperates with strategic partners for implementing these technologies and/or establishes agreements for licensing the technologies to local partners for use. Partnerships are formed with local architects, EPC companies, and general contractors for project completion. Biopolus provides the technology and the specialized know-how (engineering support) for successful implementation of the technology. Biopolus continues to develop its technologies based on consumer/ partnership feedback and the regularly changing needs of urban areas. This ensures on-going product development, resulting in the state-of-the-art solutions that clients are looking for unique circular value proposition.

Unique circular value proposition

Biopolus solutions are established around the concept of water-based urban circularity. Since water is the basis for all life, and a necessity for most major systems, Biopolus believes that urban circularity cannot be achieved without first creating a sustainable water cycle. That's why Biopolus' first circular technology came in the form of a modular, expandable water treatment system powered by its patented MNR technology. Currently, this is the main product line. However, Biopolus has also developed technologies for organic recovery and vertical farming, which are at various stages of roll-out.

The Biopolus approach is unique in that Biopolus developed and designed its circular solutions to fit inside a beautiful building, which Biopolus named the BioMakery. These buildings, thanks to smart architecture- can be placed in any environment.

The BioMakery is a model for decentralized wastewater treatment, to which varying technologies or circular modules can connect, in order to create value from waste. The BioMakery was created based upon the principle of water-based urban circularity, where energy, food, and waste systems are built around a regenerative and sustainable water cycle.

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The aim is to create a multi-level network of circular processes with extensive cross-connections.

The diagram below (Figure 22) illustrates the circular business model of a Biopolus BioMakery, with multilevel networks of circularity. The Biopolus Water Treatment is the MNR technology, while the Biorefinery is a process unit that can breakdown organic wastes to their basic components. These two processes are the primary (platform) technologies to which other supplemental processes and/or technologies can be added to create new nodes of circularity (production platforms- ex: Water Factory, Plant Factory, Protein Factory, etc.). These production platforms can produce valuable products.

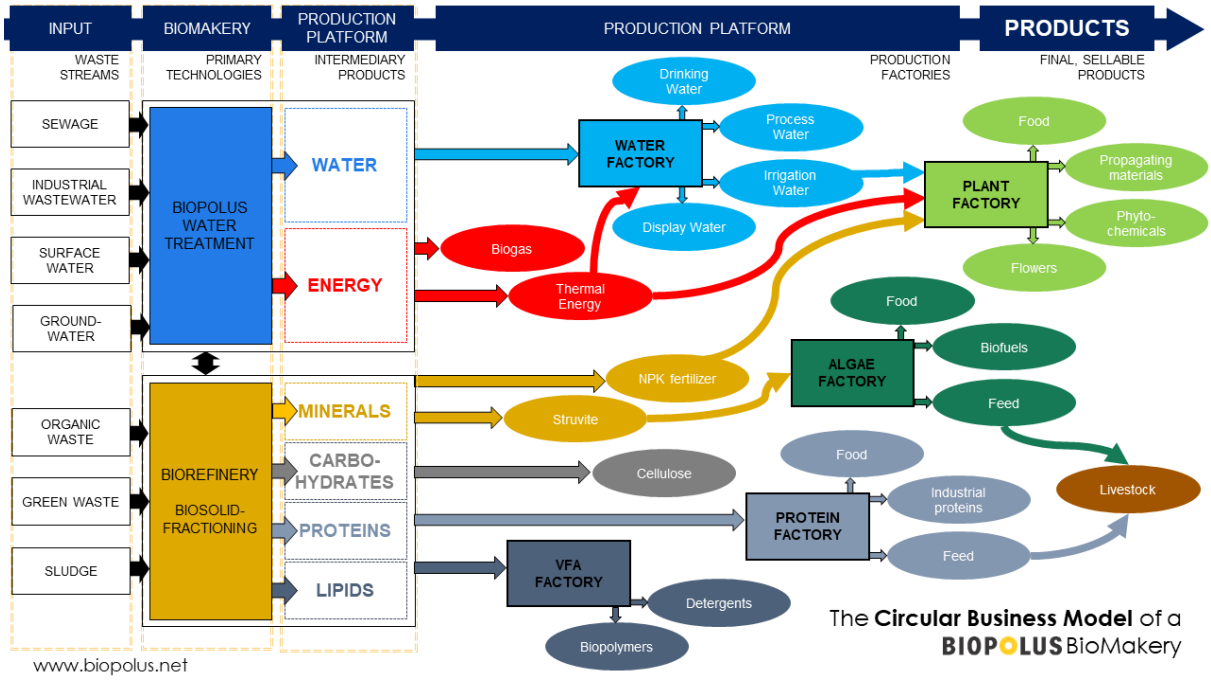

Figure 22: Circular business model of a Biopolus BioMakery

We are TECHNOLOGY PROVIDERS, serving clients through local partners and providing support throughout the project lifecycle. Our activities include:

1. FEASIBILITY: Concept Design
2. DESIGN: Process Design, Basic Mechanical & Electrical Design, Control & Instrumentation, Architectural Concept
3. CONSTRUCTION: Specialized Equipment (biofilm carriers, control & instrumentation, etc.)
4. STARTUP: Commissioning
5. OPERATION: Remote Supervision, Technology Support

Biopolus consists of URBAN PLANNERS SPECIALIZING IN METABOLIC MAPPING material and energy flows to provide assessment and insight on how to close the traditional linear urban cycle of consumption and waste.

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Communications and sales

Biopolus has worked to establish strategic partnerships to collaborate on various projects, on technological developments, and to gain access to different regions of the globe. Biopolus works with its partners to attract customers. They engage stakeholders at international conferences and are active in organizations such as the Ellen MacArthur Foundation. Biopolus strives for collaborative innovation and takes pride in mutual successes, which in turn leads to more project opportunities.

Biopolus cooperates with strategic partners for implementing these technologies and/or establishes agreements for licensing the technologies to local partners for use. Partnerships are formed with local architects, EPC companies, and general contractors for project completion. Biopolus provides the technology and the specialized know-how (engineering support) for successful implementation of the technology.

Biopolus technology and services are available throughout the globe, with the help of strategic partners.

Customer and stakeholders' relationships

Biopolus strives to maintain good relationships with clients, stakeholders, and partners throughout the entire length of a project: from the design phase to completion.

Revenue streams

Biopolus income stems from licensing technology to engineering services associated with the technology. Biopolus provides feasibility studies and consulting services. Biopolus is also involved in large-scale EU grants.

Need/Problem/Challenge

Non-resilient, wasteful cities, that are desperately looking for solutions to help tackle climate change and to find sustainable solutions for food and water. Biopolus intends to help solve this problem by closing urban metabolic loops through a system of decentralized hubs, using nature-based circular urban technologies.

Key resources

Biopolus uses human resources and technological solutions (which must be maintained and adapted) in order to solve the ever-changing problems cities, encounter. Clients need enough investment capital to finance activities.

Circular Value Chain

Main stakeholders include developers, industries, and municipalities, which use Biopolus technological solutions. In addition, residents benefit from the nature-based solutions, because they provide green spaces and promote health and well-being.

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Cost structure

Biopolus costs are generally associated with employment, technology development, and materials needed for manufacturing the technologies.

Foresight and Impact – Environmental

The environmental challenges expected in the coming years will provide Biopolus with an opportunity to expand its business and its outreach. As climate change and other environmental impacts continue to grow (draughts, floods, food scarcity and waste), new solutions are needed to address these problems. As natural resources become scarce, communities will be willing to invest more in order to create urban areas that are green and resilient.

Biopolus wastewater technology can treat water to reuse levels, creating a sustainable water cycle. Through organic recovery, products can be made from waste, reducing the load on landfills. Some of the products produced, such as fertilizer and compost can be used to help maintain urban green spaces. Biopolus urban farming technology can provide urban areas with a resilient method of crop production, available year-round in even the harshest climates.

Foresight and Impact – Social

All of the solutions described above, create more liveable and loveable cities. Nature-based solutions can be applied in areas where people live and work. The beauty of nature-based solutions will likely create citizen support, which push governments to more actively fund green/ circular practices.

Citizens will also directly benefit from lush green spaces in their city. With the longer, hotter, drier summers, green areas are more important than ever to reduce the urban heat island effect. Access to blue green urban spaces has positive effects on the mental and physical health of urban citizens and they also provide homes for wildlife.

Circular business model and innovation

The main circular strategy is **Cycling**. Natural resources such as water and organic wastes are treated for reuse. Natural resources needed for plant production (water & nutrients) are reduced in vertical farms. Wastes created during treatment and production are cycled back for further use.

