MASTER THESIS

The market potential of the wastewater recovery case study COMPRO

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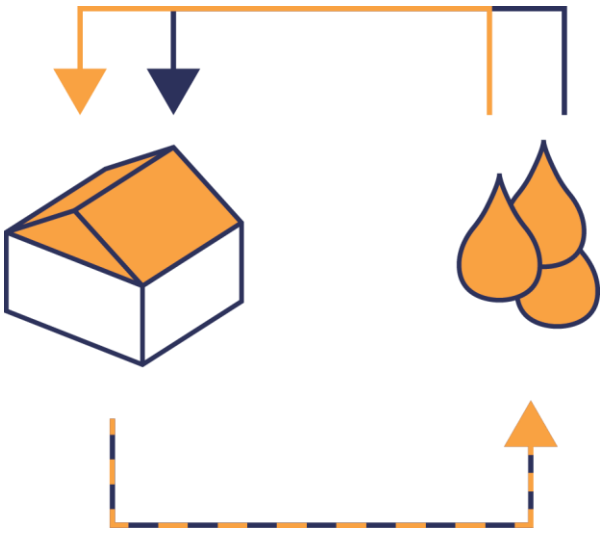
and how to raise the acceptance of COMPRO in HavenStad



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CONTENT

I. List of abbreviations

Abbreviation	Meaning
CE	Circular Economy
COD	Chemical oxygen demand
EU	European Union
LCA	Life Cycle Analysis
MGP	Milieu Prestatie Gebouwen (environmental performance indicator)
MoA	Municipality of Amsterdam
P	Phosphorus
RR	Resource recovery
RRS	Resource recovery systems
WW	Wastewater
WWT	Wastewater treatment
WWTP	Wastewater treatment plant

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ABSTRACT

Amsterdam wants to become a city that complies with the principles of a Circular Economy (CE) by 2050. In this regard, the integration of resource reuse strategies into urban planning is indispensable to approach the urban challenges of the near future.

The COMPRO project, initiated by the Amsterdam Institute for Advanced Metropolitan Solutions (AMS)-Institute is an example of an on circular principles based reuse of wastewater (WW). In short, cellulose and the biopolymer Kaumera, two main components out of the WW can be turned into a bio-composite for construction. The lightweight bio-composite of the COMPRO-project called 'RE-PLEX' is extracted from aerobic granular sludge originated from the 'Nereda' WWT process. It could be used as a viable alternative to a variety of fossil-based materials in different economic sectors such as in the construction sector. Compared to conventional fossil based composite materials, RE-PLEX production consumes up to 88% less energy during the production process. The COMPRO-consortium aims to build a prototype for an application of RE-PLEX by 2021.

Since WW recovery concepts such as COMPRO are relative recent developments, current knowledge of the market potential and the measures that could raise the acceptance amongst various involved stakeholders, is still limited. Therefore, research on the barriers for the potential of WW reuse concepts is of major importance. This in-depth research on the barriers of the potential of COMPRO reveals opportunities and threats for the project. In a second step the findings should help to give advices on the application in urban development projects such as HavenStad.

HavenStad is the biggest urban-development-project in Amsterdam. The big port-area to the northwest of the centre of Amsterdam is planned and built according to principles of circularity. The companies in HavenStad could be pioneers in using the wastewater-recovery strategies integrated into their businesses. Therefore possible measures for an integration of the COMPRO project into HavenStad such as the concept of 'Industrial Symbiosis' are presented.

1 INTRODUCTION

1.1 Relevance and research question

In the 21st century, resources are becoming continuously scarce. The increasing population – in Amsterdam with around 11 000 additional inhabitants - and the coupled urban growth, with 5 000 homes each year, not only lead to a higher vulnerability to pandemic diseases such as COVID-19, but also threaten the availability of non-renewable resources, such as fossil fuels (van Leeuwen et al. 2018; Amsterdam 2020c; Hamidi et al. 2020). The extraction of resources in combination with the greenhouse gas emissions are causing severe damages to the environment (Gläser and Laudel 2010; van Loosdrecht and Brdjanovic 2014). Therefore, the reuse of resources is of utmost importance. Wastewater (WW) should no longer be seen as waste, but instead as a resource. Water itself is a restrained resource as well as a transport medium for materials, chemicals, and energy. Especially the urban WW carries a lot of resources that potentially can be recovered (van der Hoek et al. 2016). The shortage of water and the contamination-frequency make the sustainable treatment of WW, combined with a maximised reuse and recovery of resources in WW, even more important (Libralato et al. 2012).

In the past WW treatment plants (WWTP) were mostly valued by their function, safety and economic performance. These traditional paradigms and engineering infrastructure of the 20th century have now been replaced by a paradigm-shift in progress, where WW is increasingly seen and used as a resource (Puchongkawarin et al. 2015; Guest et al. 2009). Within this shift, sanitation systems are now continuously described as resource-recovery-systems (RRS). To see WW as a resource offers promising opportunities for the WW industry. Consequently, the reuse should not be limited to water reuse but also the resource recovery (RR) from water, which integrates WW into the concept of the circular economy (CE) (van Leeuwen et al. 2018; Guest et al. 2009).

The more circular use of resources calls for intensive research on circular RRS (Kehrein et al. 2020). In the recent past, a lot of academic institutions have begun to work on the development of technical solutions to recover water, energy, and fertilizers, in order to impede their dissipation. Due to academia's increased interest in RR-technologies, the amount of different available technical solutions as well as the specific products that can be derived are continuously on the rise. More recently the research is also concentrating on other recoverable resources from WW, such as biopolymers, cellulose, and bioplastics with an additional added value (van der Hoek et al. 2016).

COMPRO is one of the most recent innovations to use recovered resources from WW. Cellulose and the biopolymer Kaumera, two components out of the WW can be turned into a lightweight bio-composite called RE-PLEX for construction. It is extracted from aerobic granular sludge originated from the 'Nereda' WWT process, an effective treatment method

invented by the TU-Delft. RE-PLEX can be used as a viable alternative to a variety of fossil-based materials in the construction-sector (Peter Mooij 2019). As the construction sector is one of the biggest waste-producers in the Netherlands, to find biodegradable and energy saving solutions for the construction materials would not only save CO_2 emissions, but also significantly minimize the waste production (Amsterdam 2020b).

According to the strategy 'Amsterdam Circular 2020-2025', the City of Amsterdam wants to become circular by 2050. The biggest urban transformation in Amsterdam 'HavenStad' is guided by the circular paradigm. It aims at a 100% re-use of raw materials in public spaces and buildings by 2050. The urban development project in the port area of Amsterdam provides the adequate playground to implement new RRS and a potential application field for the recovered products.

So far, only some of the inventions such as COMPRO have been realized on a larger scale. The potential of transforming WWTP's into water resource facilities is currently still rare and lacking on a large scale (Kehrein et al. 2020). Which RR-technology has the highest potential also depends on the market potential of the products resulting from the technologies. How the technologies and products can be applied in a certain system, is subject to a complexity of social, market, legal and technical factors that in most cases are difficult to answer (Kehrein et al. 2020). Especially the market potential of the recovered resources in their context still needs to be further examined (Kehrein et al. 2020).

The market is understood as the network of institutions and companies along the value chain of materials that flow according to supply and demand (Rijksinstituut voor Volksgezondheid en Milieu 2016). External factors such as other new evolving technologies and market developments depict a network of complex, dynamic, and uncertain situations, which makes it difficult to give certain recommendations for the implementation of RRS from WW in a certain space (van der Hoek et al. 2016). Market stakeholders and decision makers ought to have a clear understanding about the technologies and the products to be recovered and their advantages and disadvantages, in order to be able to make appropriate decisions about their implementation (Kehrein et al. 2020). Hence, for innovative solutions to find its application in a certain urban realm, the process of stakeholder integration is of utmost importance. As not one technology fits into all urban spaces, it is of high importance to evaluate the different options in an urban context with social technological planning and design approaches (Guest et al. 2009). So far, only a few studies have been dedicated to the identification of factors, which influence the implementation of RRS, respectively their potential for a certain space.

Kehrein et al. (2020) identified nine different bottlenecks that might influence the potential and complicate the integration of RRS into WWT. Of those, six are of economic concern (process costs, resource quantities, resource quality, market value, application and distribution), whereas one concerns environmental risks (emissions) and health risks

(contaminations), and two concern the social acceptance of the product and policy issues. Another study by van der Hoek et al. (2016) examined on how different RRS could find their application in an urban realm, by assessing different measures of RR with an integrated approach. Van Leeuwen et al. (2018) examine in how far market stakeholders such as the water authorities in Amsterdam can contribute to RR innovations. However, specifically for recent projects and product-innovations from resources out of WW, the market potential has rarely been assessed.

Different criteria for the market potential of projects such as COMPRO and their application in urban developments such as HavenStad can only be found and interlinked if different stakeholders in the value-network and their estimations on the potential of the recovery technologies and their resulting products are included.

Although the COMPRO project is still in the lab-phase, the acceptance of the concept as well as the product on the market already needs to be examined, in order to develop it into the right direction and identify barriers that could prevent an application. Thereby the social, legal and technical aspects that contribute to a market acceptance should also be involved. On this basis a research-gap can be defined, that leads to the research question that should be examined in this thesis:

> *'What is the market potential of innovations dedicated to recovered resources from waste water such as the COMPRO project and what measures can be taken to raise the acceptance for an integration of COMPRO into urban development projects such as HavenStad?'*

The introduced problematic and the research question can be sub-divided into a set of questions that underlie the potential of the COMPRO project on the market:

- *What type of organizational difficulties and interdependencies might arise between the stakeholders in projects such as COMPRO?*
- *To what extent does the external framework of political and legal regulations influence the market acceptance of the project?*
- *What technological aspects does the product need, in order to be accepted as a waste-based application?*
- *What market volume and costs of applications made from RE-PLEX could lead to a higher potential of the material on the market?*
- *What product solutions could the RE-PLEX have and which competition does the RE-PLEX need to confront on the market?*
- *How can COMPRO find its application in an urban development such as HavenStad?*

1.2 Aim and structure of the work

The aim of this Master's thesis is to detect barriers and promoters for the market potential of the COMPRO project. Additionally, it seeks to examine to what extent measures can be taken to overcome barriers and instead raise the market-acceptance of the COMPRO project, in order to be implemented in the urban realm of HavenStad.

The remainder of this study is organised into four sections. At first, a comprehensive literature review will be given by reviewing the main bodies of literature surrounding the topic of this thesis. An introduction into the urban context of Amsterdam, respectively HavenStad is given. Continuously the WW management system in Amsterdam is introduced. Thereby the relevant actors and institutions, as well as the basic elements of the WW management system are described to further introduce WW-recovery methods and the materials that can possibly be recovered. In the next step, the COMPRO project and the RE-PLEX product are presented. Consequently, the field of application of the RE-PLEX - the construction sector in Amsterdam, is introduced. The last part of the contextual framework presents the legal and political guidelines that are relevant in regards to the COMPRO project.

Secondly, this thesis introduces the study's methodology, which is based on expert interviews. Expert-interviews with different stakeholders along the value network of the COMPRO project and with potential stakeholders that could be involved into the concept in the area of HavenStad, have been conducted, in order to examine the market acceptance. This chapter further compiles the explanation of the interview guideline, the selection of the stakeholders, the fieldwork (respectively the realization of the interviews), and the description of how the interviews are evaluated. Lastly, the validity and reliability of the method is discussed.

Subsequently in the evaluation part, the outcomes of the interviews are interpreted according to the structure of a hybrid category system and in the light of the theory. A summarizing interpretation of the categories serves as the basis for the interpretation of the category of urban integration. The category of urban integration is interpreted separately to draw a direct spatial connection to the potential practical application of the project in the urban realm of HavenStad.

Finally, a conclusion will provide a brief summary and highlight the contribution of this study to reveal the potential of the project as well as some measures of acceptance for an urban integration. The limitations and an outlook of the conclusion will be the closing remark. This work should not be seen to give finalized concrete recommendations for actions, but more as a first approximation to the market acceptance and the contextualization of the project.

2 THEORETICAL FRAMEWORK AND CONTEXT

2.1 Concepts of circular flows

Circular Economy

The concept describing the recovery and reuse of resources is the known as *circular economy* (CE).

> *'A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems.'*
> *(Ellen MacArthur Foundation 2017).*

The CE seeks to promote a sustainable global development, according to the Sustainable Development Goals (BMZE 2020). According to the circular economy understanding, waste that is generated through production cycles is kept in biological and technical cycles to return it into a resource after its usage (Daniel Puyol and Damien J. Batstone 2017). A related concept is the so-called *Cradle to Cradle* concept invented by William McDonough and Michael Braungart. They postulate that everything can be designed for disassembly and returned into its respective cycles. Hence, the cradle to cradle concept aims to eliminate the concept of waste by keeping resources in a technological or biological cycle, instead of disposing them (William Mc Donough 2020). Put in other words, waste is not understood as a resource that is wasted after its usage or production, but instead re-used for future production cycles. In relation with this Master's thesis' research object, the design of a CE also encompasses an innovative approach of designing WWTP's, where energy, nutrients, and other resources can be recovered as valuable by-products (Daniel Puyol and Damien J. Batstone 2017).

The aims of the CE can be addressed by a joint collaboration between the government, companies, and research institutes (van Leeuwen et al. 2018). As Amsterdam wants to become circular high ambitions are formulated for their urban agenda.

Urban metabolism

A second circular approach that frames this research is the concept of *urban metabolism*. Christopher Kennedy (2007) defines urban metabolism as the 'sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste' (Christopher Kennedy 2007). In order to be able to design sustainable cities it is necessary to understand the flows of energy and materials. The COMPRO project is in its entirety connected to the approach of urban metabolism.

2.2 The urban context

Current developments such as the exhaustion of fossil resources cause big challenges for cities as the density of population in confined spaces is the highest. The importance of sustainable innovations to counteract these developments and to align economic with environmental and social interests is of utmost importance. In the following the urban context, where circular innovations such as COMPRO can have the highest impact is presented.

2.2.1 Amsterdam - circular

Amsterdam policies

The municipality of Amsterdam (MoA) recently developed a CE strategy for Amsterdam 'Amsterdam Circular 2020-2025' (Gemeente Amsterdam 2020). In that strategy the MoA states, that Amsterdam aims to be completely circular by 2050. The MoA refers to the importance of businesses in the change to a CE and emphasises the transfer of knowledge between stakeholders in order to promote innovations. Within the strategy, three value chains are specifically selected to emphasize Amsterdam's circular ambitions. Those are first, food and organic waste streams, second, consumer goods, and third, the built environment. The MoA seeks to achieve these ambitions through an integrated approach: *'We will therefore work intensively with knowledge institutions, businesses and the government to research, innovate and implement.'* (Gemeente Amsterdam 2020).

The MoA is currently shaping several policy instruments to guide the transition to a CE and thereby takes a leading position, especially when it comes to the built environment. Especially for the built environment it has the authority to recommend policies that have a far-reaching influence, thanks to its guiding role in spatial planning and its commissioning authority for the construction and demolition of public space. The value chain of the built environment not only encompasses the construction of circular buildings, but also specific constructions in the public space. The MoA recognizes itself as responsible to organize the circularity of the public space as well as an end-user of the buildings in Amsterdam, since the buildings ultimately are also built for public institutions. Lastly the MoA sees the construction sector as a major impacting sector where a change can have a significant influence (Gemeente Amsterdam 2019).

To reduce the use of primary raw-materials, the MoA regards the existing national 'Environmental Performance for Buildings assessment' [Milieu Prestatie Gebouwen (MGP)], which calculates the environmental performance of a material for a dwelling or office building, as an essential instrument to encourage a high sustainability of a building. The lower the MGP, the better the environmental performance of the building (Nico P.M. Scholten 2012). To make sure, that the ambitions not only remain ambitions, concrete performance requirements ought be established in each phase of an urban development that apply to all

urban developments that still need to be developed (Gemeente Amsterdam 2020). The city has the special task to promote the integration of circular construction, by tying network structures and knowledge-transfer (Gemeente Amsterdam 2019). To assess the progress of the city, it has developed a 'Monitor' which maps the raw material flows entering the city until their processing (Amsterdam 2020b).

2.3 HavenStad

The population and economy of Amsterdam is growing in a fast pace. Within the Ring A10 (yellow line in *Figure 1*), along the IJ (harbour basin) the city is part of the most economic regions in the Netherlands. The actual space for the growing development is rather scarce, hence the central area needs to be extended to accommodate more and more offices and dwellings. For a logic development the developing areas need to be connected to the existing centre. The 'structural vison' of Amsterdam describes two big movements: First, the 'rollout of the centre', which concerns the centre-oriented development of the districts inside the ring-road connected to the centre and second, the 'rediscovery of the water-front' (Gemeente Amsterdam 2011). HavenStad is the area that lies in between (Gemeente Amsterdam 2017).

HavenStad is a big port-area in the Amsterdam metropolitan region, which extends to the west and northwest of the centre, and the north and south of the river basin IJ, which connects directly to the existing centre (light-green area in *Figure 1*). It almost amounts to the size of the city-centre of Amsterdam, and there are expected to live and work 150.000 people (Gemeente Amsterdam 2019).

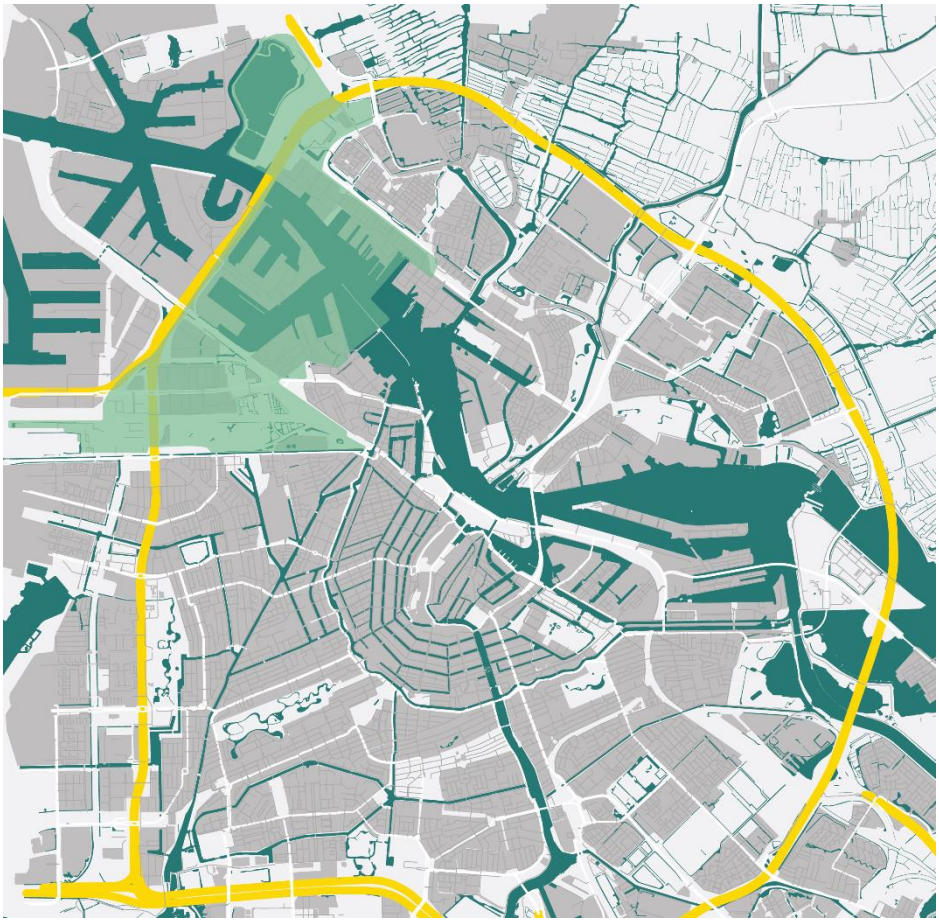

Figure 1_Amsterdam base-map (own illustration 2019)

Development strategy for HavenStad

HavenStad has 12 sub-areas (visualized in *Figure 2*) which are planned to be built in phases and will develop over decades with a structural vision until 2040. In the present the sub-areas differ a lot regarding their respective urban identity. In one area, water and port activities predominate, while in the other areas the green or the industrial character are dominant. Exemplarily the Cornelis Douwesterrein district consists of more robust harbour basins, while the area around the Transformatorweg has a lot of nature and Sloterdijk-Center is a good example for the increasing high-rise environment. The work has already started in Sloterdijk Centrum and Sloterdijk I Zuid, which is a part of the red area in *Figure 2* (Gemeente Amsterdam 2019, 2017).