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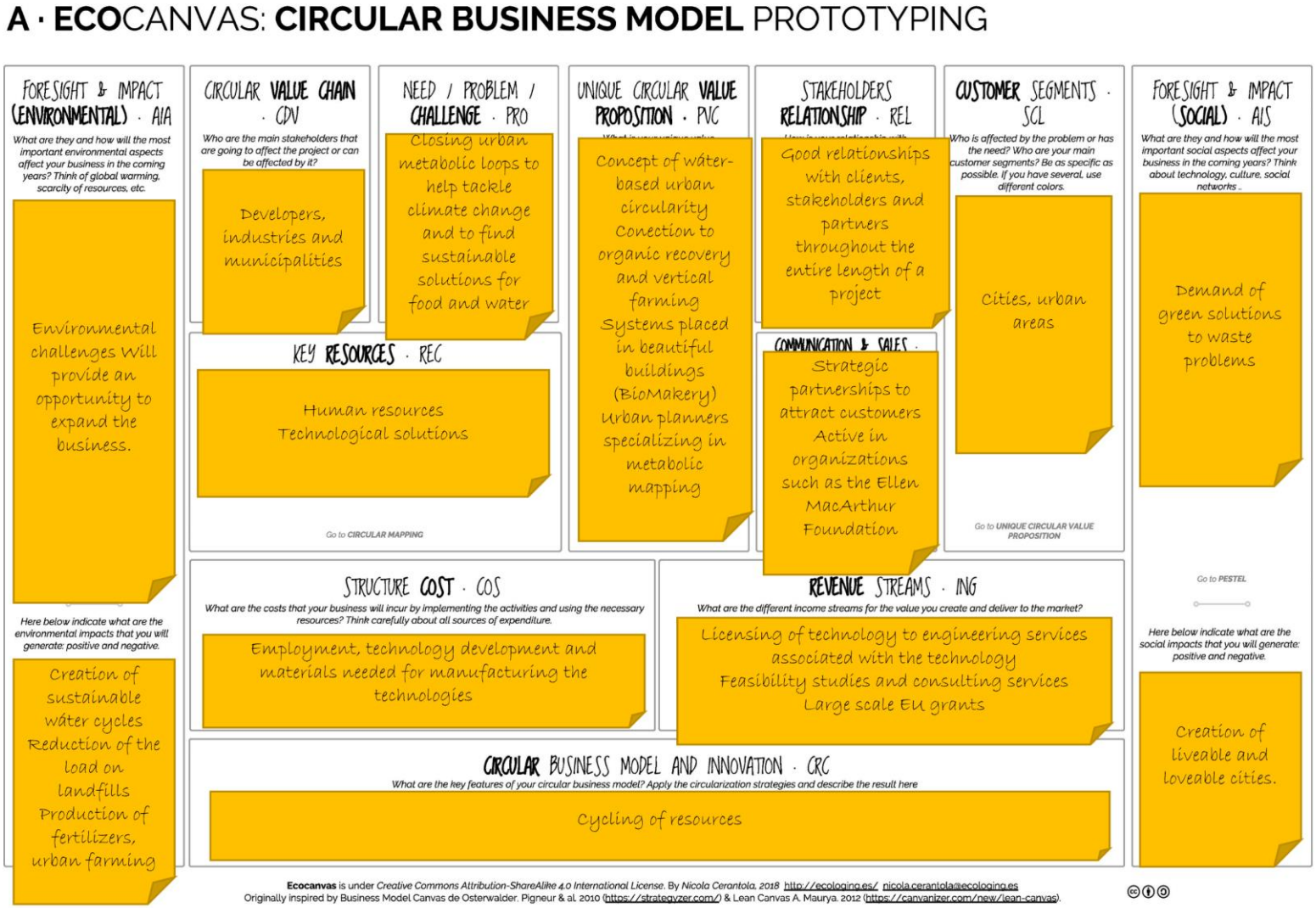

Figure 23: Ecocanvas Biopolus

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Technical aspects

Biopolus' main product is the MNR technology, a modular, expandable, wastewater treatment system based on microbial biofilm developed on the roots of aquatic plants. Besides, they have developed technologies for organic recovery and vertical farming.

Their main source of revenue is the license of the technology to engineering services associated with the technology. They develop feasibility studies and consulting services and are involved in large-scaled EU grants.

Their costs are related to employment, technology development and materials needed for manufacturing the technologies.

Table 49: Biopolus SWOT.

Strengths	Weaknesses
Nature-base solution clean and sustainable Allows the recovery of nutrients The technology is very beautiful and can be attractive from the marketing point of view for cities	The system can be unstable and is sensible to variation on the quality of the stream The system needs time to stabilize after a contamination episode
Opportunities	**Threats**
High interest of cities to develop water solutions with the features of the MNR technology	More stable systems available

Market aspects

The main need covered by this solution is a way of tackling climate change in non-resilient, wasteful cities and a sustainable solution for food and water through closing urban metabolic loops using decentralized hubs with nature-based circular urban technologies.

So, cities are their natural customers. In addition, Biopolus cooperates with local strategic partners such as architects, EPC companies, etc. for implementing the technologies locally.

Regarding the market trends, this solution has some advantages:

- Wastewater treatment from municipalities
- Nutrients recovery
- Circular systems
- Biogas production
- Low energy consumption

The main market barrier is the low experience and knowledge of municipalities about this kind of solutions, that can become a problem of confidence on its application.

Marketing aspects

The unique circular value proposition includes the offering of a decentralized wastewater treatment system to which varying technologies or circular modules can connect in order to

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create value from waste. This system can be the center of a circular business model with multilevel networks of circularity.

Regarding sales channels, Biopolus has created a strategic network of strategic partners that allow to offer their technologies and services throughout the globe.

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4.4.5. Chemitec

CHEMiTEC is a company active in Greece, Cyprus, Balkan Countries and others (mainly European countries), since 1996 in the following sectors:

- Industrial process water and wastewater treatment including transportation sector
- Municipal potable water and wastewater treatment
- Environmental technologies (air, water and solid waste)

CHEMiTEC supplies innovative technologies, combined with compliance with environmental standards.

Customer segments

CHEMiTEC's prospect customers are the Municipalities, Green & Environmental business units at Municipalities and communities, Municipalities with hot-dry weather and therefore low urban greenery (e.g., islands, beaches etc.) that with Sewer mining minimize the level of engagement of the main WWTP and also lower the transportation cost of treated clean water from the WWTP back to the city for watering. EYDAP (ΕΥΔΑΠ) stands for "Athens Water Supply and Sewerage Company" and is the largest water supply and sewage company in Greece. EYDAP is based in Athens and provides water supply and sewage services to the greater Athens area, including Piraeus and nearby municipalities. The company is owned by the Greek government and is responsible for the management and maintenance of the water supply and sewage infrastructure in the region, providing services to over 4 million people. EYDAP for example, could develop the combination of both sewer pipes of their own and MBR technology to sell irrigation water or industrial process water locally.

In addition, CHEMiTEC covers a wide range of clients:

- Power Stations (Ultra-Pure Water)
- Sea and airports, bus stations etc.
- Chemical and Refinery Industries
- Steel Mills and metal processing plants
- Food and beverage industry
- Cosmetics, detergents and pharmaceuticals
- Hotels and hospitals
- Green houses, animal and agricultural farms
- Technical – Constructing companies
- Municipalities, local authorities, etc.

with a high-quality back-up of leading specialist companies like KOCH, THERMO – SYSTEM, SONOTRONIC (spin off of TU-Hamburg), WEHRLE, ENTSORGA, UTS, ANAERGIA, GES, PROTECNO, EISENMANN, etc.

Unique circular value proposition.

They offer a sewer mining system to recover water and nutrients from the sewer pipe.

The company's products enable its clients to receive comprehensive responses, while complying with international quality standards and achieving economical optimization.

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CHEMiTEC supplies a wide range of consultation and client support services, in order to ensure high quality and professional application (supplier and/or subcontractor).

CHEMiTEC offers solutions, products and services for:

1. Membrane technologies for Reverse Osmosis, Ultrafiltration, Nanofiltration and Continuous Microfiltration systems using any kind of membranes (Hollow Fibre, tubular, plate – frame, disk – plate etc.) as well as EDI and EDR technologies. Large scale Desalination Plants for potable water production (from the sea).
2. Filters, softeners, demineralizers.
3. Activated Carbon, applications in water, wastewater and air processing systems, for purification, odour control and recycling material purposes.
4. Specialty chemicals for RO, cooling and steam systems made by us (CHEMiTEC).
5. Membrane based wastewater treatment plants (MBR) and tertiary treatment (UF-RO) of WWTP's effluent (Compact Systems).
6. Membrane based leachate of Landfill treatment plants (UF, MBR, RO etc.). (Compact Systems) – LTP (Leachate Treatment Plants).
7. Ultra sonar Applications in WWTP (USR) and biogas production (digesters).
8. MSW reclamation and compost production (Aerobic + Anaerobic compost) or Incinerator Technologies combined with Biodiesel production (Anaerobic digestion). MSW treatment plants (MBT) for SRF + RDF production. Continuous Compact Composting Units (CCCU) for several applications up to 5.000 tn/year (patent of our company with the NTUA-National Technical University of Athens).
9. Industrial Waste Recycling (In. Wa. Rec.) Technologies (water, milk whey etc.).
10. Ultra-Pure Water for electricity production and metal surface treatment with combination of RO units with Mixed Bed and/or EDI (up to 0,02 µS/cm).
11. WAS (Waste Activated Sludge) drying process (Belt drying, Paddle Drum Dryer, Combination of Belt Dryer with Cement Factories etc.).
12. WAS pyrolyze and gasification systems.
13. Manure and organic material decomposition – anaerobic digestion and production biogas for green
1. energy (Electricity, steam etc.) as well as Digestate Treatment Plants.
14. Purification of potable water by UF hollow fibres membranes instead of Gravity Sand Filters.
15. Sanitation of water by UV, ozone etc. systems.
16. Solar Dryers for organic materials like WAS, manure, etc. up to 92% DS.

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17. ZLD (Zero Liquid Discharge) for LTP (Leachate Treatment Plant) with a combination of MBR-RO LP/RO HP – Evaporator(s) etc. to recycling 95-99% of influent w.w.

Communications and sales

CHEMiTEC has a strong network that helps finding clients and new projects.

Creation of partners through joint ventures, for example EYDAP/CHEMiTEC with the objective to use the EYDAP network, which attract great consumers of water (industrial or green end use) and construct sewer mining units where water would eventually be sold (+ operation personnel, service and maintenance, etc.)

There is also a sector named Total Water Management where it can supply by drinking water to hotels and small communities, camps etc using membrane technology to treat wastewater for secondary uses like toilet flushing, irrigation, and car cleaning and by second recycling (black and grey wastewater) to produce water for disposal.

Customer and stakeholder's relationships

CHEMiTEC co-operates with big Technical and Construction Companies in Greek Market like:

AKTOR, HELECTOR, MESOGEOS, THALIS, SETE TECHNICAL, ENVITEC, MYTILINAIOS, ITA, M+T, TECHNIKI PERIVALLONTOS, TERNA ENERGY, AVAX, MYBA, CONSTANTINIDIS, INTRAKAT, DEVICE, etc. as Consultant, Technology Provider, sub-contractor or supplier in the sector of Water Treatment Plants and Environmental Technologies in big public or private projects.

The company also cooperate with R+D centers like NTUA (National University of Athens), European University of Cyprus (Nicosia), TEPAK (Limassol), Chemical Engineering Faculty of University of Patras etc. to develop pilot units for different applications of European R+D projects with EU funding and supporting.

Revenue streams

Technology and consultancy services. Development of European R&D projects.

Need/Problem/Challenge

The Sewer mining systems provides a solution to the scarcity of water, giving a second chance to water and nutrient from raw wastewater from the sewer pipe.

Key resources

The key resources in this case are the technologies involved and the human resources.

Circular Value Chain

The main stakeholder in this sense are the Municipalities that gives access to the sewage water. The water is then sold as irrigation water of industries and the biosludge can be converted into among others compost and soil enricher, etc.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541

Cost structure

CHEMiTEC manages to maintain the process cost more economical than the purchase price of primary water, but in many cases where water scarcity is an issue, the cost is high and therefore not comparable. The basic benefit is that you don't transfer water from other sources that deplete the physical water supply and also don't deplete the groundwater with artesian wells. An artesian well is a type of well in which water is able to flow to the surface without the need for pumping. This is because the water in the well is under enough pressure to push it up to the surface. The pressure comes from the water being confined in a confined aquifer, which is a water-bearing rock layer that is sealed by overlying layers of rock. When a well is drilled into this confined aquifer, the water is able to flow up and out of the well, creating an artesian spring or flow. This type of well is often used for irrigation, drinking water, and other domestic and industrial uses.

Moreover, the process through biological stage allows the processed water not to eliminate phosphoric, nitrates, nitrides, sulphates etc., providing to the soil except moisture, "organic" fertilization without the use of chemicals.

Therefore, we achieve faster flourishment and plants growth without hypertrophy of P or N to the soil and avoiding fertilizer cost. The processed "clean" water is channelled on the spot to cover the needs of irrigation without creating additional transportation and usage cost.

Foresight and impact – Environmental.

The municipality of Athens has extensively developed plant nurseries and parks. Both of them consume drinking water or brackish water (drill) for irrigation and also fertilizers for the plants' growth as well as maintenance for urban green.

CHEMiTEC manages to maintain the process cost more economical than the purchase price of primary water, but in many cases where water scarcity is an issue, the cost is high and therefore not comparable. The basic benefit is that you don't transfer water from other sources that deplete the physical water supply and also don't deplete the groundwater with artesian wells. An artesian well is a type of well in which water is able to flow to the surface without the need for pumping. This is because the water in the well is under enough pressure to push it up to the surface. The pressure comes from the water being confined in a confined aquifer, which is a water-bearing rock layer that is sealed by overlying layers of rock. When a well is drilled into this confined aquifer, the water is able to flow up and out of the well, creating an artesian spring or flow. This type of well is often used for irrigation, drinking water, and other domestic and industrial uses.

In contrast, during the winter months (October – March) where the demand of water is limited, the excess produced clean water is poured in a lake where with controlled soil absorption enriches the groundwater with positive results, or you don't mine wastewater for treatment.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541

Based on the above concept, the whole process is included in the circular economy framework and has the capabilities to further expand the usage of the process byproducts like the biosludge that can be converted into compost, soil enricher etc.

Foresight and impact – Environmental.

Construction of local urban parks with environmental importance for the local society, schools etc. and creation of microclimates with flora and fauna due to lake waters and wetland parameters of development, as well as poultry habitats (ducks, flamingos, swans, sea gulls, etc.), small forests and artificial lakes with gardens, green and animals, birds, etc.

Circular business model and innovation.

The main circular strategy is **Cycling**. Sewer mining is used to recover water and nutrients used to support and create green environments.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541

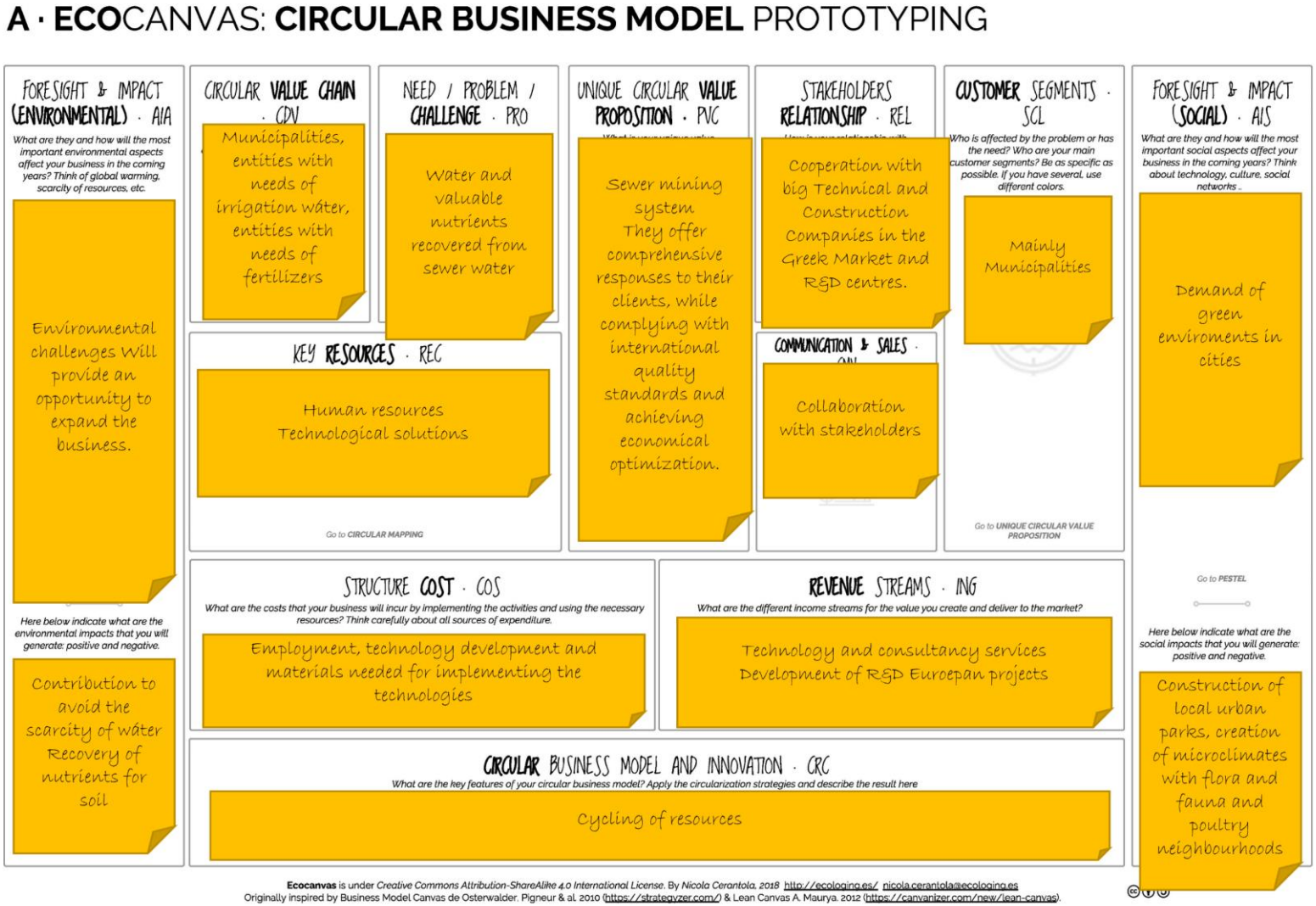

Figure 24: Ecocanvas CHEMiTEC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541

Technical aspects

Chemitec offers both products and services. Their products are several technologies related to water treatment and sewer mining to recover water and nutrients from the sewer pipe. The company supplies as well a wide range of consultation and client support services, in order to ensure high quality and professional application.

Their main source of revenue comes from the products and services mentioned above and from the participation in European R&D projects. Their costs are related to the implementation of the technologies.

Table 20: Chemitec SWOT.

Strengths	**Weaknesses**
Sewer mining is a new way of nutrient recovery that still have little competition. Their solution is implemented in such a way that decreases (or even avoid) the use of groundwater. Technologies and services contributing to improve the environmental impact of wastewater in cities.	The system's costs depends on the specific conditions and may be too high in some cases.
Opportunities	**Threats**
Innovative solution at international level for nutrient recovery.	Regulations sometimes can limit the use of the treated water and the recovered nutrients.

Market aspects

The solution offered by Chemitec helps solving the need of water and nutrients through sewer mining, giving a second chance to those recovered from raw wastewater from the sewer pipe.

Their customers are private or public companies of the sector of water treatment plants and environmental technologies. Their strategic partners are big Technical and Construction Companies and R&D centres.

Their solution is aligned with the following market trends:

- Improvements of wastewater treatment from municipalities
- Nutrients recovery
- Water reuse
- Circular systems

Marketing aspects

The unique circular value proposition is the comprehensive response they offer to their clients about wastewater treatment and nutrients recovery, while complying with international quality standards and achieving economical optimization.

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Regarding sales channels, Chemitec has a strong network that helps finding clients and new projects. They develop many European projects in collaboration with their R&D partners to test pilot units for different applications and improve their technologies.

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4.4.6. Aquatim

AQUATIM SA is a company that is involved in wastewater treatment and management. The pilot implementation of a new technology or process, possibly related to energy production or biochar production, is currently delayed due to the COVID-19 pandemic. Once the pilot is installed, the company will have the opportunity to explore new business models, such as reusing the energy produced inside the wastewater treatment plant (WWTP), selling the biochar, or making a contract for testing it. The company may also explore the possibility of implementing a circular economy loop in the future, using new technologies. Additionally, AQUATIM SA may also consider the possibility of reusing wastewater within the WWTP Timișoara and potentially for third parties in the future.

Customer segments

Table 21: Aquatim customer segment

Primary customers segment	Secondary customers segment
• Landscape gardening companies Timișoara • Industrial platforms within the city • Municipal companies (streets cleaning, irrigation of green areas, waste collection)	• Academia and R&D sector from Timiș county • Schools • Municipalities and local administrations in rural areas (where AQUATIM offers services) • Agricultural (crop and berries) companies around municipalities within county

Unique circular value proposition

Table 22: Aquatim unique circular value proposition

Value proposition	Description
Biological wastewater treatment	The wastewater resulted is safe for reuse in application that has no contact with human food, drink, etc. An initial step could be to reuse it for the cleaning of the WWTP Timișoara and later to test the reuse by other customers in the city
Less environmental impact	By using a technology to transform the dried sludge into a consumable product the environmental impact due to sludge disposal elimination will be reduced
Sustainability	The aim is to achieve a sustainable use of water, energy and chemicals. The investments done for the WWTP Timișoara modernisation have considerably reduced the impact on the aquatic environment. The sustainable use of the sludge resulted from

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	the WWTP will improve the circularity and also strengthen the business case change into circular economy
Creates revenue	The investment in the sludge management will benefit of EU funds support that will ease the financial effort that AQUATIM SA has to make (with current networks expansions) and also will bring potential benefits by reduction of the energy bill or from biochar sells.