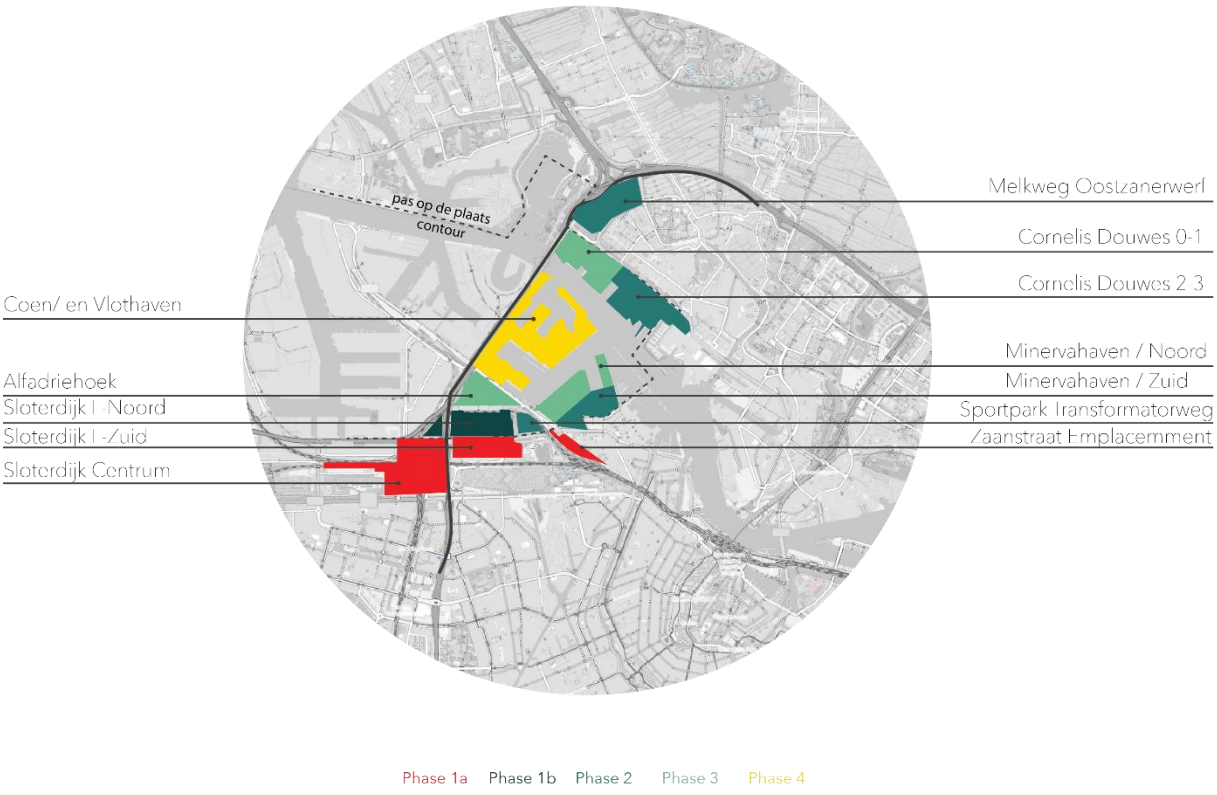

Figure 2_Development phases of HavenStad (own illustration 2020)

HavenStad will be developed as a new combined working and living area district, with a ratio of 80% living and 20% non-living. The mixed area will combine high-density-housing, shops, businesses, green areas, and public facilities. It will be a neighbourhood with a combination of functions, activities, and housing types for different social income groups, this way following the Amsterdam tradition – that is striving for inclusive neighbourhoods with a mixed population (Gemeente Amsterdam 2017). The realization of the building plans will take place per sub-area and conducted by different market parties (Gemeente Amsterdam 2017).

The 'Pas op de plaats'-contour, also visualized in *Figure 2,* is a dividing line within Haven-Stad that specifies the areas around the port covered by the Houthaven / NDSM wharf agreement. The agreement is arranged between the port and a number of large companies, in order to protect the business of the existing companies that currently are located in that area. The strategy clearly states that no residential houses may be built here until 2029 (Gemeente Amsterdam, 2017).

The high demand of housing puts a high pressure on the urban development, hence the neighbourhood will comprise 40.000 to 70.000 homes, and 45.000 to 58.000 jobs. The resulting building density would be very high (Gemeente Amsterdam 2018).

The grand dimension of HavenStad emphasizes the importance of realizing all current and upcoming innovations in the realm of circularity, especially its energy, waste separation and reuse, or circular construction. In the planning and decision-making phases, enough flexibility needs to be granted for changes and technical innovations to take place, while taking into consideration the long-term ambitions laid down in the strategy (Gemeente Amsterdam 2017). Due to the big scale, the strategy for HavenStad is very connected to the Sustainability Agenda of the MoA.

2.3.1 Objectives for HavenStad

Sustainability in HavenStad

According to the MoA HavenStad should offer a 'healthy, attractive and sustainable living-environment' (Gemeente Amsterdam, 2017). The sustainability goals are sustainable energy, immediate CO2 reduction (85 to 100% by 2050), emission-free mobility by 2029, water-resistant neighbourhoods, 50% re-use of raw materials in public spaces and buildings by 2029, and a 100% reuse of raw-materials by 2050. Furthermore they aim a 65% separation of household waste and 100% by 2050. These theoretical ambitions are only possible in practice, if the economy turns circular and space is given to circular innovations (Gemeente Amsterdam 2017). Some incentives are set already. Exemplary, heat and cold is generated from the water of the IJ. Energy is generated by a waste energy company. Even though these activities are only a starting point - new opportunities need to be created, to further increase sustainability and innovation practices on a large scale. Thereby the role of the market is highly important and influential to certain changes, which will be taken into account in the development strategy of HavenStad. Therefore, the city aims for a mutual collaboration with all stakeholders, in order to monitor opportunities and solutions from an inclusive perspective.

An environmental impact assessment is also part of the development strategy, where ambitions and principles are periodically tested. This tool will help to assess whether the respective interventions fulfil certain area-oriented and environmental criteria. Furthermore,

they foresee to find optimized measures for building constructions (Gemeente Amsterdam 2017).

2.3.2 Companies in HavenStad

The present situation

The presence of water and industry areas and the direct connection with the North Sea Canal Area and to the regional road and rail network make HavenStad a strategic location for enterprises (Gemeente Amsterdam 2019, 2017). The companies in HavenStad together generate an added value of 2.7 billion euros annually. This makes up about 7% of the total added value in Amsterdam (Gemeente Amsterdam 2013). Many companies are part of the construction sector and manufacturing industry with light to heavy industrial activity. A big share of the companies in the port already are considered part of the circular industry (Port of Amsterdam 2020). Companies in the construction sector are in the heavy industry, such as the steel and concrete industry and in the infrastructure construction. Furthermore, there are construction material retailers with a sustainable orientation and smaller architectural and manufacturing companies.

Strategic plans for the economic sector

Within the transformation phase there should emerge a mix of small-scale business spaces with more office spaces but also with workspaces for crafts, small-scale productive services, urban care services, and technical incubators that are compatible with the residential areas (Gemeente Amsterdam, 2017).

As the heavy industries do not fit within the strategy for HavenStad the city proposes to eventually relocate the more industrial existing companies after 2029 with the expiring of the 'Pas op de plaats-grens'. For the wet port business and for companies with heavy environmental categories, finding replacement space certainly is not easy. One possible area for a re-location could be the Houtrakpolder (see *Figure 3*), which so far seems the most suitable location, but is not within Amsterdam territory. This area, in the west port area of HavenStad offers space for a new port basin and for approximately 180 hectares of land for quays, terminals, storage, and processing. If it is decided to expand the area, there is more than enough space available to also accommodate the companies from the Coen and Vlothaven area in the centre of HavenStad (Projectgroep Haven-Stad 2013).

Figure 3_Relocation to the Houtrakpolder (own illustration 2020)

But how could this development-strategy contribute to the CE ambitions? A measure, which could help to improve the circular industry is the concept of 'Industrial Symbiosis', where the by-products (waste-products) of one company become the products of another (Chertow 2000). The companies could be spatially located so that industrial-symbiotic relationships could be easier realized - especially innovations on a larger scale along the whole value chain of products (Gemeente Amsterdam 2020). The concept of Industrial Symbiosis will be further emphasized within the *urban integration* part (4.4) of this research.

2.3.3 Circular Constructions in HavenStad

The field of circular construction is an elementary part of the development strategy of HavenStad. As the construction develops in a fast pace, it initially needs to be assessed with the market parties what measures are necessary in order to achieve the ambition of circular construction. The responsibility of the realization of the built environment is given to the respective landowners and building-developers. Therefore the market has a huge influence on the circular development and constructions of HavenStad. Consequently, this dependency on the market makes the realization of ambitions highly dependent on the absorption capacity of the market (Gemeente Amsterdam 2017).

The MoA aims to promote the reuse of raw materials and building materials for as long as possible. In the sub-area Sloterdijk I Zuid, the aim of circular construction already has partly been implemented in buildings and in public space. One instrument is the construction of 'flexible buildings' which can be adapted according to the particular function they fulfil in their neighborhood at a certain time, without being entirely renovated when the company or function changes (Gemeente Amsterdam 2019). In that way they are not only suitable for the first users, but also for the inhabitants in the following period(s).

In the CE strategy the MoA also states, that so-called 'expertise centres' will be established to serve as a knowledge transfer regarding circular constructions, the regulations,

legislations, and maintenance criteria. It is highly recommendable that these are integrated into the development of HavenStad (Gemeente Amsterdam 2020).

In the construction industry, there are already existing technological possibilities to build with circular construction materials. In their strategy, the MoA states that some raw materials are already and can be reused and stresses the construction industry as an advisor for commissioning and legislation.

For HavenStad three main missions are established:

1. *Preserve the airframes of those high-rise buildings that are already present*
2. *Ensure the reuse of raw materials in new buildings, which will be 4 times as high as in the present buildings.*
3. *Ensure the reuse of raw materials in public space (Gemeente Amsterdam 2013).*

The reuse of waste-based or bio-based construction-materials is not explicitly stated in their mission.

This chapter sought to give an understanding of the different dimensions of the urban context of this research. The next chapter introduces into the wastewater (WW) management in the context of Amsterdam.

2.4 Wastewater management

2.4.1 Wastewater

Municipal WW is discharged from residential, commercial, institutional, and public facilities. Industrial WW derives from industries (Tchobanoglous et al. 2014). Municipal and industrial WW besides municipal solid waste, industrial solid waste, and agricultural waste originate from living organisms and are therefore both types of organic waste (Teresa C. Donkin 2020). Apparently also a lot of organic waste is present in WW (van Leeuwen et al. 2018). As Kaumera, the bio-polymer in the COMPRO project is extracted from the organic matter content it is described more detail.

WW that is discharged contains a high amount of solid matter. As visible in *Figure 4*, the amount of organic matter in Amsterdam's WW is around 42 kton COD/year (chemical oxygen demand). COD is the measuring-variable for organic matter. The organic matter is mainly composed of urine, faeces, toilet paper, and grey water. Grey water is mainly generated in the kitchen and the bathroom besides the toilet-water (or black water) (Larsen et al. 2013). It has with 36 % the biggest share in WW, followed by faeces (34%), and cellulose and toilet-paper (23%). Only 7% are urine. In most countries in the so-called developed world this WW is conducted to a WWTP (van der Hoek et al. 2016).

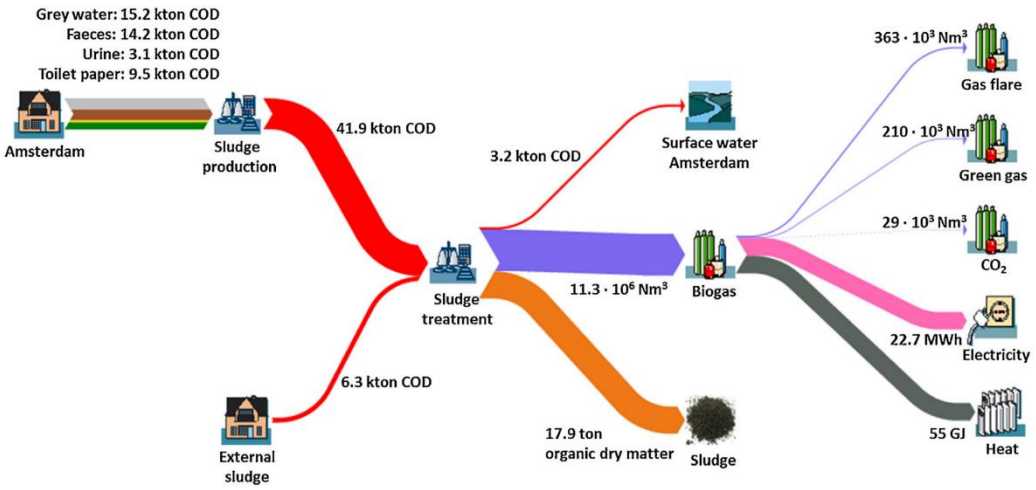

Figure 4_Organic matter in Amsterdam's wastewater chain (van der Hoek et al. 2016)

2.4.2 WW management in Amsterdam

Water authorities in the Netherlands

An important stakeholder when it comes to WWT in the Netherlands, are the water authorities. They are providers and processors of the waste stream, the extractors of the raw materials and co-developers of products (Rijksinstituut voor Volksgezondheid en Milieu 2016). The responsibilities of the water-boards are regulated in art. 1 of the Water Board Act which consists of the water management of a specific area, the care of the water-system and the purification of urban waste water (Rijksinstituut voor Volksgezondheid en Milieu 2016). Also the legal responsibility of the water management is dedicated to those autonomous governmental institutions. They translate European and national developments through policy-making, research, and innovation into practice and advices the MoA on water aspects in spatial developments (Waterschap amstel gooi en vecht 2016).

The altogether 21 water-authorities in the Netherlands have a collaborative network called Energy and Resource Factory (ERMF), which mutually combines their respective interests, efforts and knowledge, and together seeks to contribute to the fulfilment of a CE (van Leeuwen et al. 2018). They see WW as a valuable source of renewable energy, raw materials, and clean water (Energie- en Grondstoffenfabriek 2020). The water authorities have the ambition to generate 40% of their energy consumption from their own resources (Rijksinstituut voor Volksgezondheid en Milieu 2016). According to the vison of the CE, they focus on the recovery of six resources from the municipal WW: cellulose, bioplastics, phosphate, bio-ale (Kaumera), biomass and biogas (van Leeuwen et al. 2018). The recovery of phosphorus (P) (as struvite), cellulose and biogas currently already takes place, even though the continuing process will be a longer-term challenge (Energie- en

Grondstoffenfabriek 2020). In the future, a high fluctuation of the market scale and price-policies and competing products is predicted. The marketization is more difficult for governmental institutions. However other stakeholders and parties are connected to the authorities, so that they are interested in the linkage to their authorities and can commercialize their by-products which will be further explained in chapter 2.5.1 (van Leeuwen et al. 2018).

Waternet

Waternet manages the entire urban water-cycle in Amsterdam, respectively also the area of HavenStad, and is a joint organization of the City of Amsterdam (Amsterdam) and the Regional Water Authority Amstel Gooi and Vecht (AGV), which includes drinking water production and distribution, water safety, surface water and household and industrial WW transport and treatment in Amsterdam (Waternet 2020c). Waternet manages 12 WWTP's and the WW flow in Amsterdam is around 74.9 million m^3/year (van der Hoek et al. 2017).

2.4.3 WWT in Amsterdam

The sewer pipes in Amsterdam and its surrounding area compromise a network of 4000 kilometres in total (*Figure 5*). The treatment facilities clean the sewer water, which is subsequently released back into the surface water. The biggest amount of water (38.9 million m^3) is returned by households and 16.3 million m^3 by businesses, whereby 4.3 million m^3 is used by industries (van der Hoek et al. 2016). Most of the WW in Amsterdam is treated centrally. However, there also exist other smaller treatment plants in and around Amsterdam. Additionally, some bigger industries have their own treatment plants (van der Hoek et al. 2016).

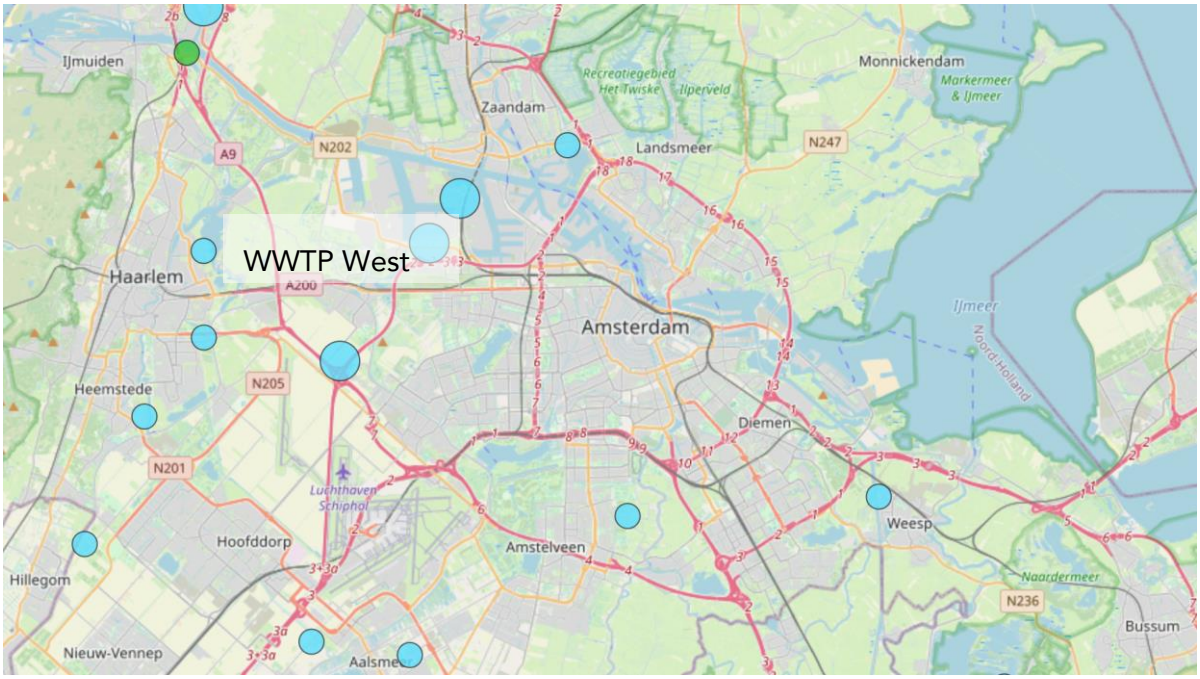

Figure 5_WWT plants in and around Amsterdam (European Commission 2020d)

According to Daigger, the infrastructure status of systems in so-called developed countries with a growing population are '*generally traditional centralized water supply and WW management systems, which provide adequate service but are increasingly judged not to be sustainable. Significant water supply problems in areas with growing populations, which are driving increased use of novel water supply approaches, such as water reclamation and reuse.*' (Daigger 2009, p. 812).

Nowadays the demand towards the traditional centralized technologies for WWT are rather complex – while being efficient and reliable at the same time they should be preferably economically feasible concerning construction, management, and maintenance and be circular. According to Libralato et al. 2012, if all those circumstances are fulfilled, they could have a high degree of acceptance by different stakeholders and the general public (Libralato et al. 2012).

WWTP West

The biggest WWT plant in Amsterdam is the WWTP Amsterdam West and has a capacity of 1 million population equivalents (van der Hoek et al. 2017). At this plant, sludge form a wider region is treated. The current treatment technology is an biological treatment method - via anaerobic mesophilic (35–37 °C) digestion whereby microorganisms break down biodegradable material in the absence of oxygen (van der Hoek et al. 2016). The WWT plant in Amsterdam West purifies Amsterdam's WW in seven treatment lines. Each of them consists of an aeration tank and two post-settling tanks (*Figure 6*) (Waternet Research & Innovation 2019).

Figure 6_WWTP Amsterdam West and nearby Waste and Energy Enterprise AEB (European Commission 2020d)

A minimal to zero input of chemicals is needed in the biological treatment to remove nutrients. After treatment the water is discharged into the harbor. The remaining sludge it mostly converted into energy in the form of biogas right now (Waternet 2020b). To produce district heating, the sludge, digested and dewatered by the WWTP, is combusted by the Waste and Energy Enterprise AEB (Fig.: 'Afval Energie Bedrig') in incineration furnaces, which are located next to the WWTP Amsterdam West (van Nieuwenhuijzen et al. 2009).

Biogas production

The biogas is mostly used for combined heat and power production. A small part of the biogas (around 3%) cannot be stored and used and therefore gets lost as gas flare (van der Hoek et al. 2016). The biogas production still has a very high importance compared to other RRS. In the WWT plant, 25.000 m^3 biogas are produced on a daily basis. A part of the biogas is already burned at the WWT plant. Also the heat of the cooling water of the energy company is returned to the WWTP to heat the sludge digestion (van der Hoek et al. 2017). This industrial symbiotic exchange is profitable. Consequently, the biogas production will further increase in the coming years, even though other reuse strategies are significantly developing as well (van Leeuwen et al. 2018).

Phosphorus recovery WWTP Amsterdam West

A phosphate recovery process was also introduced in line to this treatment plant, with the Airpex process. The recovery process was mainly introduced due to the problems with blockages of the pipes by struvite precipitation (van der Hoek et al. 2017). The Airprex process is based on the addition of magnesium chloride ($MgCl_2$) to the digested sludge to raise the pH and produce struvite ($MgNH_4PO_46H_2O$). It is developed by Berlin Water and is a sludge optimization process that recovers struvite after anaerobic digestion and before the dewatering process. Since 2014, the WWTP West produces 1250 tonnes struvite a year (Schoumans et al. 2014). By selling the generated struvite an annual revenue of € 400.000 per year is generated (van der Hoek et al. 2017).

These recovery methods are very efficient in centralized WWTP, nevertheless also decentralized treatment methods increasingly receive more and more attention for their high possibilities to recover resources (Daigger 2009; Larsen et al. 2013). Therefore, a short excursion into a recent decentralized treatment method in Amsterdam will be given in the next chapter.

2.4.4 Decentralized WWT in Amsterdam

The decentralized treatment produces smaller residual flows, this implies that the recovery of raw materials is less economically attractive (Rijksinstituut voor Volksgezondheid en Milieu 2016). Nevertheless, the treatment methods always need to be considered in its spatial context. Decentralized systems are receiving increased attention in the urban realm and are defined as:

> *'…standalone systems used for treating dispersed small WW flows, for example, individual residences, residential clusters, isolated buildings and small communities. Process residuals may be processed on-site or hauled to another facility. The WW is*

collected, treated and dispersed or reused at or near the point of generation (26–28%)' (Larsen et al. 2013, p. 99).

Decentralized water treatment systems are considered to be effective, beneficial, and useful for the urban realm (Larsen et al. 2013). In Amsterdam, a small decentralized source separating concept for energy production, where domestic wastewater flows are separated and reused, has recently been implemented (van der Hoek et al. 2016).

Example Nieuwe Sanitatie

The regional water authority of Amsterdam 'Amstel, Gooi en Vecht' together with the MoA are working on a new decentralized system called 'Nieuwe Sanitatie', that is constructed for two areas in Amsterdam - Buiksloterham and Strandeiland. The core idea is the extraction of resources, such as energy and raw materials. For the highest possible RR the WW in the house is separated into a black-water flow and a grey-water flow (see *Figure 8*). Therefore, a multiple sewer system is needed. The pipe for the grey-water is a small diameter vacuum pipe for concentrated black-water. The greywater is a free-fall pipe. Apart from the advantages of efficient local WWT and RR, the wastewater no longer has to be pumped over long distances, which simultaneously saves energy (Waternet 2020c).

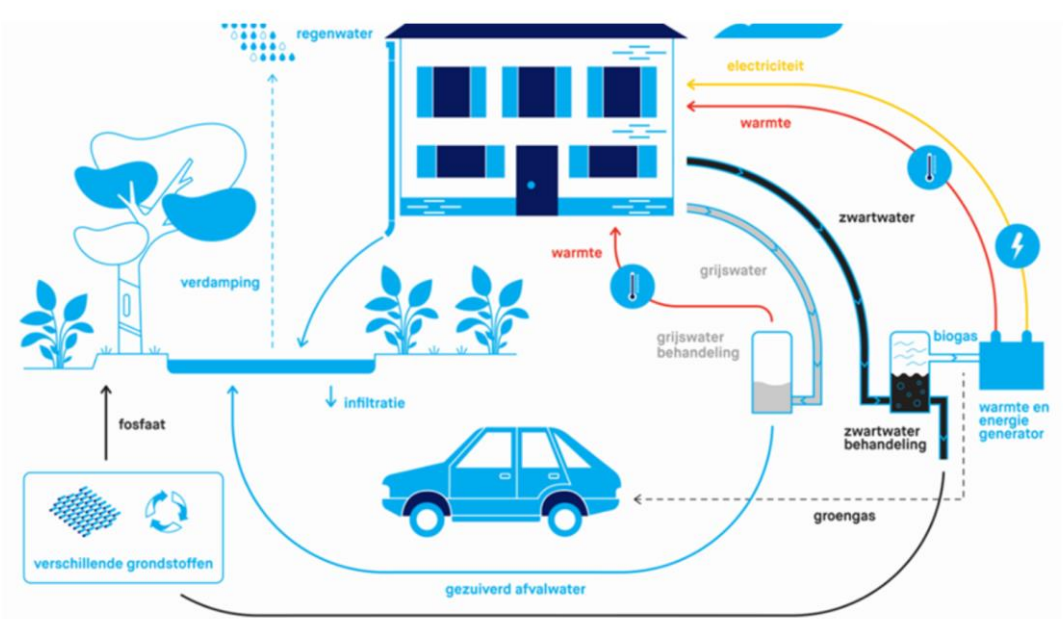

Figure 7_The principle of Nieuwe Sanitatie (Waternet 2020c)

Particularly through the concentrated collection of the black water, biogas can be produced more efficiently. The thermal energy can be reused in the district in form of a low-temperature heating network. Furthermore, through the use of vacuum toilets and vacuum

sewers, up to 30% of drinking water can be saved. Another advantage is the processing of fruit and vegetable waste from the kitchen via the vacuum sewer (Waternet 2020c).

Nevertheless, there are still some aspects that are currently considered as disadvantages: Higher investments than for conventional systems are needed, for example for the management and maintenance. Another risk is that a smooth wastewater process is dependent on the behaviour of residents. The residents are responsible for a proper use of the facilities such as the vacuum toilet, cleaning products, and the food waste grinder (Waternet 2020c), hence sensitization and education are important measures in this regard. A technology that can be applied in a decentralized as well as centralized treatment system is the Nereda technology that is a prerequisite for the practical implementation of this research.

2.4.5 Nereda®

Nereda is an aerobic granular sludge WWT-technology, invented by the Delft University of Technology in the 1990s. The technology developed in a unique public-private-partnership between the Delft University of Technology, the Dutch Foundation for Applied Water Research (STOWA), the Dutch Water Authorities, and the Royal Haskoning DHV (Royal Haskoning DHV 2020b). The first Nereda installations were built in Zutphen and Epe in the Netherlands. Currently 18 Nereda WWT plants in the Netherlands are currently in operation, under construction, or in design (Nereda® Plants 2020).

The Nereda technology consists of self-immobilised bacterial communities that consume wastewater and which are used to produce compact granules. Extracellular polymeric substances (EPSs) are responsible for the structure of the granules. They are sticky polymers which induce cell-cohesion and formulate the aerobic granules (Kehrein et al. 2020). The granules settle faster than floc-structures of conventional treatment-plants and are pushed out of the tank. Therefore, Nereda does not depend on a separate decant phase that would require a lot of time. Additionally, only one tank is needed, as the biological treatment processes occur simultaneously (Royal Haskoning DHV 2020b). The smaller amount of mechanical equipment, no separate clarifiers, and the lower energy consumption make Nereda very space and cost-effective technology.

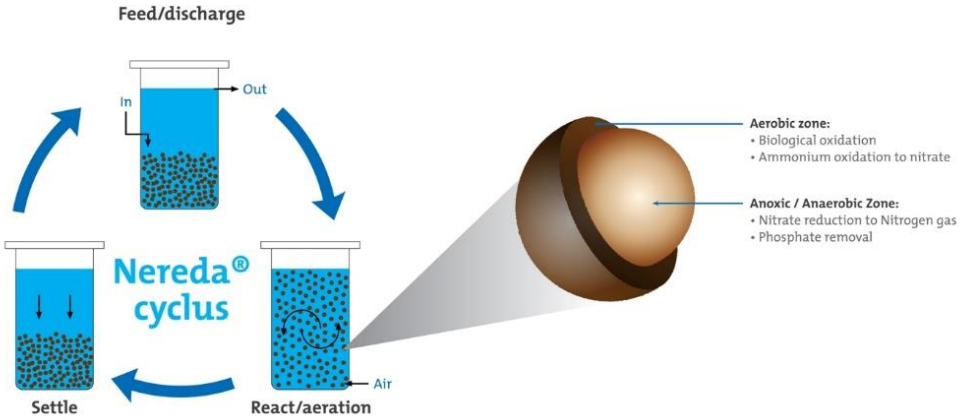

Figure 8_Nereda cycle (van Leeuwen et al. 2018)

The Nereda cycle can be divided in three steps (see *Figure 9*):

1. WW is introduced from the bottom of the treatment-plant. Simultaneously, the treated effluent from the previous batch is discharged.
2. Simultaneously, a biological removal of organic pollutants, nitrogen and P components that penetrate into the granules, occurs, which store the nutrients.
3. Granular sludge settles to the bottom of the tank, which occurs within minutes, compared to one hour in conventional plants. In this phase the biomass is separated from the effluent and a new cycle begins (Royal Haskoning DHV 2020b).

The Nereda cycle requires only 25% of the area that a conventional activated sludge-technology needs, as it combines several steps of traditional WW-treatment in one reactor. Consequently, the need for space and energy for WW-treatment by a Nereda plant is very low (van Leeuwen et al. 2018). This effective process can reduce up to 50% of the energy-costs. The technology can be applied for new WWTP´s but old plants can also be retrofitted. It can be applied to conventional activated sludge systems, as well as decentralized systems. Industrial as well as municipal WW is treated with this technology (Royal Haskoning DHV 2020c).

After having emphasized the most relevant WWT-systems in the context of Amsterdam, respectively HavenStad, the next chapter examines which RRS from WW are relevant in this context.

2.5 Resource recovery from WW

RR from WW plays an important role in sustainable urban development. The RR-technologies have been intensively examined in the recent years. Different methods of WW recovery are amongst others biological recovery routes, energy and product recovery from sewage sludge, and nutrient recovery with microalgae-based treatment systems (Kehrein et al. 2020). The decision regarding which raw-materials can be recovered from which location, is mainly

decided upon economic and technical terms, so far other criteria, such as the sustainability of the recovery-products, are not commonly taken into consideration yet. No matter what technology is applied, not all materials can be recovered in the same process (Rijksinstituut voor Volksgezondheid en Milieu 2016).

In *Table 1*, 21 measures are listed that were identified by van Hoek et al. (2016) that change the material flows in Amsterdam's WW chain. All those measures change the amounts of resources that can be recovered from WW. They are sorted by the different locations in the WW-chain Households and Businesses, Collection, WWTP, and sludge disposal.

Table 1_Measures of WWT and RR changing Amsterdam's wastewater chain (van der Hoek et al. 2016)

Category	Measure	Description
Households & Businesses	1. Green waste disposal	Waste disposal grinders are installed at households and/or businesses. Therefore, green waste is transported to the WWTPs.
	2. Water use reduction	Installation of water saving showers and toilets.
	3. Separate urine collection	Separate collection of the urine from larger hotels, offices and events. Treatment and recovery is done in the traditional way at the existing WWTP, but urine is inserted in the sludge treatment.
	4. Separate urine treatment	After separate urine collection, resource recovery is done at a separate urine treatment facility.
	5. Pharmafilter	Installation of Pharmafilter at hospitals and other care facilities.
Collection	6. More separated sewers	Combined sewers are replaced by separated sewers so less stormwater ends up at the WWTPs.
	7. Reduced groundwater infiltration	Old sewers are replaced by new ones resulting in less groundwater infiltration.
Wastewater treatment plant	8. Primary settling tank	Separation of primary sludge from the influent at WWTPs by settlement due to reduced flow velocities.
	9. Bioplastic production	Through fermentation (mixed or rich culture) the bioplastic PHA can be produced from (mainly primary) sludge.
	10. Cellulose recovery from primary sludge	After primary sludge is separated from the influent using a primary settling tank, cellulose is recovered from the sludge.
	11. Fine-mesh sieve & cellulose recovery from sievings	A fine-mesh sieve is used to separate larger particles, including cellulose fibers, from the influent.
	12. modified University of Cape Town process (mUCT)	Current biological treatment process that removes phosphorus and organic matter from the water and stores it (partially) in activated flocular sludge.
	13. Nereda	Biological treatment process that removes phosphorus and organic matter from the water and stores it (partially) in granular sludge.
	14. Alginic acid production	Alginic acid, a polysaccharide, can be produced from granular sludge.
	15. Thermal hydrolysis	Pre-treatment of sludge using heat and pressure that sterilizes sludge and makes it more biodegradable.
	16. Mesophilic digestion	Current sludge digestion at approximately 36 °C and with a residence time of 20 days.
	17. Thermophilic digestion	Sludge digestion at approximately 55 °C and with a residence time of at least 12 days.
	18. Struvite precipitation ('Fosvaatje')	By adding magnesium chloride to digested sludge, struvite precipitates. This struvite is separated from the sludge and thus phosphorus is recovered.
Sludge disposal	19. Sludge incineration at waste plant	Digested sludge is incinerated. Currently, sludge and solid waste are incinerated together (by AEB).
	20. Mono-incineration	Digested sludge is incinerated separately from solid waste to enable phosphorus recovery from sludge ashes.
	21. Phosphorus recovery from sludge ashes	Phosphorus in sludge ashes is precipitated using iron salts.

According to van der Hoek et al. (2016), the Nereda technology has a positive correlation with the recovery of P and biogas. P and biogas have a very high recovery priority in Amsterdam. The effects of the measures onto the recovery of different products can help to estimate the competition between the various measures (such as listed in table 1) and the concomitant products (van der Hoek et al. 2016).

To narrow the focus of this research, only the selected relevant resources to be recovered in the context of Amsterdam are examined, which are biogas, phorphorus (P), cellulose, and bio-ALE, respectively Kaumera.

RR from WW in the Netherlands

As shown in *Table 2*, recovered resources form WW in the Netherlands have an added value of approximately 26 million Euro/year in 2018. The biggest amount is biogas with 100 installations and an amount of 120 million m³ and an added value of 24 million €. The second biggest is P with 4 ktons and a revenue of 2 million €. Cellulose and Kaumera (Bio-Ale) have not generated a revenue yet. However, Kaumera is estimated to generate an added value of 170 million € in 2030, which would significantly contribute to the total added value of recovered resources in the Netherlands (van Leeuwen et al. 2018). This shows the economical market potential of Kaumera in different future product applications.

Table 2_Recovered resources in the Netherlands

Resource	Installations	Quantities 2018	M€ 2018	Quantities 2030	M€ 2030
Biogas	100	120 million m^3	24[a]	200 million m^3	40[a]
Phosphate	12	4 Kton	2[b]	20 Kton	8[b]
Cellulose	2	5 Kton	0	50 Kton	15[c]
Bio-ALE	10	0 Kton	0	85 Kton	170[c]
Bioplastic	1	–	–	–	–
Total			26		233

[a]Preliminary estimate. Biogas will mainly be used by the producers and utilities for own energy use

[b]Estimate based on total revenues including reduction of maintenance costs

[c]Currently there are 10 Nereda plants that can potentially produce Bio-Ale. Estimates for cellulose and Bio-Ale are based on input from Waternet and Royal HaskoningDHV experts

Value of different materials

One method to assess the value of different resources which are recovered from the biomass of WW, is through the value pyramid of Betaprocess 2020 (see *Figure 10*). The value-pyramid shows the valorisation of different applications from biomass in four layers. The more the biomass is refined and separated, the higher the value of the products. According to the value pyramid the lowest value is resigned to fossil and bio-based energy resources, the second stage concerns chemicals and materials such as fertilizers, on a the third stage layer are valued the food products and on the highest stage pharmaceutical products and fine chemicals (Betaprocess 2020).

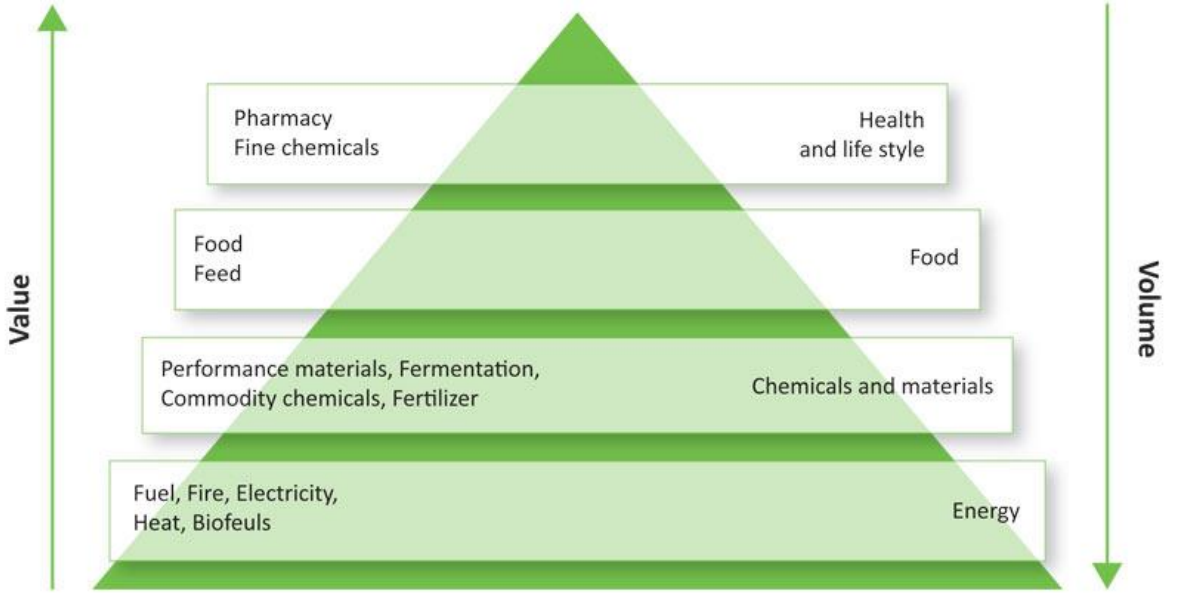

Figure 9_Value pyramid (Betaprocess 2020)

2.5.1 Materials to recover

In the following paragraphs, different materials that can be recovered from WW are described. Thereby, it is also referred to their value according to the above-mentioned value pyramid. The major known alternatives for RR are water, energy, and nutrients, especially P recovery (Rijksinstituut voor Volksgezondheid en Milieu 2016; Mo and Zhang 2013). More recent resources to be recovered are cellulose fibres, biopolymers and bioplastics.

Energy recovery

As indicated, the production of biogas (a mixture of CH_4 and CO_2) by anaerobic digestion with its high economical value (price of € 0.20 per m³) is of very high importance in the Netherlands. Apart from this, the production of biogas covers a lot of the energy consumption of the water authorities (van Leeuwen et al. 2018). With the extraction of Kaumera, the biogas-production would drop, since 30-35% from the discharge sludge ends up in the Kaumera and cannot be converted into biogas. The production of biogas would therefore decrease, if Kaumera were extracted from the sludge. However, through the Nereda-process, the energy demand for WWT would drop significantly. Altogether, it is estimated that the biogas-production will increase in the coming years (van der Hoek et al. 2016). Waternet, the water-authority of Amsterdam is already very experienced when it comes to the recovery of biogas (van der Hoek et al. 2016). According to the value-pyramid, biogas has the lowest upgrading value.

Phosphorus (P)

To protect the environment, preventing nutrient pollution in surface waters is becoming increasingly important. A concentration lies on the implementation of removal technologies for P (Kehrein et al. 2020).

P is a nutrient necessary for food production. Therefore, its priority in the value pyramid is on the second level. As in the case of biogas, Waternet is already experienced in the production of P (van der Hoek et al. 2016). Moreover, P is becoming increasingly scarce. At least 12 P recovery-installations are operational in the Netherlands (van Leeuwen et al. 2018).

So far, not all advantages and disadvantages of the P recovery are known yet. Since *P* recovery occurs at the end of the WWT-process, P has no impact on other recovery measures and therefore does not provoke a competition. However, a minimum P concentration is needed to be an effective recovery measure (van der Hoek et al. 2016).

Currently in Amsterdam around 16% of the P in the sludge is recovered as struvite ($MgNH_4PO_4 \cdot 6H_2O$) and can be used as a fertilizer (van der Hoek et al. 2016). P can also be recovered as struvite in the Nereda technology, which removes a higher P content into the sludge (van der Hoek et al. 2016). P recovered as struvite can already be linked to technical and hygienic quality certification criteria. In contrast to cellulose, struvite is already seen as a product instead of waste. From the Dutch market the demand is still too low, therefore it is mainly exported to the foreign market (Rijksinstituut voor Volksgezondheid en Milieu 2016).

Cellulose

Cellulose is a polysaccharide. The fibres in toilet paper are called cellulose. WW in the Western Europe countries contains a substantial amount of cellulose. Therefore, an extraction and reuse should be considered. The use of toilet paper is culturally determined, therefore the cellulose recovery should be seen in the framework of the Dutch or European market (Rijksinstituut voor Volksgezondheid en Milieu 2016).

180 000 t of toilet paper yearly are flushed down the toilets in the Netherlands. Above 80% of the toilet paper ends up in WWTP. This is equal to the amount of 180.000 trees – if all this toilet paper would be recycled, the deforestation of those trees could be prevented (Kehrein et al. 2020), which again enhances the importance of the design of a WWS according to CE.