Communications and sales

The Aquademica Foundation and AQUATIM SA use their 'Aqua News' portal 56 and social media platforms to attract customers and engage with stakeholders. They also use water-related events, such as the Danube, as opportunities to conduct educational activities with schools. Additionally, they have upgraded an old industrial water unit in the city to serve as a lab for children.

Customer and stakeholders relationships

Table 23: Aquatim customer and stakeholders relationships

Customer relationships	Description
Customer consultancy services	The current relationships with customers are only connected with the water supply and wastewater networks. In the future it should maybe give also advice about freshwater consumption reduction and rain harvesting and efficient home use.
Trainings and knowledge sharing	Through Aquademica Foundation there are organized specialized trainings and knowledge sharing events for the water specialists and experts as well as for interested citizens
Maintenance and communication	Through the maintenance of water supply and wastewater management systems and communication activities about various issues (e.g. pipe broken).
Circular economy for the sludge (biochar, energy) and Urban Meadow Bega project	By implementing the pilot project within the NextGen Water project as well as the large project for the sludge management the reduction of environmental footprint will have benefit for the environment. Obtaining an official protection for the water intake for Timișoara area will bring benefits to biodiversity and environment

[56] https://aquastiri.ro/

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Revenue streams

Table 24: Aquatim Revenue streams

Revenue streams	Description
Direct sale	The main revenue stream for the company would be selling directly biochar and wastewater (in addition to the current revenues, somehow limited)
Operational costs	The use of energy from sludge for the WWTP operation will reduce the expenses of the company – no landfill tax and lower energy consumption from the grid.
Consultancy services /EU projects	AQUATIM SA could provide consultancy services to other water companies and industry and could participate in other National or EU funded projects. Also, the services can be offered to other local industries, in an effort to create an efficient water consumption.

Need/Problem/Challenge

Table 25: Aquatim Need/Problem/Challenge

Customer segment	Customer problem/needs
Industry	Technical: WWTP Timișoara is located downstream while the industrial platforms are upstream. To pump the wastewater back in the city might make it more expensive than the fresh one and in historical cities as Timișoara it might be a challenge to install underground or surface pipes. A potential relocation might be taken into consideration, in case of operational efficiency process. Funding: Although there are sources for project application, the AQUATIM SA does not have the capacity to apply and run such projects. Cooperation: Local partnerships and cooperation on projects between Timișoara stakeholders is limited for the moment. Legislative: current water legislation in Romania should comply with European (more flexible and business oriented) legislation.
Landscape gardening and agricultural companies	There is little experience in Romania with the use of biochar. There are few importers of biochar for agriculture sector. There is no water re-use project known at the Timișoara level of cooperation.
Research institutes	Cooperation between R&D organizations and Water utilities is considered weak. The start of cooperations with local /national

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	organizations in their field of expertise is necessary.
Municipalities and local administration in the rural area	Investments for development or rehabilitation of water supply and wastewater management systems should bring lower operational costs as well as resilient and circular water systems. For the moment, the client base in rural areas is slowly increasing. Policy regulation should be satisfactory in terms of beneficial for both water sector and clients (used to be supplied by unsecured water wells).

Key resources

The key resources needed to operate are:

- Financial stability (no debts)
- Pyrolysis equipment for the pilot implementation and testing
- Human resources trained to use new systems

Circular Value Chain

The new potential value chain for WWTP Timișoara is shown below:

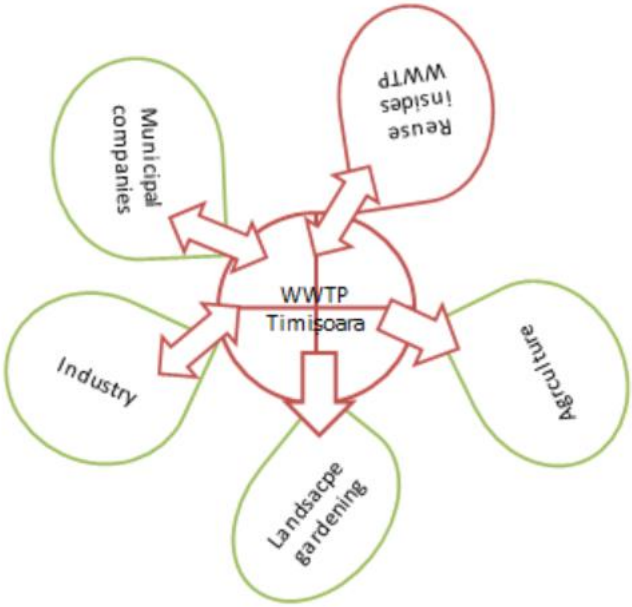

Figure 25: Potential new value chains for WWTP Timisoara. The assumptions made are based on planned pilot implementation - that should generate biochar to be sold to landscape gardening and agricultural companies and energy to be reused inside WWTP.

Cost structure

The costs for the above business case depend on the pilot installation and monitoring of needed operational costs, human resources, energy as well as of the marketable quality of by-products obtained through pyrolysis. The current business model is based on operational costs

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for the water supply and wastewater treatment to achieve the NTPA 0002 (the national standard for wastewater discharge in a surface water body) and dewater and dehydration of the sludge for disposal in the landfill. The new business model that should be implemented in the next period will change the sludge management bringing a circular loop in the system. It is difficult to estimate now the cost structure as operational costs in the local conditions will play an important part and without testing it with the pilot estimations could be wrong. AQUATIM SA has launched a tender for the energetic valorisation of the sludge for Timișoara WWTP. The estimated budget is approximate 9,4 mil Euro but one important selection criteria will be based on the lowest operational costs (which in conjunction with limited knowledge about technology might be very risky situation).

For the moment, being in the incipient phase of the pilot, the cost structure is to be defined.

Foresight and Impact – Environmental

The environmental impact of sludge management has a positive impact on the environment as it eliminates the sludge disposal in a landfill. Of course, the energy consumption and emissions during sludge new treatment will play an important role in estimating the total environmental footprint. In 2020 the WWTP Timișoara had a consumption of 10,5 mil. kW/h and the expectations are that the energetic use of the sludge will lower the total energy consumption therefore a lower emissions percentage. For the future, if there will be a wastewater reuse system in place the impact on freshwater intake will be also reduced. Circular water economy is a new concept, at least for Romania, but projects as NexGen Water bring into focus the subject and generate useful debates about that contribute to a faster adaptation of new concepts.

Foresight and Impact – Social

From the social point of view, circular water systems contribute to environment protection and less resources used in the process. To implement circular solutions there are needed specialists to operate new equipment and technologies, experts to evaluate the energy, water and emission footprint, expert to evaluate the impact of wastewater reuse in agriculture, the use of biochar, etc.

The social implications (children in schools, local CoP, etc.) will create a long-term framework collaboration.

The increasing water quality using new technologies will have a positive impact in diminishing the health county costs (including mental diseases by small nature-based solutions projects using by products from circular economy water applications al local level).

Circular business model and innovation

The pilot to be implemented at AQUATIM SA WWTP Timișoara in the NextGen Water project will treat the sludge with an innovative technology that through pyrolysis will transform the dried sludge into biochar, oil and gas, products that could be sold on regional market or

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reused. If the pilot will be implemented in the next period, the pilot monitoring data could be used for evaluation criteria in the ongoing tender for sludge management for the WWTP Timișoara. The strategy behind this tender is to valorise the sludge for energy production and to eliminate the sludge disposal in the landfill. The energy produced could be used for the WWTP operations therefore a circular loop will be setup. For the future, this technology or the pilot technology could be implemented for the WWTPs around the county and for other water companies in Romania changing the current business-as-usual model to a circular economy one. The circular business model could bring benefits to the water companies by reducing their environmental footprint and reduce their emissions with benefits for the environment and people.

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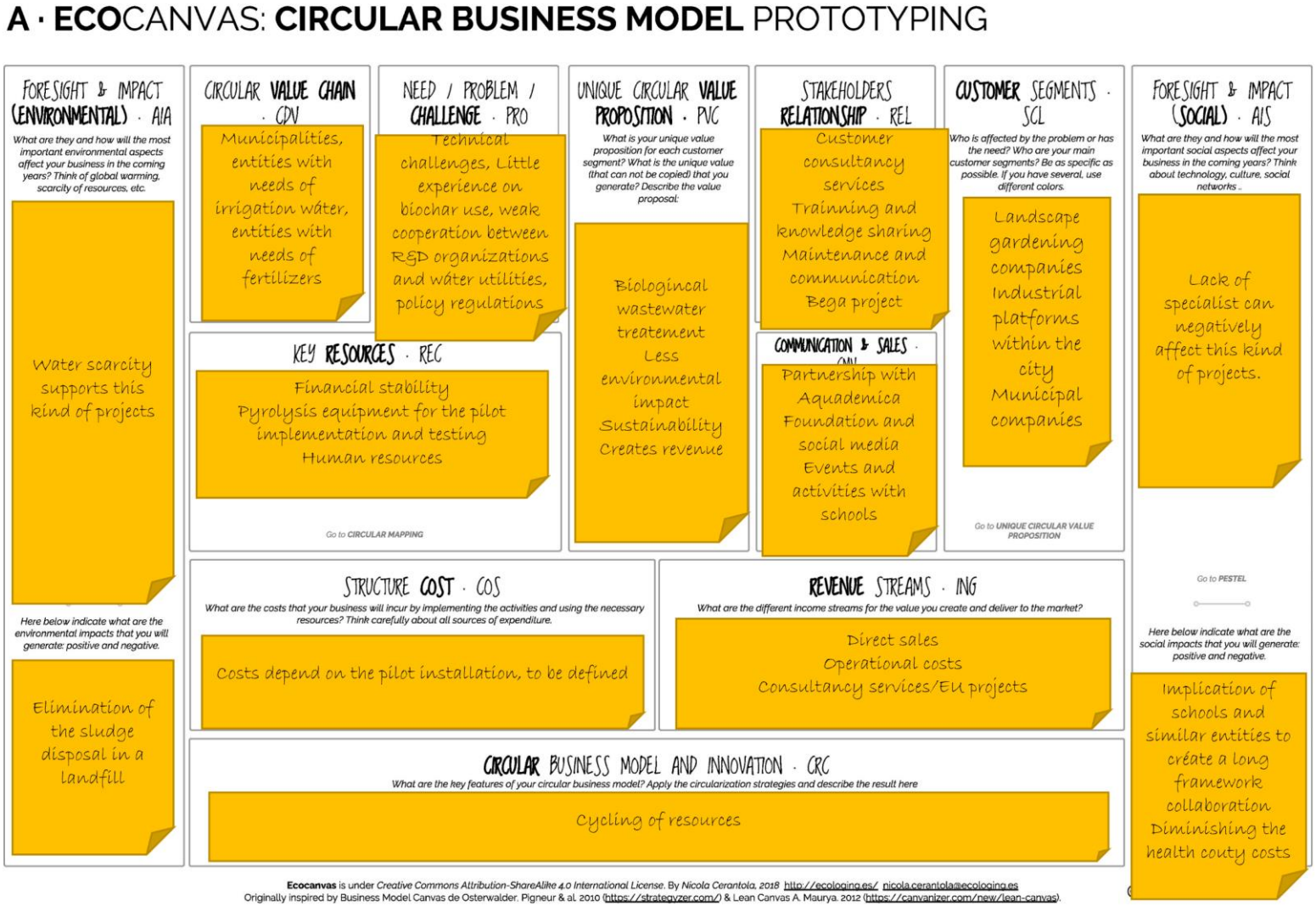