Cellulose recovery

Measures to recover cellulose-fibres are the recovery from primary sludge and fine-mesh sieves (<0.35 mm) as a pre-treatment method for WW. First, coarse materials are removed. Second, the water is filtered by the fine-mesh-sieves. Thereby, 50% of the organic material can be removed from the WW. 63% of the fibres consist of reusable fibres. They can replace for example flax, hemp, or wood fibres, and can be reused in different ways for example to produce building-materials such as bio-composites like the RE-PLEX. Therefore, cellulose is placed at the second level in the value pyramid. However, concrete products are still in the development phase and there is still a high degree of uncertainty, especially regarding the hygiene and perception of the product. As a result, the market is still not open enough for a regular supply and demand, also due to the fact that thermal treatment techniques currently promise a hygienic cleaning (Rijksinstituut voor Volksgezondheid en Milieu 2016).

The priority to recover cellulose is lower than the priority of recovering bioplastic, P and alginic acid. As cellulose is traditionally produced from the renewable source wood, it is already considered as more sustainable (van der Hoek et al. 2016).

Nevertheless, since the energy output of processing cellulose in anaerobic digestion is very low, while the percentage of cellulose in WW is very high, it is more sustainable to recover cellulose from WW (Kehrein et al. 2020). It is exemplarily recovered by the relatively small treatment plant 'Blaricum', operated by Waternet. In that case fine mesh sieves have been introduced as a pre-treatment (van der Hoek et al. 2017). Before it can be used for the RE-PLEX, the quality of the material gets upgraded, which implies the removal of odour, colour, fats, and other contaminants. The upgrading is done by a combination of filtrations, a microscopically purification step, sieving, and drying. The resulting fibres have an average length of less than 1 mm. The length and width of the fibres influence the strength of the end-product (Nono Leermakers, Moja Reus, Mike Schroten, Sya Hoeke & Laurens van der Wal 2019a).

Alginic acid and Kaumera

The natural occurring polysaccharide, alginic acid is very versatile. It can be used in the pharmaceutical industry, the food industry, for textile printing, and in the paper-industry. Normally alginic acid is obtained from brown seaweed and can form hydrogels that are biocompatible, non-toxic, non-immunogenic and biodegradable. However, it is complicated to produce it chemically which makes the market position more attractive for similar recovered alternatives (van Leeuwen et al. 2018).

Alginates perform similarly to Kaumera, an Alginate-like Exopolymer (or Bio-Ale) that can be recovered from the granular sludge of the Nereda-technology (van Leeuwen et al. 2018) (Kehrein et al. 2020). The material is used for the production of RE-PLEX.

The bio-polymer (organic mixture of polymers) Kaumera, is produced by bacteria and extracted from the Nereda WWT process (Kehrein et al. 2020). In the language of the original inhabitants of New Zealand, Maori, Kaumera means 'chameleon' and is meant to describe the versatility of the material (Yuemei Lin 2020).

Kaumera is a relatively recent discovered material. It can be applied for different purposes in the agricultural, construction, and the textile and paper industries. It can be used as a coating material for slow-release fertilizers and paper; furthermore as a bio-stimulant in agriculture, as a binding agent to make pellets from powder-like materials such as struvite, and in various forms as fibres, gel, or foam (van Leeuwen et al. 2018). It is a fire retardant and also is applicable as a curing agent for concrete. Last but not least, it can be combined with other raw materials into a bio-composite material (Royal Haskoning DHV 2020a). However, the abundant material properties and the potential application range, substituting conventional polymers still need to be further investigated. Kehrein et al. (2020) state that the production of Kaumera is too costly to be competitive with conventional alginates.

Kaumera recovery

The production of Kaumera consists of several steps. First, the aerobic granular sludge is collected form the Nereda plant. In a second step, it is extracted and separated in the following summarized steps:

1. The mixture is heated until the sludge falls apart.
2. The Kaumera is extracted:
   2.1 Sludge and water containing Kaumera are separated by centrifugation.
   2.2 The sludge is decanted.
   2.3 Contaminates in the water are removed by lowering the pH of the mixture, to flocculate the Kaumera. The remaining water is centrifuged and removed.

Kaumera is mainly composed of proteins and polysaccharides, but the recovery also involves elements in the sludge that are not desired (see *Figure 11*). It also contains heavy metals and pathogens, such as E. coli. that need to be killed during the high-temperature extraction process. Therefore, before it can be used in material applications it needs to be upgraded, by removing the heavy metals, pathogens the colour and the odour by ion-exchange and adding hydrogen peroxide. After this process, the RE-PLEX is produced by mixing the cellulose fibres and the Kaumera by a heat-press technique (STOWA 2019).

Figure 10_Kaumera (STOWA 2019)

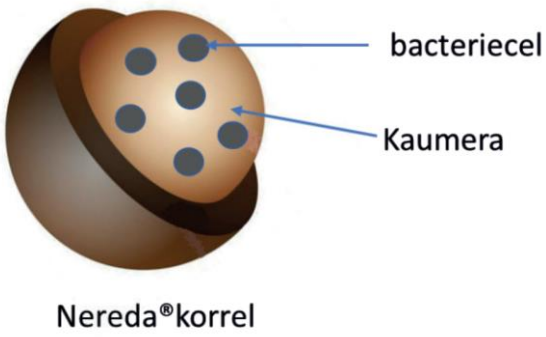

Figure 11_Schematic view of aerob grain of bacteria and Kaumera (STOWA 2019)

In the value pyramid, the product alginate lies at the second level, which means that it is rated higher than biogas (Betaprocess 2020). Consequently, the Nereda treatment process together with the Kaumera production should be considered a valuable technology for WWT (van der Hoek et al. 2016).

2.6 COMPRO

The concept of the COMPRO-project is to produce a bio-composite called RE-PLEX from Kaumera and cellulose, two resources that are recovered from the WW and can be applied in the building and construction sector. So far the researchers of the COMPRO-consortium consider the construction sector as the most valuable sector for the application of RE-PLEX.

2.6.1 Parties involved

The project is a collaboration between the Delft University of Technology, ChainCraft, NPSP, BAM Infra and the AMS Institute. All companies are based in the Netherlands.

The TU-Delft is a leading university in topics surrounding bio-composites out of WW and seeks to increase the value of knowledge about this specific project. The TU-Delft provides the laboratory equipment to conduct world-leading research for the understanding of Kaumera and RE-PLEX (Yuemei Lin 2020).

Chaincraft is an innovative company that specializes in the conversion of organic by-products to products with a high value application. It is the supplier of the Kaumera feedstock and concentrates on finding new and economic applications of RE-PLEX. They aim to find improved Kaumera formulations and seek to lower the legal barriers for Kaumera (Chaincraft 2020).

NPSP is a manufacturer as well as a product developer and provides the expertise on the production of high value light weight fibre-reinforced bio-composites, which have the potential to have a competitive advantage compared to traditional composites. NPSP already has gained experience with the development of products from bio-based composites for an application in building, design, mobility, and industry (NPSP 2009).

BAM Infraconsult B.V. is designing large-scale urban infrastructure such as ports and pursues to contribute to finding sustainable solutions for urban infrastructure. The company is a potential end-user and designer of the product, while providing tender strategies, risk management, systems engineering, and environmental management, and hence reflects an extensive market experience. BAM Infraconsult B.V. is very experienced in the market introduction of innovations and can specifically contribute to the COMPRO-project with functional specifications of product applications. Furthermore, the company is experienced with identifying market-possibilities and constraints (BAM Infra Nederland 2020).

Finally, AMS Institute is the managing party of COMPRO. The Institute's contribution to the COMPRO-project is its vision on closing the loop of waste-streams in Amsterdam, in order to help it to be more circular. The production of a bio-based composites for the construction sector from urban WW for the urban realm fits neatly in their ambition. AMS has an excellent expertise in integrated research to involve all stakeholders of different fields.

2.6.2 The composite material RE-PLEX

Kaumera in combination with cellulose makes up the RE-PLEX (see *Figure 13*), a fibre reinforced composite (Peter Mooij 2019). Traditional composites are composition materials that consist of two or more different materials with significantly different properties, for example a resin and a fibre. The combination often leads to improved or specialized properties such as strength, stiffness, and a low weight to do fulfil a certain function (TWI Ltd 2020). Traditional resins or binding agents such as epoxy or polyester are derived from fossil resources. Kaumera can serve as a replacement for a fossil binder and a lot of energy can be saved compared to the production of a fossil binder (Peter Mooij 2019).

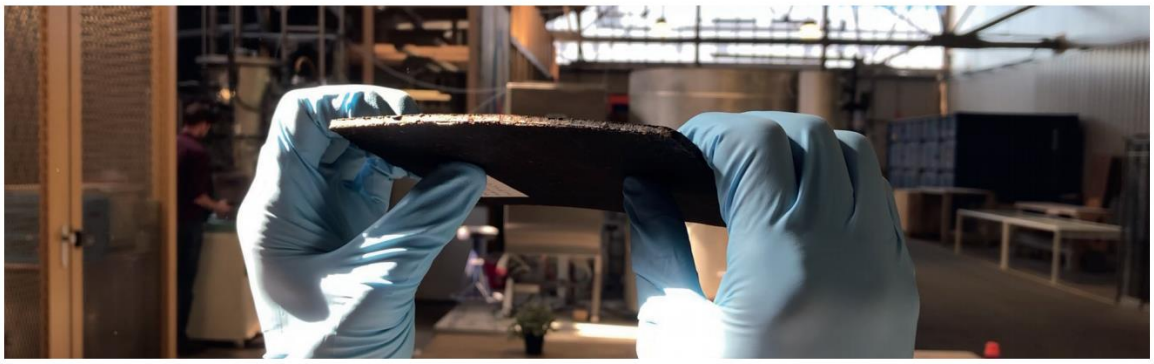

Figure 12_The RE-PLEX (Nono Leermakers, Moja Reus, Mike Schroten, Sya Hoeke & Laurens van der Wal 2019)

2.6.3 Energy demand and CO2 reduction of the RE-PLEX

The production of polyester resin consumes around 130 GJ / ton (Chard et al. 2019). The primary energy consumption of Kaumera, is 18.6 GJ / ton, according to the water authority Waterschap Rijn en Ijssel (Peter Mooij 2019).

In addition to this, the use of cellulose as fibre can save energy compared to glass fibre. The energy needed to produce glass fibre is 48 GJ / ton (Joshi et al. 2004). According to the calculations of the Foundation for Applied Water Research (STOWA), retrieving cellulose from WW consumes approximately **1.1** GJ/ton cellulose. Refining cellulose retrieved from a WWT plant is compared to the energy consumption of refining cellulose from used paper, which is **1.2** GJ/ton (STOWA 2010). Therefore to use retrieved cellulose from WW is calculated to approximately consume **2.3** GJ / ton.

18.6 GJ/ton for Kaumera + 2.3 GJ/ton for Cellulose is 20.9 GJ/ton. Therefore a composite that is half made from Kaumera and half from cellulose is assumed to consume a primary energy of 10.4 GJ/ton. In comparison to a composite of polyester and glass fibre, which consumes 89 GJ/ton, 88% of the primary energy is saved. Therefore with an energy saving of 78.5 GJ/ton the RE-PLEX is much more energy-efficient. Furthermore, given the fact the RE-PLEX is very light-weighted, energy can be saved in the phase of usage (AMS Institute 2020).

The COMPRO consortium estimates that 1 ton of RE-PLEX would save 15.3 tons of CO_2. The glass fibre reinforced plastics market in the Netherlands is around 20.000 ton/year (AVK 2018). If the RE-PLEX would fully replace this market, with an energy saving of 78.5 GJ/ton, the RE-PLEX has the potential of an energy reduction of 1571 TJ of energy, and CO_2 reduction of 307 kton CO_2 (Peter Mooij 2019).

2.6.4 The market size of RE-PLEX

The TU-Delft estimates a source generation of Kaumera 5 kg/per person/year. The Dutch WWT capacity is laid out for approximately 25 million people (inhabitants + industry) a year (Rijksoverheid 2017). Considering the source-availability the potential Dutch market size of Kaumera lies around 125.000 ton/year. The potential for the cellulose market is around 150.000 ton/year. Therefore the potential production of RE-PLEX is around 250.000 ton/year (Peter Mooij 2019). This would be more than sufficient to replace all glass fibre reinforced plastics in the Netherlands. Even though the supply of Kaumera is dependent on the installations of Nereda-WWT plants in the Netherlands. If enough Nereda plants would be provided, the future Dutch Kaumera-cellulose stream would probably be larger than the demand to replace glass fibre reinforced plastics.

However, Kaumera not only has the potential to replace glass fibre reinforced plastics but also other composites, such as hardwood and aluminium and as mentioned in the description

of Kaumera it also can be applied for other sectors, besides the construction sector (Kaumera 2020).

2.6.5 Costs of the RE-PLEX

The estimated costs of a product made from RE-PLEX are 5.30 €/kg. These costs result from the following calculations:

The material costs of Kaumera are estimated to amount to 1.25 €/kg, which includes the cost of the production in the Kaumera plant and the purification of the Kaumera. The profit margin for ChainCraft is of 0.31 €/kg. The material costs for Cellulose are 0.08 €, which entails to retrieve the cellulose and cleaning the cellulose (150€/ton). The production of the composite is estimated at 2.00 €, while the production of the product is estimated at 1.00 €. The profit margin for NPSP is 0.65 €/kg. (1.63+3+65=5.82)

The material costs of the RE-PLEX 1.63 € (1.25+0.31+0.08) are lower than of a conventional composite (glass-fiber 2.00€ or polyester 3.00 €) (Peter Mooij 2019).

2.6.6 Properties and application areas of the RE-PLEX

Apart from environmental friendly properties such as biodegradability, energy savings, and independency of fossil fuels, RE-PLEX also seeks to fulfil other useful properties that fit into the construction-market, such as its lightweight, strong, stiff, and non-flammable characteristics. The current state of the research reveals that the RE-PLEX is fire-retardant and lightweight (Nono Leermakers, Moja Reus, Mike Schroten, Sya Hoeke & Laurens van der Wal 2019b). Other mechanical properties such as stiffness and strength are still in the development process. The exact product properties of the RE-PLEX still have to be assessed by an ongoing laboratory research-process by the TU-Delft (Peter Mooij 2019).

The COMPRO consortium aims to build a prototype from the RE-PLEX technology by 2021. The specific application of the prototype that should be built is still unclear. However, different application fields within the building and construction sector can be identified. One field are temporary construction materials. In the case of temporary constructions, the biodegradability after their usage phase would be an environmental and economic benefit. Applications for temporary usage could for example be cable trays in the soil, soil reinforcement mats, as well as temporary building constructions.

Permanent low-end constructions could be another application field with low to moderate material properties and could for example replace materials such as gypsum. Possible product applications are ceiling plates, door panels, thermal and acoustic damping plates, facing sections, scaffolding boards etc.

The upgraded versions of the RE-PLEX could possibly be high end permanent construction materials with good material properties such as strength and stiffness, which could be a replacement for e.g. wood or aluminium (Peter Mooij 2019).

The COMPRO-members aim to design one or more prototypes for the building and construction sector. The prototypes should fit neatly within the social, technical, legal, and market possibilities of the product. With the prototypes, a field-test and life cycle assessment should be conducted, in order to assess their performance in practice (Peter Mooij 2019).

2.7 The construction sector

The construction sector is responsible for 40% of the global energy- and process-related emissions (IEA 2019). In *Figure 13* the share of energy and emissions of the residential, non-residential and construction industry is visualized.

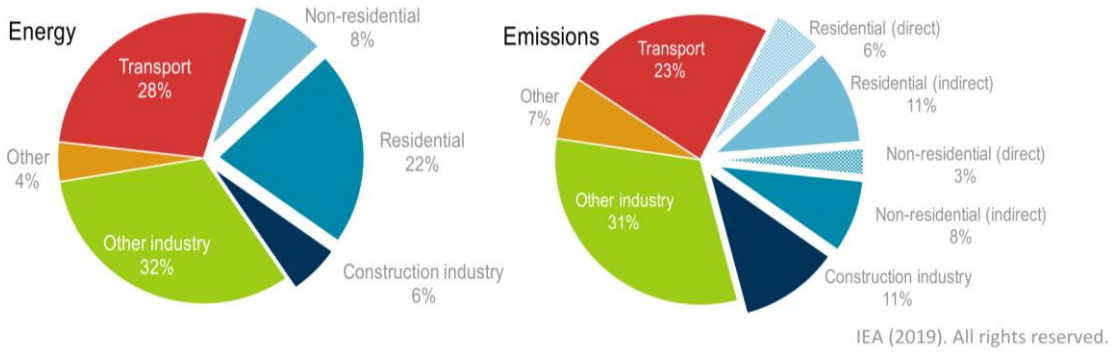

Figure 13_Global share of buildings and construction final energy and emissions, 2018 IEA

Building materials that still dominate the market are conventional mineral products such as concrete, steel and glass, stone, plaster, and aluminium. They are manufactured from finite raw materials and have a high environmental impact. Most of these building materials can be reused in new constructions, which is considered as a sustainable architecture. However, with each re-use of materials, the quality of the materials is reduced significantly (Wikipedia 2020b). The sustainability of a construction material is calculated by the full life cycle assessment (LCA) and the resulting CO_2 emissions during production, construction, use, demolition, and waste processing (IEA 2019).

In *Figure 15*, different materials which were used in Amsterdam within the construction sector in 2018 are highlighted. 670 ktons of materials were used for housing, 40 ktons for office buildings and 309 ktons for infrastructural works. Steel has the biggest impact in CO_2-emissions with 22%, followed by concrete (20%) and brick with 19% (Amsterdam 2020b). If some of those construction materials could be replaced by the RE-PLEX, CO_2 emissions could significantly be lowered.

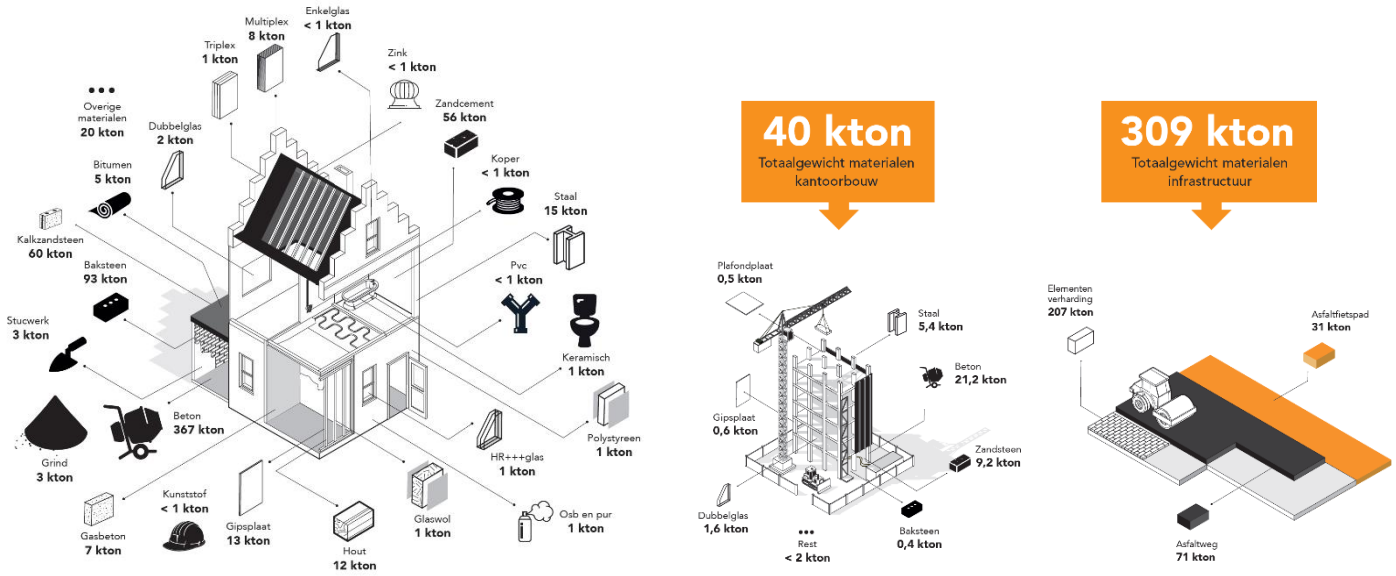

Figure 14_Construction materials used in Amsterdam in 2018 (Amsterdam 2020)

2.7.1 Potential competition for RE-PLEX

It is difficult to determine the share of fully circular building materials. Nevertheless, the demand for sustainable and circular building materials is rising and the supply of sustainable materials has improved significantly. However, the usage of circular products is still stagnating, since the background knowledge on how to use circular materials and which products are available is still lacking (Jan van Dam, Martien van den Oever 2019). So far, a big variance of composition materials, conventional as well as circular alternatives, with various ingredients can be distinguished. Composition materials are for example glass fibres and are often used for indoor applications, such as system walls, floor parts, and ceilings. Opportunities to replace petrochemical fibres and glues with bio-based or natural fibres (hemp, flax etc.) and bio-resins are also increasingly investigated amongst practitioners and academia. Often those composites have a low fire safety and are not completely waste-based. The RE-PLEX could be an opportunity for a circular waste-based composite material with high fire resistance (Jan van Dam, Martien van den Oever 2019). However, the existence of other possible resistances of the RE-PLEX are not fully investigated yet (personal communication with the manufacturer 06.08.20).

Within this study, only the bio-based and circular materials should be examined in more detail, since only a comparable potential market-competition for the RE-PLEX will be assessed in detail.

Bio-based Composites

Bio-based composites are natural fibres combined with bio-based polymers. The market share of bio-based polymers in the polymer-market lies around 1%. According to the graph of the Nova Institute in *Figure 16*, the market share of bio-based composites in Europe will rise from 400.500 t in 2018 to more than 800.000 t in 2027 (Nova Institute 2020).

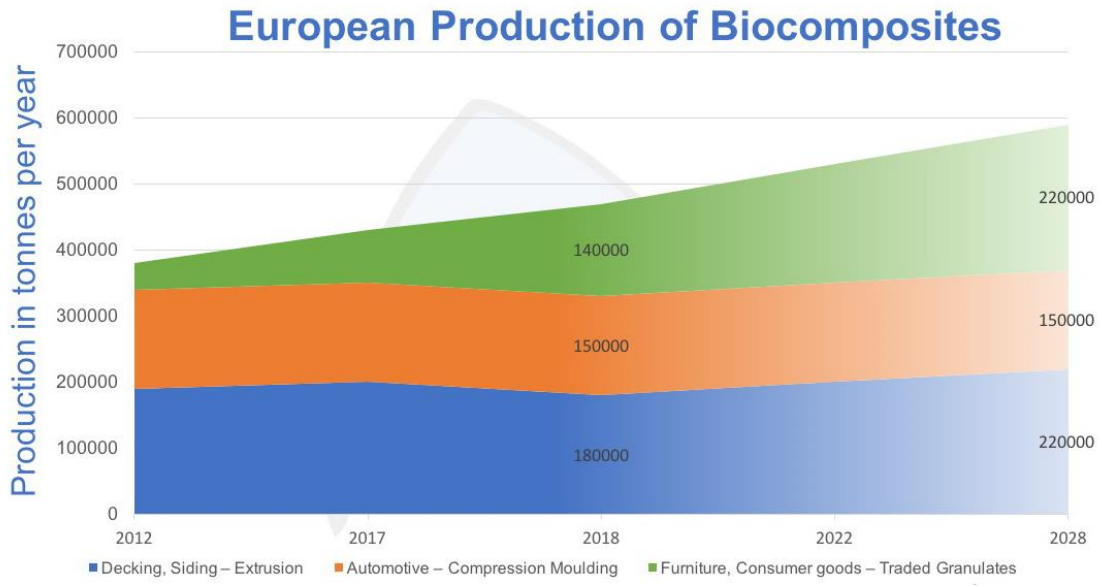

Figure 15_European Production of Biocomposites (Nova Institute 2020)

Renewable polymers are an increasingly emerging market such as the biodegradable biopolymers from synthetic bio-based feedstocks (polylactic acids (PLA)) and synthetic polyhydroxyalkanoates (PHA) and various cellulose derivates that can be 100% composed of natural raw materials. These are so far successful examples to address sustainability from a resource-perspective. Bio-polymers can be reinforced with different bio-based fibres such as plant-based fibres (Jan van Dam, Martien van den Oever 2019).

However, a lot of the bio-based raw materials such as flax and hemp or crop-based materials, are not waste based, which is a competitive advantage for the RE-PLEX. The biomass-feedstock is a necessary factor to consider, especially while taking the debate of conflicting uses of food production into consideration (bioplastics magazine 2020). Waste-based

reinforcement possibilities are agricultural wastes, consumer food waste, or industrial co-products.

Bio composites can be divided into three main groups: (a) bio fibre-reinforced petro-based polymers (no degradable), (b) bio fibre-reinforced bio-based-polymers (biodegradable), and (c) synthetic fibre (glass or carbon fibre) reinforced bio-based-polymers (non-biodegradable). The RE-PLEX can be related to the second category.

Apart from NPSP, there are many other companies that develop bio-composites that range from partly bio-based to fully bio-based. Some of the companies and their products are listed in the following database: https://www.bio-basedconsultancy.com (InnProBio 2020).

However, the use of those bio-composites is still limited. The reasons can be manifold, such as high costs, small scale productions, and sometimes lower mechanical performance properties, such as an insufficient mechanical strength (Chang et al. 2020).

The high competition in the construction sector makes is difficult for the sector to foster innovation. Another reason can be political or legal barriers, such as the process of certification that prevent a market-introduction, which will be examined more deeply within the next chapter.

2.8 European and Dutch policies and certifications

The following chapter describes the political preconditions for the environment that shape the market in which the product must meet certain conditions in order to reach a market potential. Several legislations, European as well as national ones, regulate the field of waste products. These regulations ensure the environmental and responsible handling and processing of waste materials, end-of-waste criteria, and rules for the trading of substances, which are recovered from waste materials (Rijksinstituut voor Volksgezondheid en Milieu 2016). The most important regulations will be revealed in the following.

On a European level, the EU has implemented diverse political supporting instruments for upcoming sustainable innovations. For instance, the strategic EU policy for sustainable growth sets the raw material efficiency and the aim of less dependence on fossil resources as one of the seven aims in regards to the Horizon 2020 research and innovation program, which supports sustainable innovations in the EU (European Commission 2020a).

On a national level, the transition agenda for the CE with the construction sector as a priority sector was formulated in 2018 by the 'Nederland Circular in 2015', which draws attention to the circular use of materials (Crielaard, Machiel 2015). The Dutch government has set out three goals, which aim at converting the Dutch economy to a circular economy as soon as possible:

- *'Ensure that production processes use raw materials more efficiently, so that fewer are needed.*
- *When new raw materials are needed, use sustainably produced renewable (inexhaustible) and widely available raw materials, like biomass – raw material made of plants, trees, and food waste. This will make the Netherlands less dependent on fossil fuel resources, and it is better for the environment.*
- *Develop new production methods and design new products to be circular*'.

Another political instrument is the sustainable procurement, which favours companies that acquire their goods under the umbrella of Corporate Social Responsibility (CSR) in their decisions and specifications (EcoVadis 2020). CSR certifies the voluntary sustainable action of an enterprise that surpasses the standards for sustainable economy (Wikipedia 2020a). According to the Netherlands Enterprise Acency (Rijksdienst voor Ondernemend Nederland), sustainable procurement will be the standard for the municipalities, provinces, and water boards by the end of 2020. Therefore, the government installed the so-called Socially Responsible Procurement Program (Maatschappelijk Verantwoord Inkopen). Part of this program, which is relevant for the COMPRO project, is the circular and bio-based procurement (Rijksdienst voor Ondernemend Nederland 2020c). Altogether, these exemplary policies promote circular and bio-based product innovations. It can be demonstrated that several political instruments are in place and that the topic of circular construction is seen on a political level. However, at the same time several legal regulations regarding the waste management can impede the sustainable development.

2.8.1 Legislation policies

Several European and national regulations are important when it comes to the recovery of raw materials form sewage sludge. Cellulose as well as Kaumera are both recovered from WW. The regulations contain rules for processing and trading waste materials in an environmentally-conscious way. These regulations determine whether and when a product is considered as waste and when it can become a product, and secondly when materials recovered from WW can be registered and marketed. The most important European regulations are the Waste Framework Directive (2008/98 / EC) and the REACH Regulation (1907/2006). The most important Dutch regulation is the Wet Milieubeheer (in English Environmental Management Act). Especially regarding the RE-PLEX in the first place the end-of-waste criteria are relevant.

2.8.2 The Waste Framework Directive (2008/98 / EC)

According to the Waste Framework Directive (2008/98 / EC), when screening material is extracted from the WWTP, it is classified as waste: 'Waste' means any substance or object which the holder discards, intends to discard, or must dipose of (Waste Framework Directive (2008/98 / EC; Article 3.1).

End-of-waste criteria define when a waste becomes a product. To make products from resources such as RE-PLEX, the waste-label must be removed. According to Article 6 of the Waste Framework Directive, waste becomes a product 'when it has undergone a recovery operation and complies with specific criteria to be developed in line with certain legal conditions, in particular:

- *'the substance or object is commonly used for specific purposes;*
- *there is an existing market or demand for the substance or object;*
- *the use is lawful (substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products);*
- *the use will not lead to overall adverse environmental or human health impacts.'* (European Commission 2019).

In the Waste Framework Directive no end-of-waste criteria have been set for WW or the recovered substances out of WW, even though, WW falls within the definition of waste. As there are no end-of-waste criteria defined in the EU-policies for WW, the member states are responsible to decide upon whether a waste material no longer is waste.

2.8.3 Dutch Environmental Management Act (Wet milieubeheer)

Since 2002, the Dutch Environmental Management Act, (in Dutch „Wet milieubeheer") depicts the Dutch environmental law. According to Article 1.1 of the Environmental Management Act, waste materials are substances that meet the definition of the European Framework Directive. No specific national end-of-waste criteria for urban WW are defined yet either. Therefore, at least the requirements under Article 6 of the Waste Framework Directive need to be fulfilled, unless an exemption is requested (STOWA and Ruiken 2010).

To avoid to be classified as waste, the product first needs to fulfil certain requirements such as safety and technical standards, which assures, that the product does not cause any social or environmental risks. One of the risks are hygienic issues, as WW always contains a certain amount of rest-pathogens after its purification (Rijksinstituut voor Volksgezondheid en Milieu 2016).

The water authorities are responsible for the assessment for each recovered substance, by assessing whether a substance is waste or already a product (Rijksinstituut voor

Volksgezondheid en Milieu 2016). The Dutch government for water-issues Rijkswaterstaat (has developed a tool, called 'Waste or Raw Material' (in Dutch 'Afval of Grondstof') that provides guidelines for the end-of-waste-criteria (Rijkswaterstaat Ministry of Infrastructure and Water Management 2020). As soon as it becomes clear for which kind of applications the product requires which type of properties, the 'waste-label' can easier be removed (Rijksinstituut voor Volksgezondheid en Milieu 2016).

Another regulation that regulates if a product is waste or not, is the Dutch 'Leidraad afvalstof of product'. However, also in this regulation no criteria are defined for products out of WW (Ministry of Infrastructure and Water Management 2018).

When a product is approved, it can be supplied to third parties. In this regard, certifications systems such as REACH need to be considered, which will be explained in detail in the next chapter.

2.8.4 REACH

In case the waste declaration does not apply to a product anymore, it may still be liable to the REACH regulation. REACH is the European chemicals regulation (EG) 1907/2006 for the Registration, Evaluation, Authorisation, and constraint of CHemical substances (Umwelt Bundesamt 2020). REACH applies to any enterprise that 'produces, imports, distributes or uses chemical substances, preparations and articles that contain chemical substances in the European Union' (Rijksinstituut voor Volksgezondheid en Milieu 2016). Any company or water authority that has recovered a product from its waste streams and seeks to subsequently trade it (in an amount of> 1 ton / year per legal entity), needs to fulfil the REACH conditions (Rijksinstituut voor Volksgezondheid en Milieu 2016). If the product fulfils the conditions of the REACH legislation, the next step that is applied is a certification process of a specific product for its respective application in buildings.

2.8.5 National environmental legislations for building materials

Environmental government requirements for constructions are included in the 'Building Decree' (in Dutch 'Bouwbesluit'). The Building Decree regulates the minimum requirements a building such as a home or an office must meet with a usable surface area greater than 100m2. These concern the safety, health, usability, energy efficiency, and the environment (Bouwbesluit online 2020).

The environmental performance of materials is rated by the MGP environmental performance indicator (MilieuPrestatieGebouwen). The lower the measure, the more sustainable is the use of materials in the building. The MGP is calculated by a LCA conducted by a qualified expert (Rijksdienst voor Ondernemend Nederland 2020b). Specialized quantification-tools, such as the software 'GPR-Gebouw', are used in order to calculate the performance of energy, environmental, health, and quality of the product (GPR software 2019). The resulting

indicators from the LCA are collected in the National Environmental Database. The supplier of a product should be aware of the fact that the product gets listed in this database (Nationale Milieu Database 2020). As long as products are not listed in the database due to uncertainties in choice, they are not obviously considered for choice by end-users. Furthermore, there is no standardized assessment for circular building materials in place yet. Therefore conventional building materials such as wood and timber are increasingly chosen as the bio-based choice of materials (Jan van Dam, Martien van den Oever 2019).

2.8.6 Certification system

Internationally, there are various certification systems for the use of sustainable materials (LEED, Green Star, HQE, WELL etc.). Certification systems can help companies in their procurement activities as a source of information regarding the technical product specifications (InnProBio 2020). Exemplarily, the most widely used certification systems in Europe that could apply to the RE-PLEX are 'Seedling', the 'DIN Geprüft', and the 'OK compost'. These specifically refer to the biodegradability and the bio-based character of products (InnProBio 2020).

In a subsequent step, when it comes to the application in buildings, certification systems such as the BREEAM-certification might become relevant. BREEAM is a British labelling methodology to determine the sustainability performance of buildings and projects. The Dutch Green Building Council (DGBC) opted for a system that can be internationally compared and adapted to international BREEAM certification system (Dutch Green Building council 2020).

Generally, for the RE-PLEX it is still not yet clear which requirements will arise from the certification systems and whether they will create additional barriers. This can first be identified when a prototype gains a foothold on the respective market.

Altogether, this chapter served to set the COMPRO-project into its political and legal context. In respect of the evaluation of the market acceptance of the RE-PLEX they are relevant and are picked up in the evaluative part of this research. The next chapter will give an overview of the used methodology in this study.

3 METHODS

In light of the lack of research concerned with the market potential of strategies to use recovered resources from WW, this study aims at closing this gap by looking at one specific project in detail, namely the COMRPO-project. The case seemed appropriate for analysing the market potential in detail, since it is already connected to a network of stakeholders that can contribute with their expertise. In this chapter, the methodology that was pursued to collect and analyse the empirical data, in order to answer the research question will be described. A qualitative research design was adopted, since this enables to involve the expertise of stakeholders into the research. In short, the data collection consisted of expert interviews. The data analysis was conducted through a combined content analysis by (Mayring 2015).

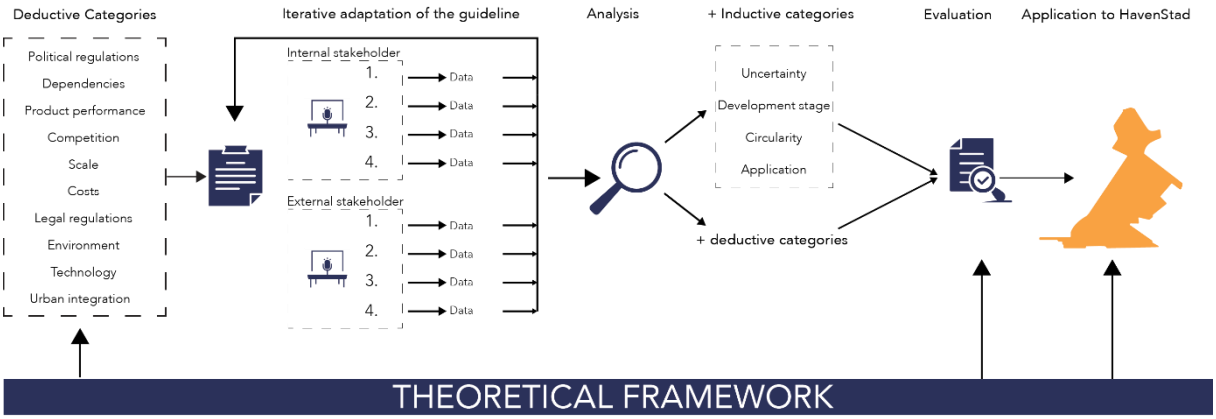

Figure 16_Methodological structure of the work (own illustration)

3.1 Data Collection

3.1.1 The guided interview as a qualitative research methodology

The method used for this research is a guided interview. The interview that follows a determined guideline underlines several methodological principles. According to Gläser und Laudel (2010), the theoretical approach towards an interview guideline is based on the fact that questions should be formulated according to the general interest of the research question. Hence, the guideline considers the theoretical background in a sufficient way. A second formulated principle is the principle of openness, whereby questions are formulated in a way that the interviewee has enough realm for the interest and knowledge of the interviewee (Gläser and Laudel 2010). The operationalization of these principles during the interview has been summarized by Hopf (1993):

- *Scope*: the interview should refer to a wide scope of problems, securing that the interviewee has a sufficient scope to react from different perspectives.
- *Specificity*: To prevent standardized answers, the topic and questions of the interview should be asked in an open form. It also refers to the translation of the knowledge of interest into the context of the expert
- *Depth*: The interviewee should be supported in its involved cognitive and value based situations.
- Personal context: the social context of the interviewees should be considered.

According to Gläser and Laudel (2010), a guided interview that adheres to these principles has a widely accepted application realm. This approach is considered suitable for the wide stakeholder-network of the value chain of COMPRO.

3.1.2 Expert interviews

The empirical data collection of this thesis was specifically conducted by expert interviews, as this method permits an unproblematic access to expert knowledge in this research field (Gläser and Laudel 2010). Professional data can be quickly generated and further contacts might be generated through a reference of experts to further experts (Meuser and Nagel 2009). The expert knowledge can be translated into three dimensions; *technical knowledge, process-knowledge, and interpretive-knowledge (Menz et al. 2008)*. The *technical knowledge* is characterized as operational and technical know-how. The *process-knowledge* consists of the information regarding interactions, routines, organisational constellations, as well as former or current events, into which the expert is involved owing to its practical work. In contrast to the *technical knowledge* it is less expertise-based but more based on experiences in their respective context. Lastly, the *interpretation-knowledge* is a rather subjective knowledge that filters the perception of the expert connected to ideas and ideologies (Menz et al. 2008). For the purpose of this study's research question, all three dimensions of knowledge were relevant and applied.

3.1.3 Interview guide

The interview guide was introduced with a summarizing exposé regarding the purpose of the interview and the research interest, as well as the introduction of the COMPRO-project and the urban development HavenStad.

The interview guide was the framework for the collection of data and their evaluation as well as a thematic structure to ensure the comparability of all interviews. The structure was divided into three parts, an organizational part, an urban integration part, and finally, a product part.

Amongst the clusters, the questions of the interview guide were slightly adapted according to each expert and based on the results of the previous interviews. In some cases questions

were considered more or less relevant after the results of the previous interview. This follows the principle of flexibility according to Gläser and Laudel (2010), which states that empirical research during the whole research process needs to be adapted flexibly according to the situation and relation of the interviewer and the interviewee. As the context of each expert in relation to the COMPRO project differs, it was considered useful to slightly adapt the questions according to the experts' field of expertise, in order to get more precise answers to the respective questions. Nevertheless, it was always assured that the questions were still related to the structure of the interview guide so that the comparability of the interview guides could still be guaranteed (Gläser and Laudel 2010).

The requested knowledge by the researcher was rather complex, as the research consists of multiple layers, such as stakeholders and political conditions, urban specifications, as well as specific product and technological components. Therefore the experts were asked for their contextual as well as their entrepreneurial knowledge. The entrepreneurial knowledge was more focused on the actions and principles of the expert in its own institutional regulations. In contrast, the contextual knowledge was more focused on the perspective of the actions and contextual conditions of other stakeholders (Meuser and Nagel 2009).

To be able to reconstruct both forms of knowledge, the interviews were conducted semi-structured. The questions in the interview guide were structured but were handled in a flexible order. Put in other words, the situational reflections of the expert could be picked up by the interviewer with additional and random questions to complement the information (Gläser and Laudel 2010). The interviewer's openness to narration gave the interviewees the possibility to illustrate and exemplify their principal-related opinions and actions, by encouraging the interviewees to talk about their experiences. Thereby, the information emphasized by the interviewee was subsequently prioritised as relevant for the researcher.

In this part the exemplary structure of one interview guide, for an expert with the role of an end-user will be explained in more detail (all different interview-guides in the Appx. 7.4.3) In contrast, in the interview guide for the manufacturers the emphasis was rather put on the technological questions, while in case of governmental experts the emphasis was dedicated to urban and social aspects, and finally, the interview guide for the end-users concentrated on the product performance and economical aspects.

In the beginning introductory questions were asked as warm-up questions to generate a casual atmosphere. After the warm-up questions, more complex questions were raised according to a sub-topic structure, as the participants' concentration in this phase is the highest (Häder 2010).