Figure 26: Ecocanvas Aquatim

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Technical aspects

Aquatim is waiting for the pilot implementation, so their business model has not been explored on practice yet. Their product is a system that allows the transformation of sludge from wastewater treatment to biochar to be used to produce energy.

Their main revenue stream will be selling the biochar. Besides, the use of energy from the WWTP will reduce the expenses of the company. They could provide consultancy services for other water companies and industry and take part in national or EU projects to improve their technology.

Costs will depend on the pilot installation and monitoring of needed operational costs, human resources, energy as well as of the marketable quality of byproducts obtained through pyrolysis.

Table 26: Aquatim SWOT

Strengths	Weaknesses
Offers a solution for the sludge that usually must be disposed against a cost. Provides a way of producing energy that can increase the circularity of the involved entities	The business model is still not tested. Costs are highly dependent on the conditions.
Opportunities	**Threats**
Innovative solution at international level for sludge treatment and energy production.	Low interest from industry due to high costs. Different regulations in different countries related to water treatment.

Market aspects

They offer a solution to the problem of sludge disposal. Besides, contributes to a decrease of energy need thanks to the production of biochar.

As primary customers they highlight municipal water treatment companies, industrial platforms and landscape gardening companies. As secondary customer segments

Their solution is aligned with the following market trends:

- Improvements of wastewater treatment from municipalities
- Water reuse
- Circular systems
- Changes on water treatment management systems
- Decrease on the sludge to be treated
- Energy production

Marketing aspects

Their unique circular value proposition is related to reducing the environmental impact of water treatment systems thanks to the reduction of the sludge disposal elimination. The final goal is to achieve a sustainable use of water, energy and chemicals.

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Regarding sales channels, Aquatim will be supported by Aquademica Foundation and social media platforms to attract customers and engage with stakeholders. They will relate to them through:

- Customer consultancy services
- Training and knowledge sharing
- Maintenance and communication

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4.4.7. Adasa

ADASA is a global leader in water, environmental and weather technologies with over 30 years of experience. They offer specialized knowledge and sustainable, end-to-end solutions to help public and private organizations around the world solve the demands of integrated water resources management, urban water systems and water-related natural disasters. They use advanced information and communications technologies, water sciences and real-time water sensors to build and set up systems that improve decision-making, enhance efficiency and process effectiveness, and reduce risk. ADASA offers data-driven insights into the quality and quantity of water in both natural and artificial environments, allowing water authorities and water system operators to handle their processes more efficiently and comply with environmental policies.

Customer segments

Managing large water infrastructures is a complex task that requires careful planning and management to ensure that water demand is consistently met. The infrastructure must be able to function reliably and efficiently, with minimal disruptions or breakdowns. This often involves balancing multiple competing priorities, such as water supply, distribution, treatment, and storage, while also taking into account factors such as population growth, climate change, and environmental sustainability. Additionally, the infrastructure must be maintained and upgraded over time to ensure its continued operation and to meet changing water demand.

HydrOptim is a decision support tool that helps optimize the operation of hydraulic systems, with a focus on energy efficiency, cost minimization, and improved operational performance. It can be applied to a wide range of hydrologic and hydraulic systems, including bulk water conveyance infrastructures, regulated river basins, drinking water networks, sewage systems, and irrigation systems. The target market for HydrOptim's commercial activities are water utilities, water authorities, and irrigation communities, as these organizations are responsible for the management and operation of large-scale water infrastructure. By using HydrOptim, these organizations can make more informed decisions about how to operate their systems, resulting in cost savings, improved energy efficiency, and better overall performance.

Unique circular value proposition

For the Off-line mode, the advantage is an enhanced decision making, based on simulations of different scenarios:

- Infrastructure
- Investment
- Water shortage
- Breakdowns/works
- Energy contracts
- Etc.

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For the Online model, the advantage is an Optimal strategy for the operation of the system for the next period

Hydroptim includes not only the energy cost of the different elements, but also the environmental cost of each one. Once defined the hydraulic network and the scenario, the application finds and optimal solutions that minimizes the total cost of the operation system, considering the energy costs and the environmental cost.

In the off-line mode, this helps to improve the decision-making process, because thanks to the comparation of different options of Infrastructure investment, Water shortage, Breakdowns/works, Energy contracts, Etc.

An in the on-line mode, Hydroptim looks for an optimal strategy for the operation of the system minimizing cost, but accomplishing the defined constrains, for the next period.

HydrOptim is a key decision support tool for the optimization of the operation of hydraulic systems, whose market driver is the growing concern about energy efficiency, energy cost and operational costs minimization in the water sector.

Hydroptim is a software tool for optimizing hydraulic networks. It offers different services such as consultancy services, where it is used internally by a company to provide services to clients, SaaS where access to the tool is provided through a subscription fee, and turnkey projects that include system deployment, network modeling, real-time data assimilation, reprogramming remote controllers, SCADA, and maintenance contracts.

Communications and sales

In Consultancy services and turnkey project, relation with costumers is initially presential by meetings or visits, and afterwards can be complemented by on-line meetings and tools.

In Subscription fees, relation is through on-line platforms, both for sales and for after sales service (help desk, troubleshooting, …)

Also, for both, some additional channels will be used

- Success cases, Webinars, seminars, brochures, adds in specialised magazines.
- Through participation in national and international associations.
- Through participation in national and international projects.

Customer and stakeholders' relationships

The 3 revenue streams defined for the service are: Consultancy services, Subscription fees, and Turnkey projects. Consultancy services involve a visit to the client to analyze their needs and provide a commercial offer for the project. Subscription fees are collected through online purchases and provide access to the platform through a user and password. The subscription fee can be for individuals or organizations. Turnkey projects also involve a visit to the client to analyze their needs and provide a commercial offer for the project. The service will be provided online through a web portal where the Hydroptim application can be accessed with a user and password.

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Revenue streams

There are 3 revenue streams defined:

- Consultancy services. Hydroptim is used as a tool for the service of consultancy to clients that want and study of their network.
- Subscription fees. The client pays a monthly fee to access the tool. In this case, also on-line attention can be provided.
- Turnkey projects. In this case, mainly for on-line system, in addition to the Hydroptim tool, other parts of the project are
    - System deployment and network modelling
    - Real time data assimilation
    - Reprogramming remote controllers and SCADA
    - Maintenance contracts for in-house systems

Need/Problem/Challenge

Now a days, there is a complex management of the whole water-use production chain because of the different elements to consider

- There is a lack of overall view of all the elements in a water cycle where decisions are distributed among different organizations. So, the best solution for one organization may not be the best for the whole chain.
- Also, it is difficult to essay alternatives with the existing infrastructures to evaluate the results of them, so there is a poor decision-making process.
- And finally, the increase of energy prices and water scarcity needs an efficiency and resilience selection of the alternatives of operation.

Key resources

The main human resources needed to operate are

- Technical persons for support in the definition of the networks and scenarios, and interpretation of the results.
- Technical persons for maintenance and upgrade of the application.
- Commercial staff.

The main materials resources needed to operate are:

- Servers with internet access for the application.

There is a positive relation with the natural capital, as we are a water sector company, and we try to optimize the cost and usage of the water.

Circular Value Chain

The main stakeholders that are going to affect the project are:

- Electrical companies, that define de energy cost

The main stakeholders that can be affected by the project are:

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- End users of the water system, as the system will try cover all the constrains defined at the minimum cost, so it will ensure the availability of the resource.
- The managers of large water infrastructures, as the Hydroptim will help them to improve the service and cost of the system

Cost structure

The main costs are

- Server rental.
- Software licences.
- Human resources (technical, maintenance, commercial)
- Marketing

Foresight and Impact – Environmental

The most important environmental aspects that will affect the business in the coming years are:

- Water scarcity due to climate change.
- Increase of energy costs due to scarcity of resources.
- Public interest in environmental care and circular economy.

All these aspects will affect mainly in a positive way, because will reinforce the need from clients of this optimization tool and services associated to it

Foresight and Impact – Social

The most important social aspects that will affect the business in the coming years are:

- Public availability of water at an affordable price, that Hydroptim may help to get.

All these aspects will affect mainly in a positive way, because will reinforce the need from clients of this optimization tool and services associated to it.

Circular business model and innovation

The main circular business model is Cycling, as the objective of the system is to improve the recycling of the water as much as possible.

Extending is the secondary circular business model, as the objective of the system is to maintain water in the cycle as much as possible.

As the product / service is software and in SaaS model, it is already Dematerialized.

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Figure 27: Ecocanvas Adasa

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°776541

Technical aspects

Adasa offers data-driven insights into the quality and quantity of water in both natural and artificial environments. Thanks to their systems, water authorities and water system operators can handle their processes more efficiently, react quickly to mitigate negative impacts and comply with environmental policies.

They have three main revenue streams:

- Consultancy services
- Subscriptions fees
- Turnkey projects

Their costs are related to the services they offer: server rental, software licenses, human resources and marketing.

Table 27: Adasa SWOT

Strengths	Weaknesses
Long experience offering specialized knowledge through a wide range of sustainable, end-to-end solutions. Customizable digital tool (HydrOptim) already developed to offer their services, both online and offline.	The experience already developed make the system very robust, there are not big weaknesses to highlight.
Opportunities	**Threats**
Increasing demand for digital tools to manage complex water systems.	Competition from other companies with lower fees.

Market aspects

Nowadays, there is a complex management of the whole water-use production chain because of the different elements to consider. Adasa offers a solution to the problem of managing large water infrastructures in both natural and artificial environments.

The target organizations for the commercial activities are water utilities, water authorities and irrigation communities.

Their solution is aligned with the following market trends:

- Improvements of wastewater treatment from municipalities
- Water reuse
- Circular systems
- Changes on water treatment management systems

Marketing aspects

The unique circular value proposition in the offline mode is that the offer an enhanced decision making based on simulations of different scenarios (infrastructure, investment, water shortage…). For the online model, the advantage is an optimal strategy for the operation of the system for the next period.

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Regarding sales channels, they combine visits to clients to analyze their needs and online purchase of subscription fees.

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4.4.8. Alpha Wassertechnik AG

The company was founded in 1928 as Alpha AG in Nidau.

In 1960, the company, which had been active mainly in the field of hydraulic equipment, entered the field of wastewater treatment.

For this purpose, Alpha Umwelttechnik AG (Alpha UT) was founded as the result of a management buyout. Alpha UT develops rapidly and signs several cooperation partnerships, including one with OTV, which leads to the first biofiltration project in 1995.

In 2002, Alpha UT became part of a large foreign group that bought the company outright in 2005. This acquisition enabled the company to diversify its activities with the first drinking water production facility in 2008.

In 2011, following the withdrawal of the foreign group from Switzerland, Alpha WasserTechnik AG (Alpha WT) was created to take over the activities of Alpha UT.

Today, Alpha WT is a Swiss company belonging to the Membratec Group, which still has its historical headquarters in Nidau, and is active in the fields of wastewater, industrial and process water treatment.

Customer segments

Alpha offers their solution (WWTP customized to client needs) mainly to municipalities (95%), although their systems are used as well to treat industrial water from the food sector (5%). This solution is not offered in a direct way, but through an engineer desk that manages all the needed companies to make the WWTP work (Alpha just provide the equipment to be used on the WWTP).

Unique circular value proposition

Alpha plan WWTP plants from the beginning to the end adapting it to the client's necessities in terms of size and technologies. They have engineers that can dimension the plants and they are able to build and commission it. After the WWTP is done they keep the touch with clients to provide support.

Their unique value proposition includes not only the treatment of the water. The WWTP includes a digester as well to obtain biogas from the sludge that can be used on plant to produce electricity and/or heat or to be injected in the gas pipeline of a city.

In addition, their plants include a system to recover nutrients from the sludge that can be used or sold by their owners.

Communications and sales

Clients (municipalities) first reach an engineer company that develops the concept of the WWPT. Afterwards, the engineer company asks Alpha and other companies to write the details about the system. Then, they go through a selection process where the better solution is selected.

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Customer and stakeholders relationships

There are two of them:

Stakeholder (engineer company): The engineer desk is the first step before reaching their clients. They design the first concept of the WWTP and afterwards cocreate the final solution. Once the project has started, the engineer company controls the developing of the installation and the integration of the work of the different companies involved (equipment, construction…)

Customer (Municipalities): Once their project is selected, they present to the municipality the solution agreed with the engineer company and adjust it if it's necessary. In addition, they train the municipality's technicians how to manage it. When the WWTP is running, they keep in touch, make adjustments and give support. They try to make the entity feel as part of the designing.

Revenue streams

Mainly by the contracts that they get to make the projects for the municipalities. They get some income as well from the aftersales (replacements or reparations).

Need/Problem/Challenge

They treat municipal wastewater to make it suitable to go back to rivers, lakes… making the quality of the treated water high enough to do that.

Besides, they offer a circular solution for the sludge produced on the WWTP, obtaining value from it instead of disposing it into the landfill:

On one hand, they dewater the sludge to recover ammonium to make fertilizer. The clients can use this fertilizer to be sold or whatever they want, they are in charge.

On the other, they obtain biogas from the sludge that can be used to produce energy.

Key resources

Their key resources are the human resources and the know how to design the customized WWTPs.

Circular Value Chain

Mainly the Engineer desk and municipalities. As well equipment providers that provide them the materials to build the systems.

Cost structure

Human resources, IT that support the designing phase and equipment needed to build the plants.

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Foresight and Impact – Environmental

Scarcity of water is crucial to them because they treat water. To try to reduce the impact of WWTP to the environment, they try to make those plants producers of energy and nutrients (ammonium and phosphorus, as a new line), having a positive environmental impact.

Foresight and Impact – Social

Regarding the social impact, expectation of the population about water and water quality, depends on the water scarcity. If awareness on environmental issues increases on society, their solution will be more demanded.

Besides, digitalization has changed the way they work and as well have improved information systems to make a plant.

Circular business model and innovation

Cycling is the main one, while they produce clean water and recover energy and nutrients, keeping materials in the loops for a longer time.

Extending is there as well, since they provide support to the plants after their installation for at least 15 years, using high quality equipment to get that.

Finally, dematerialising has a role as well, since they try to use digital systems to reduce as much as possible the use of paper.

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Figure 28: Ecocanvas Alpha

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Technical aspects

Alpha's solution is the design of WWTPS customized to client needs. Their systems are used both to treat municipal water (95%) and industrial water from the food sector (5%).

Their revenues come from the contracts they get to make the projects and some incomes from the aftersales (replacements or reparations). Main costs are human resources, IT that supports the designing phase and equipment needed to build the plants.

Table 28: Adasa SWOT

Strengths	Weaknesses
Development of customized solutions for private and public entities regarding water treatment. They keep the contact with their clients once the installations are done, what creates a source of funding afterwards	Dependency to many stakeholders: engineer company that makes the first contact with municipalities; and municipalities to finalize the designs.
Opportunities	**Threats**
Increase on the demand of water treatment plants all over Europe	Different ways of addressing public procurements on different countries

Market aspects

They offer a solution for municipal wastewater, treating it to a quality high enough to go back to rivers, lakes… Besides, their designs include sludge treatment units that reduces the amount of it that ends up in the landfill.

As mentioned before, they have two kinds of customers: municipalities and food sector industries. Their main stakeholders are:

- Engineer companies that design the first WWTP concept with the municipality and afterwards cocreate the final solution.
- Municipalities: they adjust the design with them before finalizing it and train those how will maintain the WWTP when the facility is finished.

Their solution is aligned with the following market trends:

- Improvements of wastewater treatment from municipalities
- Water reuse
- Circular systems
- Changes on water treatment management systems
- Decrease of sludge disposal
- Improvements on energy consumption.

Marketing aspects

The unique circular value proposition is the adaptation of the WWTP to the client's necessities in terms of size and technology and the inclusion of a digester to obtain biogas from the sludge that can be used on plant to produce electricity and/or heat or to be injected in the gas

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pipeline of a city. Their plants include as well a system to recover nutrients from the sludge that can be used by their owners.

Their sales channel starts with the engineering company that reaches the municipality and develops the first concept of the WWTP. Alpha is then asked together with other companies to write the de

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4.4.9. NETICS

NETICS is a network-centric organisation, focused on research and business development in civil engineering. Creating ingenious solutions is the core business of (civil) engineers. It is their core business to turn inventions into successful business innovations. NETICS strives for the optimal combination of nature and technology: “building with and inspired by nature”.

NETICS is the expert when it comes to stabilizing and reusing sludges and holds the expertise and unique knowledge to dewater and strengthen soft sediments. NETICS owns a patent for making building blocks made out of soft sediments, the so called GEOWALL®. The above mentioned stabilization methods enables NETICS to upcycle low-grade sludges into high-grade building blocks, the solution for aluminium based sludge!

Figure 29: NETICS building blocks business model

This technique has been proven in other markets. For example, building blocks made from local soft sediments are used in a sound-resisting wall. To use this method with aluminium sludge, it requires to dewater the sludge to 23% before processing. NETICS is planning to develop a spinoff to exploit this new technology through a licence. The Ecocanvas described below is about this new company.

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Customer segments

NETICS' solution addresses two problems by repurposing the aluminum sludge produced by water companies as building blocks for construction companies. The sludge is dewatered on site to reduce its volume and then sold to construction companies, saving water companies the cost of disposal and providing a new green building product for construction companies.

Unique circular value proposition

Their unique circular value proposition comes from making a valuable product (building blocks) from waste (aluminium sludge). Besides, they plan to build a mobile unit to dewater and produce the building blocks on site, lowering the costs regarding transport of both the sludge and the bricks.

Communications and sales

NETICS already has partnerships with construction companies who are interested in using their building blocks made from aluminum sludge, and they are exploring markets in Belgium, Holland and Scotland. They are also working to change the mindset of municipalities to include green requirements in their procurement criteria, which will make more construction companies interested in this kind of product. The service will be provided on site through the use of mobile factories that will collect the sludge from water companies, fabricate the blocks on demand, and transport them to the construction companies over the shortest distance possible.

Customer and stakeholders relationships

Regarding water companies, the mobile factories will be placed on their locations to treat the sludge periodically.

Regarding the construction companies, building blocks will be made under their demand in terms of shape. Besides, these building blocks can be shredded to make new ones, so they'll stay in touch with the construction companies to recover the unused or broken material.

Revenue streams

There are two main revenue streams:

- Payments to retire the sludge from water companies.
- Selling of the building blocks.

Need/Problem/Challenge

There are two problems solved with this solution:

- Sludge disposal. They offer a cheaper way for water companies to get rid of their sludge.
- Green building blocks: Construction companies are interested on greener products.