- *How are you?*
- *For how long are you in your position in the company?*
- *What is your task/position/relation to the COMPRO-project?*

The first part of the interview guide regarding the concept and the network of the COMPRO-project frames questions dedicated to dependencies on other stakeholders, political, legal, and financial regulations, which can be assigned to the process-knowledge (Menz et al. 2008). The questions aimed at more contextual answers and therefore were asked generally to promote the openness of the interviews (Gläser and Laudel 2010).

General

- *What do you consider as social/economic advantages/risks of the COMPRO-project?*

Dependencies

- *Does an innovative project like COMPRO that is connected to a network of different stakeholders (WW-plant, manufacturers, end-users) involve operational (e.g. communication/infrastructure) difficulties for you?*
- *What organizational difficulties have you experienced/or could arise when depending on the by-product streams of a WW-treatment-plant?*

Political and legal guidelines

- *Which political or legal guidelines do you perceive as the most preventing regulation for the COMPRO-concept (e.g. waste-label)?*
- *What measures could be taken by political bodies (e.g. Gemeente Amsterdam or Rijkswaterstaat) to make those innovative concepts less risky and uncomplicated (e.g. subsidies)?*

Financial performance

- *Are there financial risks you have to accept when depending on the by-products of a partner-company (e.g. supply shortfall)?*
- *Will the installation-costs rise with the use of bio-based products?*

The second part addresses the possibilities and difficulties to integrate a project such as COMPRO into the urban realm.

Urban integration

- *How do you imagine the integration of the COMPRO-concept into an urban development such as HavenStad?*
- *Could you imagine that RE-PLEX is applied in a bigger urban scale in a symbiotic network of companies?*

The final part, the product-part, mostly concerned the profile of the product on the market. Thereby, fact-oriented questions (*technical knowledge*) are addressed but also more opinion-based questions such as the product-performance and the properties the product ought to fulfil in order to reach a customer-satisfaction (*interpretation knowledge*) (Menz et al. 2008).

General

- *Where do you see an added value of RE-PLEX?*
- *What is the motivation to integrate the RE-PLEX into the products in your company?*

Market Scale

- *Can you say which amounts of RE-PLEX would need to be generated to make it economically valuable for your company?*

Technological feasibility

- *Which technological barriers prevent the implementation of COMPRO?*
- *What applications the product can have in your company?*
- *For which applications other than those in your company, do you consider RE-PLEX most useful/more profitable?*

Costs

- *Which procurement-costs are connected to an introduction of the RE-PLEX-product?*

Product performance

- *Which quality criteria the product needs to fulfil to be competitive with conventional products? (E.g. glass-fibre; polyester composites*)

Customer satisfaction

- What are your doubts about a product (e.g. walls of a house) originating from residual waste?
- In which product-application these properties would be most accepted?
- Would it be a difference for you if the WW for the composite-material derives from municipalities or from the WW-stream of one company?

Environment

- The RE-PLEX-product has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

As a finalizing question the experts where asked, if they would like to add some information that was not included in the interview.

Conclusive

- *Is there anything that has not been considered so far, that you would like to mention?*
- *Is there something you want* to know from me?

Altogether, the interview guide made sure, that in all interviews the structured topics were addressed. At the same time, the guide guaranteed that the different interviews were comparable.

3.1.4 Selection of experts

The eight experts for this study were mainly selected according to their position in a specific market-context connected to the RE-PLEX product. They were consciously chosen as relevant stakeholders in the value network of the RE-PLEX that can provide information regarding their specific role in the value network (Gläser and Laudel 2010). The groups of experts can be divided into manufacturers, end-users, and governmental experts. To extract these experts from their specific profession and field of knowledge seemed reasonable, since through their activities in their profession they gain access to a specific knowledge (Meuser and Nagel 2009).

In the data collection phase, it was strived to acquire a selection of altogether ten different experts from an 'internal' and 'external' professional perspective regarding the COMPRO project. The *internal* experts were the experts that are members of the COMPRO consortium, whereas the *external* experts represented stakeholders that potentially could be connected to the value-chain of the COMPRO-project, respectively the RE-PLEX product. One stakeholder from each market party (producer, processor, end-user) was selected out of the COMPRO-consortium. External stakeholders were chosen in order to cover the governmental urban dimension (Waternet, the water authority and the MoA), and manufacturers and end-users of the product in the region of HavenStad.

The interview length of one interview approximately took one hour. Altogether 16 different experts were initially contacted via 28 mails and 12 phone-calls made by the interviewer in order to finally find eight experts, who were willing to give an interview. The final selection were four internal and four external experts, which enabled a balance in the perception of the project.

Five out of eight interviews were conducted with male experts. The status as well as the gender might have influenced the output of the interviews (Meuser and Nagel 2009). Specifically, the appearance of the young-female interviewer in relation to male experts with a higher social status role might possibly have led to a sceptical perception regarding the competence of the interviewer by the experts (Meuser and Nagel 2009). However, simultaneously this might have been an advantage for the information in the interview, since the interview partners tended to explain their arguments in more detail. In practice, these perceptions do not necessarily apply to all interviews and might only be materialized for some of the interviews (Menz et al. 2008). However, these biases were not further assessed in this study.

The interviewees were informed about the anonymity of the interview, in order to generate more trust and openness towards the interviewer. Consequently, in this report no names or personal information of any experts, nor the specific belonging to the enterprises are mentioned. To be able to track the content of the interviews used in this thesis they are signed by the abbreviation E 1-8.

3.1.5 Fieldwork

The first interviews were conducted with the *internal* experts. The interview guide was send to the internal experts with the agreement for the date of the interview. The interviews were conducted online. Two of the interviews were conducted with the online-meeting software 'Sykpe'. The audios were recorded with the interviewee's consent. The other two interviews were conducted via the online-meeting tool Microsoft Teams in combination with the recording tool 'Audacity'. Thereby the audio showed some disruptions, whereby some information got lost. However, through the request of some additional questions via mail to the experts after the interview, some uncertainties could be resolved.

The expertise from the first *internal* expert interviews was used partly for the selection of the *external* experts, since some broader application fields of the RE-PLEX could be revealed.

Most of the contacted external stakeholders did not know the project and the product yet. Therefore they first received a five-slide long presentation explaining the main content of the COMPRO-project [Appx. 7.1.3]. Also the external experts received the interview-guide before the interview. Two other requested stakeholders gave the feedback that they did not perceive themselves as an expert and therefore were not willing to participate. Some stakeholders gave the feedback that they were occupied with other enterprise internal issues, where COVID-19 might have been are reason. One interview (by a retailer of construction materials) was answered in a written form.

The interviews were transcribed entirely by the researcher and the software otter.ai. In this way the exact content of the interviews could be traced. Especially in two interviews, the poor audio quality and the content of the interview could only be understood by the interviewer. Hence, a complete transcription seemed reasonable as a first step. The other interviews were transcribed via the software otter.ai and corrected by the interviewer in a second step. Transcription rules were summarized in the Appendix [7.1.5].

3.2 Data Analysis

The analysis of the interview transcripts in order to answer the research question was conducted by a combined form of the structuring and summarizing qualitative content-analysis of Mayring (2015). The structuring qualitative analysis was used to generate deductive categories. The summarizing qualitative analysis was used to generate the inductive categories (Mayring 2015). The combination of the deductive and inductive

categories reflects the principles of Gläser and Laudel (2000) to create the interview guide according to a theoretical background but keeping the openness to the narrative answers of the interviewees as well. The software MAXQDA was used as an analytical tool to relate the content of the transcripts to the deductive and inductive categories.

As the theoretical framework of this work shows, the theoretical knowledge connected to the research question can already be used as a deductive framework of this study. Therefore, preliminary considerations could be taken into account through the deductive category-building. According to Mayring (2015), during the evaluation part, the deductive categories all were defined and furthermore an exemplary citation of an interview that represents the category was cited and examined (Ankerbeispiel).

The following *deductive categories* were conducted out of the preliminary research and following the interview guideline:

- *Political regulations*
- *Dependencies*
- *Product performance*
- *Competition*
- *Scale*
- *Costs*
- *Legislation*
- *Environment*
- *Urban integration*

To keep the openness for upcoming knowledge during the data collection and analysis, the set of deductive categories was supplemented by a set of inductive categories. The inductive categories were built through a reduction process according to the summarizing content analysis of Mayring (2015). Aspects that were mentioned in the interviews more often and considered as relevant but not relatable to one of the deductive categories where summarized in inductive categories. The statements were collected in a table and the important information for the category was extracted to for reduce the filtered information to a category. The table of the reduction of the data is available in the Appendix [Appx. 7.4.2]. The categories were selected carefully, by contributing to answer the research question. Consequently the following *inductive categories* could be deducted:

- *Circularity*
- *Uncertainty*
- *Development Stage*
- *Application*

Also for the inductive categories an introducing definition was formulated by the researcher before the interpretation part of the respective category.

3.2.1 Validity and reliability

The validity refers to the degree of preciseness to which a research is conducted, whereas the reliability describes the preciseness regarding the reproducibility of the results (Häder 2010). In the case of the expert interviews the validity might be influenced by the beforehand described gender and status relation that might affect the outcome of the interviews (Meuser and Nagel 2009). However, this effect was anticipated by the interviewer and compensated with a profound theoretical preparation before the interview took place, and a consequent adaptation of the interview guide according to the outcome of the previous interview.

The intracode-reliability is relevant in terms of qualitative research (Mayring 2015). According to the intracode-reliability a 're-test' is applied, when all inductive categories have been added to complete the category system. The coding (relating the data to the categories) of all eight interviews were revised, and checked by the researcher (Mayring 2015).

According to both quality principles a pretest of the interview was conducted with a person that is approximately in the same age group as the experts (35-50), and without knowing the project. The person only was previously informed with the information that also the external experts were sent in advance. The pretest aimed at knowing the time needed for the interview and testing the general comprehensibility of the questions. Furthermore it served as a training for the interviewer.

After having highlighted the methodology in use, the next chapter will highlight the main findings of the study. In the next chapter, the results will be evaluated and interpreted.

4 FINDINGS AND EVALUATION

In this thesis the market potential of the COMPRO project, respectively the RE-PLEX product is examined. In a second step, it is examined which measures could be taken to raise the acceptance for an implementation an urban development such as HavenStad. This is framed by the following the research questions:

> *'What is the market potential of innovations from recovered resources from WW such as the COMPRO project and what measures can be taken to raise the acceptance for an integration of COMPRO into urban development projects such as HavenStad?'*

The research question will be examined on different levels. Spiker and van der Grinten (2014) developed a conceptual framework 'to organize factors that influence a circular chain' (Rijksinstituut voor Volksgezondheid en Milieu 2016). The framework distinguishes between three different system levels: First, a policy landscape, second, a dynamic sector level of stakeholders, and third, a product level (Rijksinstituut voor Volksgezondheid en Milieu 2016).

The following chapter will present the data analysis, which is derived from the expertise of the experts, in the different inductive and deductive categories, by following the above-mentioned policy landscape and stakeholder, and product level. A definition of the deductive categories based on the theoretical framework will be given before setting it in relation to its respective context. Likewise, the inductive categories will be defined and in a second step interpreted, with the support of the theoretical framework. In a final step all categories will be assessed according to their interrelations and main outcomes. An exception is the category of urban integration, which will be discussed based on the outcomes in the context of HavenStad.

4.1 Policy and Stakeholder Level

On the policy and stakeholder level of the evaluation the following sub research questions are examined:

- *What organizational difficulties and interdependencies arise between the stakeholders in projects such as COMPRO?*
- *To what extent does the exterior framework of political and legal regulations influence the market acceptance of the project?*

4.1.1 Deductive Category - Political Regulations

Description

Policies define the rules in which the market operates. There are stimulating as well as

preventing policies for the reuse of materials (Rijksinstituut voor Volksgezondheid en Milieu 2016). A good political will or economic incentives are supporting instruments in order to implement a RRS (Kehrein et al. 2020).

Interpretation

As discussed in the circular strategy of the MoA, it has an essential influence on the implementation of innovations. It sets the framework and a direction with long-term transition goals. It also has the authority to set circular ambitions for the procurement of materials in public space, whereby the market is encouraged to innovate new procurement processes (Gemeente Amsterdam 2020). In their innovation strategy, the MoA also refer to the 'Milieu Prestatie Gebouwen' (Environmental Performance of buildings) instrument, in order to encourage the use of bio-based building materials (Amsterdam 2020a). The responsiveness of the COMPRO project in regard to the ambitions of the MoA is rated very high by the experts [Appx. 7.4.3, E5: 111; E3: 97]. In their interviews, several experts refer to the strategy of a CE envisioned by the city of Amsterdam by 2050.

At the same time, the Dutch government has an influence on the promotion of innovation e.g. by providing financial help. Subsidies are a simple measure that are considered as important measures by the experts [Appx. 7.4.3, E3: 97; E5: 23].

> E6:27 '*Yes subsidies are often necessary to cover the costs for testing etc. (expensive) in order to obtain the appropriate certifications for your product.'*

Some subsidizing incentives such as the so-called 'Green Deals' already exist in the Netherlands (Green Deal 2020). In a Green Deal, scientific institutions and companies are supported to create innovations and therefore a measure to promote circular innovations (Green Deal 2020). In this sense, the policy measures can essentially influence the potential of innovations in a supporting way. One Green deal (Green Deal 154) is especially dedicated to bio-based construction, which aims to improve the position of bio-based building materials. Additionally, further subsidizing incentives are provided by the government (Rijksdienst voor Ondernemend Nederland 2020a). Different Green Deals have been signed in 2014 for the recovery of cellulose, bioplastics, phosphate, bio-ALE (Kaumera), biogas, and CO2 (van Leeuwen et al. 2018). These incentives demonstrate a large political will concerning innovations in the frame of the CE.

However, one expert remarked that besides these political ambitions, the MoA could behave more like a partner by being more entrepreneurial when it comes to taking over risks for innovative products. As former reasons for a rejection of the products he mentioned their costs or the lack of compliance with all regulations. Furthermore, the MoA apparently demands very high guarantees, until up to 30 years, because they are used to a high guarantee from conventional materials. This expert encourages the MoA to take in more risk as well. Furthermore, he proposed that tender-procedures could be adapted and more

dedicated, and simultaneously demanded concrete financial incentives for bio-based and waste-based products. Thereby he remarked that this procedure ought to be coherent with the EU-tender-legislation, which could entail coherency difficulties [Appx. 7.4.3, E1:141-145]. After having exemplied the dependencies of the market on governmental bodies, in the next category the internal dependencies within innovation projects will be addressed.

4.1.2 Deductive category - Dependencies

Description

The dependencies highlight what type of commitments are required for the project (van der Hoek et al. 2016). This category concentrates on the external circumstances that influence the project, and highlights the dependencies amongst the respective stakeholders. It is based on commitment, responsibilities, and communication between the stakeholders along the value network.

Interpretation

There is a common ground between the experts, that the collaboration of different stakeholders in these projects is required, especially in case of different interests. This collaboration generally was regarded as an added value by different stakeholders [Appx. 7.4.3, E8:24; 28].

> *E3: 68: 'obviously there are difficulties in these collaborations but I think this is the way to go.'*

Especially the cooperation with knowledge institutes was mentioned as a very essential collaboration in the project and should, according to Expert 3, be developed further as the freedom to investigate nourishes the project [Appx. 7.4.3, E3: 63]. Furthermore it was pointed out that in integrated projects such as COMPRO, the research does not remain within the university but is also spread into the market [Appx. 7.4.3, E2: 29]. One expert explicitly stated that innovation does not simply occur within the own company, *'we are not a start-up'*. In his opinion innovation requires collaboration [Appx. 7.4.3: E2:49].

Nevertheless, several precautions need to be taken. For example, Expert 2 mentioned that there needs to be a '*balance between speed and agility'*, and this balance can only be reached by the 'right' amount of people involved into the project. A certain amount of project members should, however, not be exceeded [Appx. 7.4.3, E2: 13]. Furthermore, it is recognised as appropriate, if different interests towards the project exist in the team; more importantly and a prerequisite for a good teamwork is that the project members have similar values and beliefs and they can trust each other [Appx. 7.4.3, E2: 51]. In addition, is was remarked that there should be '*commercial grounds*', which means to define the rights on the product to prevent conflicts from the beginning on [Appx. 7.4.3, E2: 63].

The experts all considered themselves highly responsible regarding the project [Appx. 7.4.3, E3: 249; E1: 381]. They did not delegate the responsibility to other parties in the project and they recognized the motivation by other parties as well [Appx. 7.4.3, E8:28].

The results above show that the dependency on the other stakeholders in innovation projects rather increases the acceptance for the project. Even though it has to be highlighted that a bias could arise, since half of the experts are already involved in the project and therefore the acceptance of the project is already given. However, more difficulties might also be detected with time. In sum, the collaboration in the team can be seen as a factor that promotes the potential of the project, despite its related difficulties.

4.2 The product level

In this part of the evaluation the following sub-research questions will be examined:

- *What technological aspects does the product need, in order to be accepted as a waste-based application?*
- *What market volume and costs of applications made from RE-PLEX could lead to a higher potential of the material on the market?*
- *What product solutions could the RE-PLEX have and which competition does the RE-PLEX need to confront on the market?*
- *To what extent could legal barriers prevent the potential of the RE-PLEX?*

4.2.1 Deductive category - product performance

Description

The deductive category product performance considers the performance of the RE-PLEX on different dimensions. It concerns the quality of the product as well as how the users perceive the product in different forms of applications and thereby concerns the social dimension of the research (Kehrein et al. 2020). In an market environment, the quality of the product or the properties are named 'product specifications', which define the characteristics of a product to facilitate its procurement, production, and acceptance (BD Dictionary 2020). Due to the complexity of the category it is further divided into the sub-categories quality and customer satisfaction. Concerning the customer satisfaction, the experts were asked for their own perception of the product.

Interpretation – Quality

According to Experts 6, a product needs to be easy in use, not to costly, attractive, and a certain quality should be guaranteed [Appx. 7.4.3, E6:31]. This quite simple description is not that simple to realize. Simultaneously, the experts addressed various product performance aspects of the RE-PLEX that are currently uncertain from a technological point of view. For

instance, one uncertainty concerns the biodegradability of the product. So far the pace of the biodegradability of the product is highly uncertain [Appx. 7.4.3, E8:117-120; E4: 178].

> *E4: 210: 'I'm neutral in this what does it say biodegradable if you can recycle it than biodegradability is not that important. If you look at, what time scale are you thinking of if biodegradable means you don't have to get it out of the ground again. So you don't have to ditch it. You have to know what the time period is.'*

This statement of the expert highlights the necessary connection of the product performance to the category of application. The biodegradability is generally perceived as an advantage of the product, even though it needs to be seen in the context of the application. Some applications are temporary; in such cases the biodegradability can be an advantage. One expert advises to use the product for applications, in which the biodegradability can be an advantage [Appx. 7.4.3, E3: 209].

According to Expert 8, so far it is not clear which prototype application the COMPRO-project is aiming for. Important and certain product properties of the RE-PLEX are the fire resistance, the biodegradability, and that it is lightweight [Appx. 7.4.3, E8:84]. These product properties have academically already been deeply examined (Nono Leermakers, Moja Reus, Mike Schroten, Sya Hoeke & Laurens van der Wal 2019b), even though, there still remain uncertainties in regard to the above-mentioned as well as other mechanical properties. The most important property of uncertainty refers to the durability of the RE-PLEX. Currently, the material is not very strong and stiff yet, which are important aspects, when it comes to the application in the construction sector [Appx. 7.4.3, E8:84; 88].

To make the RE-PLEX a competitive product on the market some challenges still need to be overcome. One of the problems is the brittleness of the product. The experts emphasize that the strength and durability of the product is not given at present, accordingly a lot of laboratory research has to be done in order to improve the performance [Appx. 7.4.3, E1:313; E3:173; E8:76]. This concerns e.g. the type of fibres. The original idea to use retrieved cellulose might have more problematic properties than other types of fibres, which are more expensive and less sustainable [Appx. 7.4.3, E8:76]. Hence, future research is requested.

> *E8:76 'So it's still not easy to impregnate the fibres with RE-PLEX, not all the fibres because impregnation is very important, if you want to get a good composite, and this is one of the problems we have to solve yet because with some fibres we don't have good impregnation with some sometimes with powder we have better impregnation some sometimes with this the sludge form.'*

Figure 17_Demonstration of the texture of the RE-PLEX (Research manufacturer 2020)

Other aspects of uncertainty are e.g. the viscosity, its resistance to UV and water, and the specific chemicals of the product [Appx. 7.4.3, E8:112]. The ability of a material to be resistant to water is quite important as well. One expert considered this property interesting for the usage in cavity walls, where the material is exposed to moisture. As cavity walls of buildings are one potential application of the RE-PLEX, the research should focus on improving the water resistance. The property of water resistance also could be a competitive advantage compared to other bio-based materials, since so far there are not so many bio-based materials on the market, that are water-resistant as well [Appx. 7.4.3, E6:55]. All in all, to rate the above-mentioned specifications against each other, the durability and fire-resistance are regarded as the most important aspect by the experts [Appx. 7.4.3, E4:106; E7:179; 183].