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Key resources

The key resource for the new company at the moment is the patent for the technology used to produce building blocks from aluminum sludge, which will be licensed from NETICS. Additionally, NETICS' facilities will be used to test the building blocks and develop new related R&D. Once the new company is established, the other key resource will be the mobile factories that will collect, treat and produce the building blocks from the sludge.

Circular Value Chain

Water companies, that will have a cheaper way of getting rid of the sludge, and construction companies, that will have green building blocks available.

Cost structure

The main costs will come from the construction of the mobile factories. They plan to build three of them, two for the Scottish market and another one for the Belgian/Dutch market.

Foresight and Impact – Environmental

The environmental impact will be positive. On one hand, they are reducing the amount of material that ends on the landfill giving the sludge a second life as construction material. Besides, using the mobile units on site they are reducing CO_2 emissions because there is no need to transport the sludge.

Regulations will have a big impact in the future activity of the company, because of the current limitations to use materials made from waste. If these regulations changes, the new business will increase its impact.

On the other hand, they are providing green building blocks to the construction sector that can be reused. These building blocks will go through different tests to assure that they are not hazardous and that they fulfil the structural requirements for being used on buildings.

Foresight and Impact – Social

The creation of the new company means job creation on different regions. Besides, they are working hard on changing the mindset of municipalities about the benefits of this kind of products. Finally, reusing make cities and regions mores resilient and less dependent on externalities.

Circular business model and innovation

They are two main circular business models linked with this new company:

- Cycling: since they contribute to keep materials (aluminium sludge) on the loop instead of being disposed on landfill.
- Intensifying: Using a mobile factory means that many water companies are going to use the same facilities.

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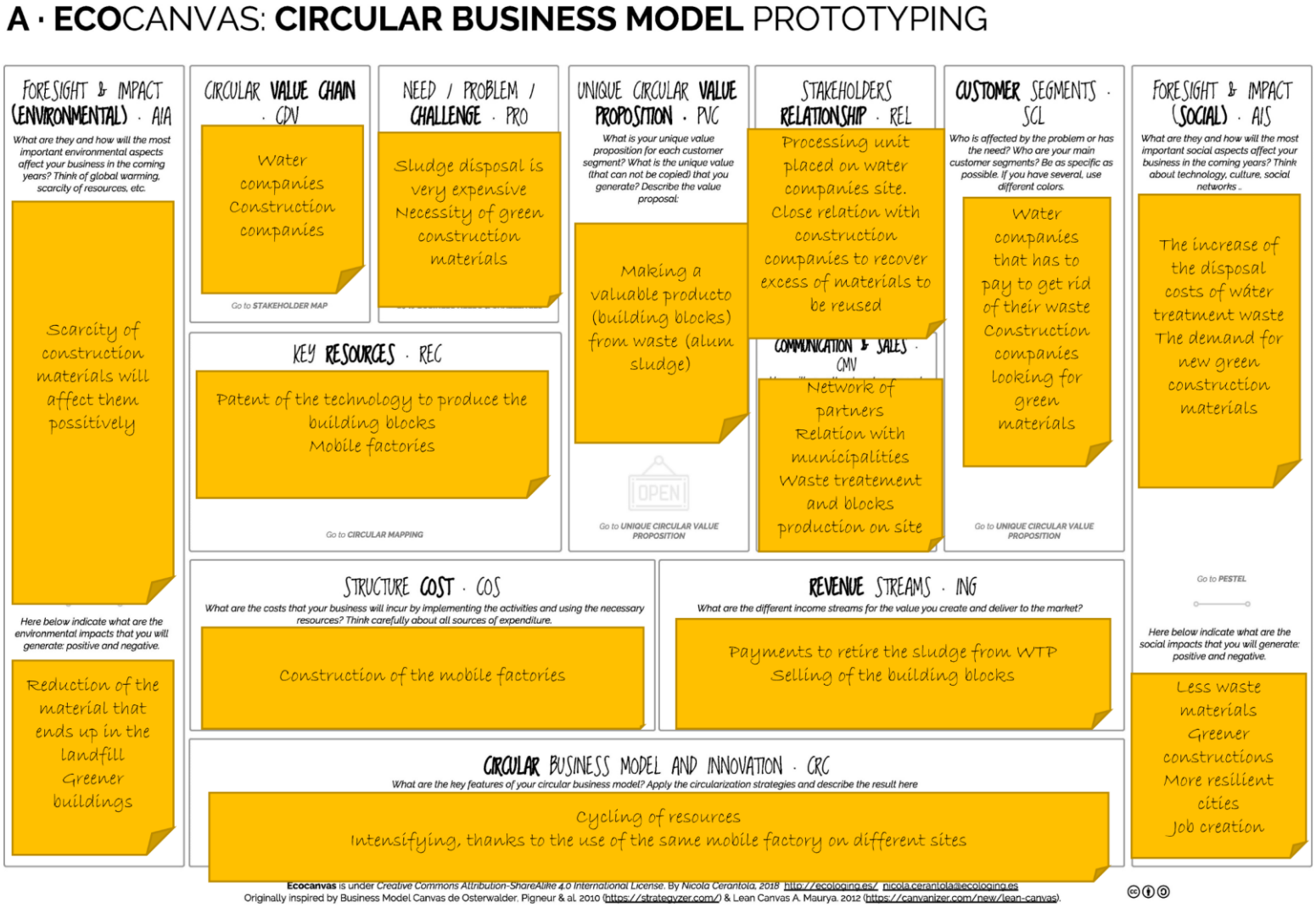

Figure 30: Ecocanvas Netics

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Technical aspects

Netics is a network-centric organization that offers a solution to sludge disposal using aluminium sludge as a material to build building blocks. Netics is planning to develop a spinoff to exploit this new technology (GEOWALL®) through a license.

They'll have two main revenue streams:

- Payments to retire the sludge from water companies
- Selling of the building blocks

Their main costs will come from the construction of mobile factories that will move to the sludge producers.

Table 29: Netics SWOT

Strengths	**Weaknesses**
They offer an innovative solution for sludge disposal and revalorization Two sources of revenue: retiring of sludge and selling of bricks	Need of developing the factories and tests at larger scales
Opportunities	**Threats**
Big market for such as solutions Few competition	Different regulation for building blocks in different countries.

Market aspects

Two problems solved with this solution:

- Sludge disposal
- Fabrication of green building blocks

They have two main kinds of customers:

- Water companies that produces sludge
- Construction companies looking for new green construction products

Their solution is aligned with the following market trends:

- Circular systems
- Decrease of sludge disposal

Marketing aspects

Their unique circular value proposition is producing a valuable product (building blocks) from waste (aluminium sludge).

Their sales channel will be created upon the partnerships they already have (construction companies interested in the building blocks). They work as well with municipalities with whom they are trying to increase the awareness about green criteria on public procurements to build new buildings with green materials. Regarding the sludge producers, they plan to create

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mobile factories that will be placed where the sludge is being produced, eliminating the need of transporting it.

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4.4.10. Discussion

The following table summarises the activity of the analysed companies:

Table 30: Companies activity

Entity	Activity
Raceway Reactor (SEMiLLA)	Water treatment and biomass production. The biomass can be used to produce fertilizer
Aquaminerals	Develop and maintain sustainable pathways for residuals originated from water treatment
Biopolus	Comprehensive water treatment systems for cities that includes the treatment of sludge to produce different products
CHEMiTEC	Nutrient and water recovery from municipal wastewater through sewer mining
Aquatim	Energy production from wastewater sludge
Adasa	Software tool for optimization of hydraulic systems
Alpha	WWTP designing including energy production and nutrients recovery
NETICS	WWTP waste collection and building blocks production

There are different strategies being used by companies anmd organisations to increase circularity in the wastewater industry. Some entities focus on developing more efficient wastewater processes or plants (Raceway Reactor, Biopolus, Adasa, and Alpha) while others try to take advantage of the waste produced by these processes (Raceway Reactor, Biopolus, and Alpha include this waste treatment in their concept; CHEMiTEC, Aquatim, and NETICS takes the waste from its producers). An interesting model is the one developed by Aquaminerals, which works as an intermediary consultant to find the best ways to use waste and help find new solutions for it.It's worth noting that the use of waste as a resource is a relatively new concept and there are companies, such as Raceway Reactor, Aquatim, and NETICS, that are exploring its feasibility as a business model. In these cases, the costs and prices are heavily influenced by the price and demand for water, so the related business models may be viable in some countries but not others. Regulations also play a significant role in the development of these models.Entities such as Aquaminerals can play a vital role in the development of new solutions in the wastewater industry. By being in touch with wastewater treatment plants and water boards, they are aware of their difficulties and needs, and can identify opportunities and stimulate the creation of new companies to address them. This was the case with NETICS in the Netherlands, who proposed the idea of using aluminum sludge to create building blocks, which is now being developed.

Some other findings from the different cells of the Ecocanvas are summarized in the table below:

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Table 31: Findings from the Ecocanvas

Ecocanvas cell	Findings
Customer segments	There are generally two types of customers in the wastewater industry: producers of water waste (such as wastewater treatment plants and municipalities) and consumers of treated water or products obtained from sludge (such as energy, nutrients, building blocks). Consumers of treated water or products obtained from sludge usually include users of water for irrigation or cleaning purposes, farmers who need fertilizer, or energy consumers. The most innovative case is the one from NETICS, where construction companies are the customers for the building blocks made from sludge. To expand this customer base, innovation is needed to find new ways to use these wastes and attract new customers. Companies such as Aquaminerals can play a crucial role in this task.
Unique value proposition	The common quality of all the value propositions shown is that they contribute to increasing circularity. In some cases, it is done by making the water treatment systems more efficient, in other cases it is done by using the technologies to close loops of water, materials or energy. The last option is to give support to find innovative solutions to close loops.
Communication and sales	In addition to traditional sales methods such as marketing, websites and social media, many companies in the industry have found that building a network of stakeholders is a key way to reach customers. This can involve building relationships with relevant organizations, government agencies, and other key players in the industry who can help introduce the company and its products to potential customers.
Customer and stakeholders relationships	In most cases, companies in the industry maintain close and familiar relationships with their customers. Before offering a service or selling a product, cocreation of solutions or consultancy to adapt them to the customer's needs often takes place. Afterwards, companies often continue to stay in touch to provide training, maintenance or inverse logistics.
Revenue streams	Revenue for companies in this industry typically comes from the sale of products or services, waste collection, after-sales, or subscription fees. Another option for generating revenue is by renting systems instead of selling them.
Need/problem/ Challenge	The main problem facing society is water scarcity, which has led to an emphasis on improving water treatment systems. The second main challenge, as a result of the first one, is helping WWTPs dispose of the waste produced by the water treatment systems.
Key resources	In all cases, human resources are the most important resource for companies in this industry. The second most important resource is know-how and technologies.
Circular value chain	The circular value chain varies from one business to another, but typically includes wastewater treatment plants (WWTPs) and/or municipalities. Many companies in this industry act as intermediaries between WWTPs and/or municipalities and companies in other sectors that use the products obtained from the treatment of waste.
Cost structure	The main costs for companies in this industry are personnel costs and equipment.