Another aspect one expert put forward is that the whole life cycle of the product performance needs to be considered e.g. for an urban application. As the use phase is a very important product phase, a lot of the above-mentioned aspects are relatable to the maintenance. Especially by considering an urban application, e.g. in public space, the product needs to be washable [Appx. 7.4.3, E7:187].

In conclusion, with certain immanent properties, the RE-PLEX has good preconditions to be applied in the construction sector, however, the durability essentially needs to be improved. Moreover, having certainty regarding which properties the product has, should be increased in order to be able to make a qualified decision regarding the application of a potential prototype. The technological development of the product is still in the lab-phase, which raises the potential of a future improvement of the properties. Thereby, the properties should be iteratively evaluated according to a potential prototype application.

Interpretation - Customer satisfaction

The circularity and low energy demand of the product provokes a high customer curiosity. In addition to these factors, also the attractiveness of the product plays an important role to reach a customer satisfaction.

> *E4: 214: 'it has to be maybe flexible, easy in use it has to be, if you have to look at it has to be designed in an inspiring way. And an interesting design. Yeah. Maybe if it's easy, if you look at generations and you think of a period of 30 or 50 years, if it's easy to change things because of this material or to rebuild things or to renovate or to whatever, then I think it's, it has a high customer satisfaction.'*

This comment illustrates that many different demands are concerned with the product, which put in relation with the RE-PLEX is still connected to a lot of challenges.

Other experts especially point out aspects such as the odour, safety, and the design of a material that essentially can influence the customer satisfaction of a product [Appx. 7.4.3, E1:333; E5:171; E4:222; E6:79]. Furthermore it was indicated several times during the interviews, that there will be no market for products that are not attractive in design [Appx. 7.4.3, E1:433; E7:171; 303], which makes the design a highly important facet to consider. Regarding the smell, in the beginning the RE-PLEX used to be very displeasing, but during the labour-test it got much less intense [Appx. 7.4.3, E8: 140]. Especially for the application in buildings, the smell needs to be completely eliminated. Concerning the safety of the product, one expert pointed out that safety tests need to be performed in the future [Appx. 7.4.3, E8:140]. Several safety tests are concerned with different aspects of safety, such as environmental safety, or the durability of the product (Intertek 2020). Furthermore, recent studies have described the Safe-by-Design-concept, which addresses the risk management in engineering, by trying to prevent possible risks in an early stage of the research (Robaey 2017).

The aspect that the product derives from WW can have a general repellent effect onto the customer. One expert points out that from her experience the acceptance of products from WW generally is not too high, and that political bodies such as the MoA should work via education on the social acceptance of products from WW [Appx. 7.4.3, E8:32; 44].

It can be concluded that the product needs to be somehow attractive and inspiring to successfully bring it onto the market. Consultancy firms or architects might be able to help in commercializing the product, especially in the beginning phase [Appx. 7.4.3, E4: 218]. In sum, there might be a risk of unacceptance if a certain product performance cannot be guaranteed.

4.2.2 Inductive category - circularity

Description

Circularity describes the recovery of resources which originates from the concepts 'Cradle to Cradle' and 'CE' (Ellen MacArthur Foundation 2017), which are the basis of this study. The category 'circularity' was added as an inductive category, since it was considered as one of the most relevant factors for the potential acceptance of the RE-PLEX.

Interpretation

E2:136: *'So, it's a completely circular building-material. So that's the biggest added value.'*

The circularity of the RE-PLEX is seen as an added value to the product, and is an elementary characteristic that significantly influences the acceptance of the product, which could be recognized in several comments by the experts form the market as well as from an governmental perspective [Appx. 7.4.3, E7:159; E8:16;20]. The fact that the RE-PLEX is 100% waste based and 100% bio-based is considered as very attractive [Appx. 7.4.3, E1: 20]. The expert from the retail company indicates that RE-PLEX has a strong unique selling proposition (USP) [Appx. 7.4.3, E6:44]. Some experts even mentioned that the circularity can compensate for other product properties, which the RE-PLEX might be not able to fulfil [Appx. 7.4.3, E4: 226; E3:221].

One expert mentions that in the future, the construction industry will '*be forced to build smarter and more local and more waste based and bio based*', which implies that the demand for circular building materials will grow rapidly [Appx. 7.4.3, E1: 36; E6:10]. Another expert calls the sustainable material business and the CE a 'technology push', which promotes the investigation about circular materials [Appx. 7.4.3, E1: 433].

On the other hand, by the expert from the MoA it was also pointed out that circularity should not be forced, because normally a new product should also go in hand with better product properties than the product that fulfilled the function before. Thereby, this expert was emphasising several demands towards the product besides the circularity, such as the durability, an appealing design, and the fulfilment of safety regulations [Appx. 7.4.3, E5:171].

Conclusively the circularity characteristic is generally regarded as favourable for the market potential of the RE-PLEX. At the same time, other product specifications should not be compromised.

4.2.3 Deductive category - competition

Description

There is a high potential of conventional as well as other circular or bio-based products to outcompete the products from RRS. This can have different reasons, such as the higher product quality and quantities, or lower production costs (Kehrein et al. 2020).

For the COMPRO project, two different types of competition can be distinguished. On the one hand, the RE-PLEX competes with other recoverable resources for the source, which is linked to the competition of different technologies of WWT with the above-mentioned Nereda technology. On the other hand, the RE-PLEX competes with other materials in the construction sector for an application.

Interpretation – competing recoverable resources

The competition of the RE-PLEX with other recoverable resources is recognized by several experts. Especially three other resources are competing with the RE-PLEX. The highest priority of resources in WW to recover in Amsterdam are biogas, and P (van der Hoek et al. 2016). The expert from the water authorities also mentioned that in the current moment of time the production of energy in the form of biogas and P are the most competing products [Appx. 7.4.3, E4: 14]. Furthermore, he stated that right now the focus does not lie on the extraction of alginates, such as Kaumera [Appx. 7.4.3, E4: 18].

This expert indicated that CO_2 emission reduction and also '*other polluting aspects*' increasingly decide upon the market application of competing recovered resources [Appx. 7.4.3, E4: 105]. Yet also many other aspects can promote or prevent the competition, such as the costs, the value of the product according to the above-mentioned value pyramid (Betaprocess 2020), or the development stage of a product or technology to recover the product. Van der Hoek et al. (2016) identified criteria that might decide about the implementation of a technology measure which are: the influences on the changes in material flows (water, organic matter, and P), the products that can be recovered, their value, the certainty of a measure's development path, how the measure depends on changes of behaviour or actors outside the water boards, and when an implementation of the technology could be expected in Amsterdam (van der Hoek et al. 2016).

One expert indicated that one way to cope with the possibilities to recover various materials is to apply an integrated approach where different aspects of products are evaluated [Appx. 7.4.3, E5:199]. One integrated approach is the concept of adaptive policymaking (van der Hoek et al. 2016): According to this approach, at first, a material flow analysis is applied, and secondly, the measures to recover products are characterized. The third step is to combine different measures of RR that lead to the recovery of a certain resource.

The cost-effective Nereda technology is compatible with the recovery of P and biogas, however, as discussed before, the biogas recovery is less effective, when the Kaumera is extracted (van der Hoek et al. 2016). According to the value pyramid, the Kaumera and Cellulose are both valued on level two, which is higher than biogas (Betaprocess 2020).

Interpretation – competition of construction products

Another dimension is the competition with other materials in the construction industry:

> *E1: 309: 'That's a totally different material, so it's not really comparable. So glass-fibre is waterproof it's easy to process it's fast to process it's really strong. It's really stiff and dirty or chemical and poisonous and not good for you. Yeah. So okay the poisonous this and it's not good for you. We can beat but all the other issues are not so easy to beat.'*

A product that is comparable to the properties of glass fibre according to the COMPRO consortium, is one prototype option to aim for. Glass fibre has a lot of properties that are valuable for the construction sector and is often used as an insulation material. Conventional materials such as glass fibre could proof and improve their product-properties over several years. However, they often have considerable environmental disadvantages. Experts recognize the urgency to find alternatives for the environmentally harmful product properties of conventional materials, but simultaneously doubt the simplicity to create environmentally friendly alternatives with comparable product properties and for the same price [Appx. 7.4.3, E8:44]. Furthermore, the usage of timber as a bio-based building material is considered to be increasingly used for Amsterdam (Gemeente Amsterdam 2020). To aim for the product properties of timber is a high ambition, however, some first experiments showed that the RE-PLEX has some similarities with timber (personal communication with manufacturer 07.08.20].

In addition to this, other circular construction materials are increasingly competitive as well. One expert from a retail company of construction materials highlighted the rising competition of circular initiatives on the market.

> *E6:13: 'An economic risk will be the competition of other circular materials. There are many circular initiatives (in particular insulations), which you will encounter. What I think can be a competitive advantage is when it can be developed to be suitable in the cavity wall (moisture wise). Not many other circular insulations can be applied there.'*

However, a manufacturer pointed out, that there are not so many completely circular bio-based materials on the market yet. Other epoxy-resins or polyesters, comparable to the RE-PLEX, are in contrast to the RE-PLEX often partially bio-based [Appx. 7.4.3, E8:104].

Other factors that make competing products in the construction industry more attractive for end-users are that they comply with the construction codes more easily (ISO 2020). One expert pointed out to be able to bring a product onto the market, product-niches have to be detected [Appx. 7.4.3, E1: 285].

The potential of the RE-PLEX on the market can essentially be influenced by the competition of other RR-technologies and other WWT-technologies besides the Nereda technolgoy.

Furthermore, other products that exist on the market, such as innovative as well as conventional products compete with the RE-PLEX. The existing and future competition needs to be taken into account when aiming to raise the acceptance of the RE-PLEX.

4.2.4 Deductive category - scale

Description

In comparison to the conventional production of products, only restricted amounts of resources can be recovered from a WWTP (Kehrein et al. 2020). Hence, there needs to be a definite understanding among the stakeholders about the quantities of activated sludge that can be recovered out of the WW. The possible amount of the product that can be recovered can essentially influence the market potential.

Interpretation

The availability and hence the scale of the product was often mentioned as highly important [Appx. 7.4.3, E6:21]. The expert from the water authority mentioned that a certain amount of available flow should be given for the production of the product:

> *E4: 'So people have to trust the product, they have to know where it's coming from a risk can be that you have to be sure that you can produce enough of this product.'*

Depending on the kind of WW there can be high variations in scale. It plays an important role if the WW comes from a municipal sewage system, or from a single industry. Industrial WW is highly dependent on the amounts of WW a factory produces, which often has high fluctuation values [Appx. 7.4.3, E3:55].

As municipal WW flows are more constant and generally involve bigger streams, in regard to the scale, it might be more secure to connect the recovery of Kaumera to a municipal WWTP, in order to raise the acceptance for the product (van der Hoek et al. 2016).

The scale of a product is also very dependent on the costs. A material that has low processing costs, as estimated for the RE-PLEX, can be produced on a far larger scale. One expert commented that the material that originates form waste has a very cheap source, therefore, it could be interesting to produce the RE-PLEX on a larger scale and sell it for a low price [Appx. 7.4.3, E1:38]. However, the final costs of the RE-PLEX can only be estimated at present.

A manufacturer commented that for the pilot scale there needs to be a minimum amount of 5-10 tons/year to be able to access a wider market. Furthermore, he states that the competition materials can be outcompeted better if the product is produced on a larger scale [Appx. 7.4.3, E1: 247]. According to another expert, the industrial Nereda WWTP, which is already in operation (Zutphen, water-authority Rijn and Ijssel), generates approximately

300 tons/year of Kaumera [Appx. 7.4.3, E3:141]. Together with the current installations, enough Kaumera can be produced for a further development of the product, which was also confirmed by the manufacturer of the product [Appx. 7.4.3, E8].

On the other hand, an expert from a more experimental manufacturing company remarked that often the amount of the materials they receive from other bigger manufacturers such as 'Henkel' in Germany are too high for the company. To start and experiment with the product it is easier to have a smaller amount of the material and sell small batches [Appx. 7.4.3, E7:247]. Regarding the COMPRO project, it is recommendable to start with a small amount of the product and upscale it, when the technology and the product already has proven itself on the market.

In the longer term, the production of Kaumera will become economically feasible on a larger scale, when also other applications besides the RE-PLEX are available (STOWA 2019). Therefore, it would be an advantage if more water authorities would dedicate their sludge to the production of Kaumera (van der Hoek et al. 2016). In conclusion, it can be said that the available amount of the Kaumera highly depends on the amount of installations of Nereda plants. Though, the increasing amount of installations of Nereda plants could raise the acceptance of the project within time.

4.2.5 Deductive category - costs

Description

Due to operational and investment costs, especially for the installation of new product recovery technologies, a RR process in its initial phase is not very cost-effective. To implement the recovery process smoothly, many investments should occur. However, the costs can be balanced, with the revenue of the recovered resource. In the best case this should turn out to be more cost-effective that the conventional product (Kehrein et al. 2020).

Interpretation

The extraction of Kaumera out of the sewage sludge is rather expensive [Appx. 7.4.3, E3: 157]. 11 € million needed to be invested by the water authority Rijn en Ijssel for the construction of a Kaumera extraction facility in the decentralized, industrial Nereda treatment-plant in Zutphen (Royal Haskoning DHV 2020b). However, the treatment technology itself is rather efficient and therefore cost-effective. The exact extraction costs of the Kaumera can only be estimated in a continuous process (STOWA 2019).

As calculated above, the total costs of the RE-PLEX (5.30 €/kg) are estimated to be rather cheap. Due to that fact also after the investment into the technologies a benefit could reduce the production costs [Appx. 7.4.3, E6:11]. Concerning the product-costs, a project-internal expert pointed out the following:

> *[E1:357] 'So if we can make a temporary application that's really cheap, it's biodegradable and we can make it now then we should do it and if we make something that is stiff and really strong, etc., but 10 times as expensive as all the competitive materials, then you shouldn't do it.'*

The expert declares that also if the properties of the product have a high quality, the product should still be cost-effective – hence, the costs still should not exceed the costs of a conventional product that fulfils similar conditions [Appx. 7.4.3, E1: 353; 357]. Here a connection to the category of product performance is visible. In the case of weighting, the experts would rather produce lower-valued products, e.g. temporary products for a lower price, than high-quality products which are not cost-effective.

As products in the innovation-phase often cost more than their financial return, political subsidies are of importance for the project [Appx. 7.4.3, E8:32]. With political instruments the costs can mostly be covered. For example, the MoA proposes new financing models for the application of circular innovations to ongoing projects. However, this ambition is still to be further developed in the coming years (Gemeente Amsterdam 2020). Further subsidizing incentives are exemplarily the above-mentioned 'Green Deals' provided by the government. Additionally, to value the circularity of the built environment the total cost ownership and total costs of use can be calculated, which concerns the costs of the entire design and useful life of a product, is reasonable (Gemeente Amsterdam 2020). The experts also mention the instrument of integrating the external costs of damages that the product causes in the environment into the price [Appx. 7.4.3, E4, p. 30] (Kosugi et al. 2009). This incentive would make circular and sustainable products compared to conventional products more cost-effective.

In conclusion, it can be pointed out that on the long run, the RE-PLEX would obviously be most accepted, if the revenue by selling the product were higher than the investment in the technologies. This might require an amortisation phase, but could be imaginable for the future. Thereby the so called 'valley of death', namely the phase between the innovation and the upscaling phase, which is financially critical, would need the support by the governmental bodies. The best-case scenario would be that the water taxes for the residents could be lowered by a revenue of the product for the water authorities, which was a vision of the water authority expert [Appx. 7.4.3, E4: 58].

4.2.6 Deductive category - legal regulations

Description

In this category, the statements concerning the legal status of the RE-PLEX will be examined. The legal regulations essentially influence the potential of innovations, especially when a product is marketed. The product conditions are subject to environmental regulations as well as quality standards. Regulatory barriers could be identified by the 'Rijksinstituut voor

Volksgezondheit en Milieu' on the product level, such as lengthy licensing procedures, and ambiguities in quality requirements (Rijksinstituut voor Volksgezondheid en Milieu 2016).

Interpretation

A preventing factor for the potential of the RE-PLEX within the construction sector is that all products have to comply with certain rules and legislations (ISO 2020). For the RE-PLEX, the first barrier to overcome is the waste label. So far, no certification systems can be applied to the RE-PLEX yet. However, this could change when a prototype is in development.

The expert from a retail company pointed out that it is important that the products have adequate certifications, so that customers can trust the products [Appx. 7.4.3, E6:24]. Therefore, in the process of manufacturing an awareness for the certification systems, described in the theoretical framework of this work, such as REACH and BREEAM should already be present (Umwelt Bundesamt 2020; Dutch Green Building council 2020). As the certification procedures are rather expensive, the connected costs have to be calculated in advance. Furthermore, another expert remarked that also if for one country the certification system are applicable they might not be applicable for the international market [Appx. 7.4.3, E2: 83] (Dutch government 2011). However, the European Commission is currently trying to find regulations that harmonise the building regulations, by eliminating the disparities of regulations between different EU member states (European Commission 2020b).

According to Expert 2, an aspect that makes the specification of a recovered product from WW even harder, is that the ingredients of the WW can be very inconsistent. This fact apparently makes a certification of the product very difficult [Appx. 7.4.3, E7:58]. A proposed solution to deal with the inconsistency could be that the material is used for an application with lower specifications. Indoor applications have lower requested specifications and are less risk full than outdoor applications, because the outdoor applications are subject to greater physical influencing factors, such as rain, temperature etc. [Appx. 7.4.3, E7:63;67;71].

On the other side, a comment was made regarding the difference in the specification standards of polymers and building products:

> *E7: 211 'But then the difficulty with the polymers is that they the way they qualify the fire resistancy of a polymer is very different from the way they qualify the fire-resistancy from a building product. These two are hard to [...] relate.'*

To make building products out of a polymers the flammability standard of a polymer always needs to comply with the highest standard, since the certification for a building product is far higher than the certification of a polymer [Appx. 7.4.3, E7:219]. Only with a very high polymer certification it is possible to create a building product such as a façade element. These complications highlight the difficulties in the certification process and can be a potential barrier for the RE-PLEX.

Regarding the fulfilment of the RE-PLEX in certification systems specifically, there exist hardly any estimations, because it is easier to apply legal regulations when the prototype already exists. First of all, end-of-waste criteria need to be defined for the RE-PLEX. One expert pointed out that it would be important to establish a coherent legal framework for a product from WW that is applicable to wider spatial scope [Appx. 7.4.3, E3: 89]. As one option to overcome the barrier of the waste label it was mentioned that there needs to be a common legislation in place that regulates how a waste material can be upgraded to materials [Appx. 7.4.3, E4: 50]. An end-of-waste framework would considerably ease the legal barriers for the RE-PLEX.

4.2.7 Deductive category - environment

Description

The recovered resource might involve some substitutes or contaminations that are a risk not only for the environment but also for the human health. Reason could be an insufficient WWT and recovery process control (Kehrein et al. 2020). As one of the main purposes of recovering resources is to treat the environment sustainably, the adverse effect could significantly influence the acceptance of the RE-PLEX.

Interpretation

Reducing the demand of fossil raw materials and energy at the same time is a sustainable treatment of the environment, as the intervention into the environment gets smaller. The circularity and sustainability of the product, and the accompanied positive effect on the environment are aspects that were mentioned several times as an important aspect of the product performance [Appx. 7.4.3, E4: 30; 70, 158]. Even though there remains a small chance that the RE-PLEX might have negative effects on the environment or the human being.

> *E5:55: 'But with furniture, it's probably I cannot answer this like, completely but what I guess might be a problem is if you use it in public space, that elements leak out and get into the surface below or into the ground or into the water system, which you want to be really really sure about is not harmful. Same goes for like children playing around or people. Or yeah, touching or using the objects. […] And I think the other one is that it's, like, has the certificates to be not environmentally safe, but You-safe so it doesn't break down, it doesn't fall down or, like most products that are used in public space are heavily tested on their safety in use.'*

In this statement by the expert from the MoA, the dimension of safety of the product for the outdoor environment is exemplified. Among the experts, a slight fear could be determined that the RE-PLEX could emit some elements or harmful gases [Appx. 7.4.3, E6:88]. This fear mainly derives from the fact that WW contains many components that are not desired, such as heavy metals, pathogens or other toxic substances, that also can be found inside the Kaumera (Daniel Puyol and Damien J. Batstone 2017; STOWA 2019). Also for the indoor

environment some concerns where expressed. Inside a building, climate gases could be harmful for the human [Appx. 7.4.3, E7:351].

Finally, a remark was made regarding the origin of Kaumera. As WW contains a lot of toxic chemicals and heavy metals, the exact content of the product is uncertain. According to Expert 1, it is not possible to make an inventory of all the chemicals in WW that is valid for any type of WW, as every WW has a different composition [Appx. 7.4.3, E1:393; 397].