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Foresight and Impact – Environmental	All the studied cases are affected by water scarcity, as it is the main trigger for their activity. An interesting negative impact for these types of companies is the use of water treatment waste as fuel, which could result in a lower availability of waste for transformation into other products. However, all of them also have a positive impact on the environment, as they decrease the amount of materials disposed in landfills, revalue waste and/or bring nutrients back to the soil.
Foresight and Impact – Social	Companies in this industry can be positively impacted if awareness of environmental issues increases, as it would lead to greater demand for their products. Policymakers also play a crucial role in this regard, as they can create a favorable environment for the use of products made from waste in different applications. Additionally, these companies help to promote the concept of circular economy, and their new business models may require new green skills and generate new green jobs.
Circular business model and innovation	In all the cases studied, the main circular business model was cycling, as the main focus is to keep water and materials in circulation. In some cases, Dematerialization can also be used, for example by offering software services or renting equipment instead of selling it. When the equipment/product is sold, the circular business model of Extending can be applied through the provision of repair and maintenance services. Finally, if the equipment is not needed for a long term in the same place, the Intensifying business model can be applied through shared use in different locations.

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5. Conclusions and limitations

5.1 Conclusions

Section 2:

- The literature review shows that there are already on place several tools (business model canvases and indicators) to help designing sustainable business models.
- Besides, there is few information or tools to describe ecosystems of business models or value chains.
- Nevertheless, those tools are different on scope (business ecosystem, offered value, company in an isolated way…) and difficulty. Thus, it is important to choose the right one depending on the goal of the analysis and the aim of the company.
- The different definitions of the circular economy concept make it difficult to recommend about the best tool to make a specific analysis, but those selected for the present work were the TLBMC and the Ecocanvas, due to their good balance between complexity and analysis capacity.
- None of the proposed tools considers the different scales of circularity, what can help understanding the circular nature of a company from a comprehensive point of view.

Section 3:

- Circular Economy, in general, and its application in the water sector, specifically, are key topics at European level. A number of new regulations are being launched about those topics that will affect the companies' transition to the circular economy,
- There are already examples about technologies that can help closing water, materials and energy loops that can be applied to the water cycle, but there's still a lot of water companies that are not aware of them and/or are using them.
- Regulations can become a barrier for the implementation of the circular economy, since they use to restrict the uses of waste and products obtained from it.

Section 4:

- Demo cases are no isolated entities but ecosystems of entities. In addition, in many cases there are no business or direct financial profit goals because they are built around WWTPs and/or public entities.
- There are no tools on place to analyse the circularity of ecosystems of entities, what makes the methodology presented in this section useful to obtain quality information about the circularity of such as environments.
- COVID situation has delayed and sometimes stopped the implementation of the pilots, what limits the continuity and availability of data for analysis and conclusions .

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- The developed tool has been successfully tested in La Trappe, Westland, Athens and Timisoara cases, and seems to be effective gathering information enough to describe several circularity aspects of an entity/circular site from a qualitative point of view.
- The developed methodology will be deeply applied to the rest of democases to analyse the value chains in D5.2.
- At company level, the Ecocanvas is a useful tool to analyse the economic, environmental, social and circular aspects from a qualitative point of view. The interviewees of the companies that are under development (Raceway Reactor, Chemitec and NETICS) found the use of the Ecocanvas to shape their businesses very interesting and useful.
- There are already some circular business models successfully working on the water sector, but many innovative ones are still being tested to determine if there is a business case behind.
- The success of these new business models depends on local circumstances such as the price of water or energy and/or the regulation regarding the use of products from waste. So, business models can be successful in a country but fail in another, which makes a detailed analysis of the environmental, social and regulatory conditions very important when starting such as business.
- Companies such as Aquaminerals that works as brokers between waste producers and other companies can accelerate the discovery of new business opportunities.

5.2 Limitations of the work

The main limitation of this work is the lack of available data. The COVID situation has lowered the implementation of the demo cases, making it difficult to get real quantitative data. On the other hand, measuring circularity is not an easy task because of the many variables involved. There are already on place different sets of indicators that depend on the circular aspect that wants to be measured, but there is not a common set applicable to all situations.

Demo cases are not isolated entities but ecosystems of entities that can be public and/or private and that have different goals. That makes traditional business model canvases not automatically suitable to be applied on them. Further research should be done to improve the methodology presented and tested on this document.

Regarding circular business modes, in general they are currently emerging and some of them are still experimental. They are quite sensible to facts such as regulation or market, but there are interesting examples already on place.

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ANNEX I. QUESTIONNAIRE

A. **GENERAL INFORMATION**
   a. Name of the company
   b. Company size
   c. Location
   d. Scope
   e. Brief description about its activity and the processes it is using
   f. Do you have subsidiaries? If this is the case, where are they placed?
   g. Have there been changes in any aspect of the company (technology, processes, customers...) thanks to the NextGen project?

B. **NANO LEVEL**
   a. **Water**
      i. Which is the water treatment process that you are using?
      ii. Where is the water you are treating coming from?
      iii. Which is the quality of the water you are treating?
      iv. Which is the quality of the water you are producing?
      v. Where is the water you are producing going to?
   b. **Materials (primary process)**
      i. **Consumables (primary process)**
         1. Which consumables are you using in your water treatment?
         2. Where are they coming from?
         3. How are they being transported?
      ii. **Outputs (primary process)**
         1. Are you generating waste that ends up in the landfill? If this is the case, could this waste be used for any purpose and what would you need to do so?
         2. Do you recover consumables to be used in your water treatment process?
         3. Do you get any output in your primary process? ("output" means any by product that can be processes to obtain another product or that can be sell to another company or client) Does your company treat it? Does your company sell it to a user? Does your company sell it to another company to be treated?
   c. **Materials (secondary process)**
      i. Do you have a secondary process to treat (part of) the output from the water treatment process? If this is the case, which is the output that you are treating? How it is being treated?
      ii. **Consumables (secondary process)**
         1. Which consumables are you using in your secondary process?
         2. Where are they coming from?
         3. How are they being transported?
      iii. **Outputs (secondary process)**

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1. Are you generating waste that ends up in the landfill? If this is the case, could this waste be used for any purpose and what would you need to do so?
2. Do you recover consumables to be used in your water treatment process or in your secondary process?
3. Which is the end of the output? Do you sell it?

d. **Energy**
   i. Does the energy used in your water treatment process come from renewable sources? If this is the case, which one?
   ii. Are you producing energy in your water treatment process? If this is the case, how it is being produced? How it is being used?
   iii. In case you have a secondary process, does the energy used on it coming from renewable sources? If this is the case, which one?
   iv. Are you producing energy in your secondary process? If this is the case, how it is being produced? How it is being used?

C. **MICRO LEVEL**
   a. **Strategy**
      i. How important are the circular principles for your CEO?
      ii. Does your strategy include the transition to a circular economy?
      iii. Does your company have specific objectives about circular economy?
      iv. Do you take part in initiatives related to circular economy?
      v. Do you use ICT or digital systems to help increasing circularity?
      vi. There is any plan in place for the end of life of your PPE assets (property, plant and equipment)?
      vii. Do you use eco-design principles?
      viii. Do you include circularity in your marketing strategy?
   b. **Communication**
      i. Do you communicate internally about your circular economy strategy/objectives/activities?
   c. **Employees**
      i. Do you deliver training about circular economy to your employees?
      ii. Do you have employees focused on circular economy activities?
   d. **Resources**
      i. Which are your key resources?
      ii. Are you using green funding?
      iii. Which is your main source of income?
      iv. In case you have a secondary process, is your primary one profitable without the secondary one?

D. **MESO/MACRO LEVEL**
   a. **Stakeholders**
      i. Who are your stakeholders?
      ii. How do they contribute with your activity?
   b. **Distribution**
      i. How is being distributed the water you are producing?

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ii. If you have other products besides water, how do you distribute them?
iii. Do they need packaging? What kind?

c. **Use phase**
   i. How is being used the water you produce? Are you involved somehow in the way it is being used?
   ii. If you have other products besides water, how are them being used? Which are their energy and material requirements along the use phase?

d. **Suppliers**
   i. Are you aware about your complete value chain?
   ii. Are you taking into account the circular economy principles when choosing suppliers?

e. **Clients**
   i. Who are you creating value for?
   ii. How many (%) of your clients are consuming green products?
   iii. There is in place any kind of return/recover procedures for your products after the end of life?
   iv. How many (%) of your clients are using them?
   v. There are in place channels for collaborative use or reuse of your products?
   vi. Do you communicate about circularity to your clients?

f. **Industrial symbiosis**
   i. Are you taking part in any industrial symbiosis network?
   ii. How are you taking part on it?

g. **Policymakers**
   i. There is in place any relationship with policymakers related to circular economy at any level?

h. **Society**
   i. Does your company have any social goals?
   ii. Do you interact with any local community? Which? How?
   iii. How is influencing your company from a societal point of view?
   iv. Do you think that the perception that society has about your company can change over time due to external threats?
   v. Do you think you can find economic challenges (regulations, market innovations, macroeconomic issues) that can threat your company?

i. **Environmental impact**
   i. Which is the ecological footprint of your company?
   ii. Does your company contribute to regenerate the environment? If this is the case, how?
   iii. There are in place environmental challenges that can affect your value chain?

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