The environmental safety of products is determined in laws and regulations (see chapter 2.8). In the Dutch 'Bouwbesluit 2012', a limit value for environmental performance is put in force (Bouwbesluit online 2020). Also other international certifications assure the environmental safety of products, such as REACH. Due to the fact that every product has to go through a certification process, it might be a barrier for the RE-PLEX to get to the market, when the environmental performance is to threatening.

Officially, since so far there is no finalized product that can be tested, the legal and environmental requirements for the RE-PLEX are not known yet. Hence, it is not known if regulations will stem for example from the REACH regulation described above.

4.2.8 Inductive category - uncertainty

Description

As could be seen in the above-mentioned categories, the category of uncertainty is connected to many of the other categories. One of the biggest uncertainties in product innovations is the technological development, respectively the product performance (van der Hoek et al. 2016).

Interpretation - Referring to the technologies

All experts expressed different kinds of uncertainties concerning the COMPRO-project. One major uncertainty, which uncovers far more uncertainties, is the respective application of the RE-PLEX in a certain product (see also chapter 4.2.10). The properties of the product are assessed according to its application, which is not defined yet. However, as discussed in the category of product performance, some technological properties of the product are still uncertain, which makes it difficult to estimate which prototype should be build. Also, the question which quality criteria the product needs to be competitive compared to conventional products, can only be judged when the application for the product is known [Appx 1, E2: 168]. Therefore, it is also difficult to say for which urban application is could be used [Appx 1, E2: 112; 152].

A further factor of uncertainty is the content of the product. First, as it derives from WW there is a risk that the product might contain certain toxic substances (heavy metals, toxics, pathogens) that might have a negative and harmful side effect. Since the exact content of

the WW is not always known, it is difficult to assess whether and to what extent there are respective negative side effects regarding the product's materials. Second, the used fibres in the product are also not sure at present. The project aims to use cellulose fibres, however, also other fibres were analysed in some experiments and sometimes showed better impregnation results, which was stated to be a very important property of the composite [Appx. 7.4.3, E8:76]. One can only suppose that some of the uncertainties might be revealed with time.

4.2.9 Inductive category - development stage

Description

The development stage of an innovation can be the idea, the lab phase, the pilot phase, full scale testing, or the proven technology (van der Hoek et al. 2016). When a decision needs to be made which product or WWT-technology will be applied in a certain moment of time, the development stage of the measure will decide if it is already feasible to implement (van der Hoek et al. 2016). For RE-PLEX, the development stage takes place in the lab phase, which means that the outcomes of the product are still highly uncertain (van der Hoek et al. 2016).

Interpretation

So far, established conventional materials were always able to improve their characteristics over time. In contrast, RE-PLEX is just at the start of its development and the product performance will presumably adapt over time [Appx. 7.4.3, E1:247]. One expert pointed out that the RE-PLEX still has a long way to go and that the beginning of a research gives completely different results than at other stages of the research [Appx. 7.4.3, E8:32; 92]. According to this view, the potential of the product will significantly differ during different development stages.

Schilling and Hill (1998) define the continuous reduction of the time a product needs to set foot on the market as one of the requirements in new product development (NDP) processes. This limitation sets pressure on the development of the REPLEX. A slow NDP can result in the fact that market demands might already be different when the product is just ready to be introduced into the market (Schilling and Hill 1998).

In sum, the acceptance and potential of an integration of the RE-PLEX in the urban space depends highly on the development stage. Other competing materials might be developed faster. The faster the product is developed, the better it might be accepted on the market.

4.2.10 Inductive category - application

Description

The application was mentioned several times and is an important category since it has an influence on nearly all other categories. For becoming successful, an application needs to be

found, that exploits the characteristics of the RE-PLEX, is socially accepted, fulfils the market demands, and complies with the legal constraints (Peter Mooij 2019).

Interpretation

According to the COMPRO consortium so far, the only certainty concerning the application is that the RE-PLEX will be applied in the construction sector. The concrete type of application within the construction sector, however, is currently still uncertain and should mainly be decided upon according to where the product can have the highest added value. One of the most certain and striking properties of the RE-PLEX is its biodegradability that essentially influences the decision about its application. Hence, the RE-PLEX should be used in products where the biodegradability is an added value [Appx. 7.4.3, E3: 161].

Possible applications of the RE-PLEX could be applications in the soil, where the material should degrade over time. A mentioned example was a temporary piping system for the wiring on construction sites that can stay in the ground. Another outdoor application could be e.g. a temporary reinforcement dike to build a highway on top, or for ground consolidations. However, in the case of bigger scale applications the product would need to have a low price [Appx. 7.4.3, E3:161; E1: 281; 349]. An overview about the advantages and disadvantages of the different application ranges is given in Table 3.

Table 3_Eventual applications of the RE-PLEX, their advantages and disadvantages

Temporary ***outdoor***	***Examples***	+	-
	piping system for the wiring on construction sites consolidations in construction sites temporary outdoor events or exhibitions soil reinforcement mats as well as e.g. temporary building constructions.	Biodegradability can be used in a positive sense; lightweight is a higher advantage in bigger applications recognition as a product e.g. in public space design is less relevant	
Permanent ***outdoor*** ***(high end)***	urban furniture, traffic signs, urban infrastructure	recognition as a product e.g. in public space fire esistance	Biodegradability could be a problem Urban infrastructure products need to compliance with high regulations Design

*Temporary **indoor*** *(low end)*	exhibitions	compatible with biodegradability	Smell (Design)
*Permanent **indoor*** *(low end-high end)*	façade elements, insulation; ceiling plates, door panels, thermal and acoustic damping plates, scaffolding boards	in the case of insulation the application safes energy demands design might be less relevant fire resistance	Smell Biodegradability Design

Many experts considered temporary applications as the better application field [Appx. 7.4.3,E3:177; E1: 281]. Reasons could be that the biodegradability is considered as an advantage in temporary applications. In regard to all applications, it would be important to know how fast the product degrades [Appx. 7.4.3, E3:209]. One expert from an integrated architectural and manufacturing perspective indicated that there also exist very highly resistant biodegradable materials on the market [Appx. 7.4.3, E7:283].

Another mentioned aspect was that the product might not be highly appealing, due to a lacking design performance and therefore could be applied in an invisible application [Appx. 7.4.3, E3:225]. These, for instance, could be applications underground or in the cavity wall, between the outer and the inner wall of a house. In this regard, one expert gave the advice that at the beginning, the product should be rather applied in interior applications and have a very high added value. In the longer term it could also be applied to standard applications and outside applications [Appx. 7.4.3, E1: 285; 289].

As it was explained in chapter 4.2.1, the acceptance of the product highly depends on criteria such as the smell of the material. In interior applications the smell would lead to a rejection of the product, in contrast, in an outside application it should not be a problem [Appx. 7.4.3, E1:337; 341]. But also in sandwich applications such as in the cavity wall it should not be a problem [Appx. 7.4.3, E8:140].

Permanent outdoor applications were far less commented, which might originate from the fact that they are not very imaginable so far.

Generally, it needs to be added that the application in public space is regulated by the city of Amsterdam, whereas the application in buildings is more regulated by the market [Appx. 7.4.3, E5; 159]. Regarding the elements in public space, the expert from the MoA highlighted the importance of the refurbishment cycles. This expert pointed out that it is imaginable to work with a modular system, in which some parts are reusable and other parts can remain for further usage purposes [Appx. 7.4.3, E5:179].

Another dimension connected to the application is the positive environmental impact that can be achieved by replacing a conventional application. In case of isolation materials, the impact might be comparably high, since current application materials have a high negative environmental impact [Appx. 7.4.3, E2: 116]. On the other side, a high positive environmental impact can be reached, when the amount of the applied material is rather large, which would be e.g. the case for temporary or permanent outdoor applications.

At present, it can be deducted that temporary outdoor applications such as can be found in constructions sites, are the most imagined application by the experts, and therefore potentially have the highest potential to be realized in the public space [Appx. 7.4.3, E8:108; 116]. But also permanent indoor applications such as façade elements or insulation material are considered as applications with an added value.

In conclusion, the performance of the product and with that the potential to be implemented in the urban space highly depends on the application of the material. In the next chapter, all the interpreted categories are summarized and the significantly promoting and threatening factors are highlighted.

4.3 Summarizing evaluation

From the interpretation of the results described for each category some general barriers such as threats and weaknesses as well as strength and opportunities about the market potential of the COMPRO project can be determined that should be summarized in the following part in form of a SWOT (Strength Weaknesses Opportunities and Threats) analysis. A SWOT analysis identifies the four factors in the external environment of the activities in the market field (Gabler Wirtschaftslexikon 2018). These can be used to further give recommendations, for necessary steps to be taken.

For the stakeholder level it can be summarized that integrated projects such as COMPRO with many different parties contribute to the market potential of the innovation. The collaboration is seen as a positive added value, as long as certain values and visions are shared by the stakeholders and therefore can be seen as a strength for the project. The project approach seems to be contemporary and ideal to address the aim of the project. The political ambitions for Amsterdam, mainly the overall goal to become circular, as well as the circular procurement and financial incentives are promoting the innovations surrounding the CE. However, the political ambitions are still only broadly defined and therefore could be refined, when it comes to the recovery of products from WW. Furthermore more actions and risks could be taken by governmental bodies such as the MoA. Hence, generally the policies can be seen as a chance but also as a threat, if no further incentives will be given by governmental bodies.

For the product level many connections between the different categories are revealed. The finally evaluated category, the product *application* is very connected to the firstly evaluated category, the *product performance*. For the *product performance* some specifications of the product, such as the fire-resistance and biodegradability are already defined. These allow an approximation towards a possible product application, which can be seen as an opportunity for the project. On the other hand very important product specifications, such as the durability are still quite vague which makes the prognoses for an *application* difficult. Elementary *uncertainties*, identified as a threat need to be resolved during the lab-phase. Thereby it is recommended to coordinate the development of the product with an iterative process to find an appropriate *application*, which for the start could be in the temporary outdoor application-field.

The customer acceptance of the product is significantly connected to the category of *circularity*. The *circularity* is a strength of the RE-PLEX that raises its potential. However, other aspects of the RE-PLEX are also considered very important and should not be compromised too much by the bio-based and waste-based character. Properties such as the smell, the design, the durability and the safety are considered highly important as well. If certain properties of the product cannot be fulfilled there is a threat that the *competition* of other circular or conventional products in the market of the construction sector, such as wood or synthetic bio-composites might outcompete the RE-PLEX on the market. Concerning the *competition* of other products in the construction market the RE-PLEX has the main advantage to be fully waste-based and circular, which could outcompete other products in the long term.

A further *competition* can be perceived by other recoverable resources such as P and biogas which have a much higher economic value. However the RR measures can be combined with the RE-PLEX. Therefore it is wise to combine recovery-measures, that benefit from each other and are coordinated and in a similar *development stage*.

The *competition* is very intertwined with the category of *costs*. The *costs* of the product should not be too high, also if the *product performance* is very high. If conventional products fulfil the same quality conditions with a lower price the market potential will be rather low. The *costs* of the whole product life-cycle should be considered in advance. These could e.g. be *costs* for the certification systems or *costs* for the maintenance of the product. Depending on in how far the costs can be lowered by the low priced source and theirby the investment into technologies can be amortised, they can be revealed as an opportunity or a threat. The *costs* are also connected to the category of *scale*. The product should rather be applied in a bigger *scale* that is cost-effective than for a smaller expensive *application*. For now, the lab-phase of the product the amount of cellulose and Kaumera production is sufficient however, for future *applications*, such as bigger temporary outdoor *applications* the production of

Kaumera would need to be up-*scale*d. Due to the low prices source, the upscaling can be a competitive advantage for the project.

Especially the *legal regulations* such as the end-of-waste criteria can only be applied to the product, if an *application*, respectively a prototype with a certain purpose is defined. Also more refined certifications such as *environmental* certifications can only be defined for a product. Hence, they ought to be seen as a threat for the product. The ingredients in WW could present a potential barrier for the product, which already should be taken into account in the lab-phase.

The category of *uncertainty* is connected to the category of the *development stage*. As the RE-PLEX is still in the lab-phase many *uncertainties* might be resolved with time. However the time is a limiting factor, especially when considering the rising *competition* on the market. Therefore an *application* for a potential integration into the urban realm should be found soon.

All those results show the barriers and opportunities for the potential of the RE-PLEX that need to be balanced. In the last category *urban integration*, it will be examined it how far the project would be accepted and which measures could be taken to apply it in the urban realm.

4.4 Urban integration - COMPRO and HavenStad

In the following chapter this sub-research-question should be addressed:

- *How COMPRO could find its application in an urban development such as HavenStad?*

Description

The category of urban integration is discussed as a separated category as all other categories can be seen as a basis for an urban integration. It aims to transfers the collected data to a spatial dimension by connecting COMPRO to the urban realm, respectively HavenStad.

Thereby it addresses the integration of the product RE-PLEX as well as how the spatial integration of the WWT could be designed to suit the needs of HavenStad as well as to raise the potential acceptance of the project in HavenStad. By this means it concerns how it could contribute to the aims of HavenStad as well what makes HavenStad suitable for the project.

The big scale of the project gives a good realm to put into practice several sustainability-innovations such as circular construction (Gemeente Amsterdam 2020). The port is a strategic location for companies that might translate innovations such as COMPRO into a bigger scale.

The transformation phases of the project through decades help to organically develop innovations by searching step by step for the right way to go.

Interpretation

4.4.1 WWT integration for HavenStad

E2:198: 'the whole communication will be from your city in your city or something'

This comment emphasises the attractiveness of the COMPRO project. It refers to the local transformation of waste materials from the city into products that can be reused locally. With the raising importance of local value-chains the localization of the project is very attractive and according to the expert could be merchandized with this marketing-slogan.

To realize this ambition different questions need to be answered. One question is how the WWT is spatially integrated. Which is connected to the question of which concept of WWT is applied in a certain urban area. This depends on many different factors such as the urban hydrology, the water supply and demand, the supply of energy and nutrient-management, infrastructure and utility governance structure (Daigger 2009). In the long term these are important factors to consider in the transformation of HavenStad which will change the urban flows. In the following mainly the market perspective of the urban integration of WWT will be considered.

Centralized versus decentralized treatment in HavenStad

The examination of the interviews with the expert's show that a decentralized treatment for HavenStad currently is not considered. Consequently the centralized treatment in the WWTP West is kept. Different reasons where pointed out. These are that the project is too big for a decentralized solutions and that HavenStad is a transformation area with mixed-development of newly build and existing blocks. Therefore it would be very difficult to make a systemic change. With areas that are completely new build it would be easier to integrate a new decentralized system [Appx. 7.4.3, E5: 116-119].

To refer to the potential of the COMPRO project the cost-effectiveness in the decentralized system is more suitable in terms of scale and amounts of residual flows. To combine COMPRO and HavenStad it appears the question if the current centralized WWTP-West could eventually be retrofitted into a Nereda system, which would be technically possible. In this regard the expert from the water authority indicates that, if valuable products arise from the resource extraction out of the Nereda plant he can imagine that it becomes very interesting for the water authorities to install or to retrofit the plants into Nereda plants [Appx. 7.4.3, E4: 165].

The current location of the treatment plant RWZI Westpoort is located in the harbour area in the west of HavenStad (*Figure 5*). As mentioned above it is the biggest treatment plant in Amsterdam and produces smell and is noisy and is visually not attractive which does not go in hand with the demands HavenStad has for the city especially for the dwelling areas. However, as it is located in the vicinity of HavenStad the WW streams of HavenStad get treated there and the products in case of a Nereda transformation could be used in the area of HavenStad. A further elaboration of a spatial concept will follow in the Industrial Symbiosis part.

Another scenario, with smaller decentralized plants is that they could be installed to use the industrial WWs of the companies currently located in HavenStad.

The expert from the water authority indicated that they are generally also focusing on decentralized WWT [Appx. 7.4.3, E4: 118]. Therefore the current centralized system might be combined with decentralized solutions in the future. One installation of the decentralized 'Nieuwe Sanitatie' system that was mentioned in the theoretical framework is located in the vicinity of HavenStad.

Buiksloterham is a big part in the north of HavenStad. In Buiksloterham a floating treatment-plant according to the concept of 'Nieuwe Sanitatie' has been built (Waternet 2020a). The location is shown in the figure 19 below.

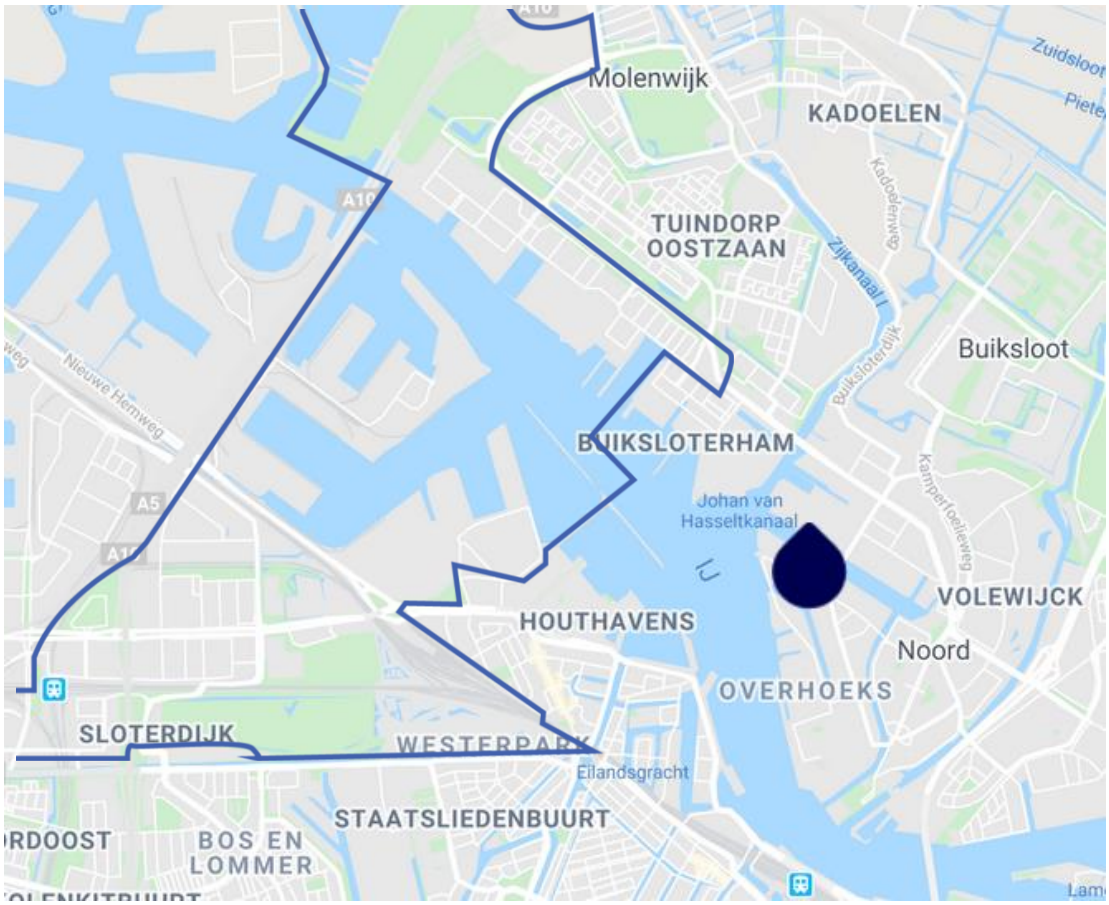

Figure 18_Nieuwe Sanitatie location Buiksloterham (Waternet 2020a)

The expert from the MoA furthermore could imagine the integration of a centralized treatment in combination with more and more decentralized systems in the coming decades, especially when the maximum treatment capacity for the centralized treatment is reached [Appx. 7.4.3, E5: 131]. However it was also remarked, that before the decentralized test-locations (Buiksloterham + Strandeiland) that are currently build are not finished and conveniently working there will be build no other pilot locations [Appx. 7.4.3, E5: 115]. As some difficulties in these 'Nieuwe Sanitatie' locations still need to be solved for a faultless treatment, this is still uncertain.

Yielding an integration of the Nereda treatment technology it is to be said, that the technology is also applicable in a decentralized treatment way. One example is the connection of the industrial WW of the diary company 'Friesland Campina' in Zutphen to a decentralized Nereda treatment plant operated by the water authority Rijn en IJssel (Royal Haskoning DHV 2020d).

Following the development plans for HavenStad which foresee to resettle the companies inside HavenStad more to the west (e.g. Houtrakpolder) (Gemeente Amsterdam 2013) of the port area also smaller industrial treatment plants could be combined with the extraction of Kaumera. In that case the concept of Industrial Symbiosis could find its application in and around HavenStad to combined different RR strategies with an economic revenue.

Industrial Symbiosis and COMPRO in HavenStad

According to Marian R. Chertow (2000) the concept of 'Industrial Symbiosis' engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity (Chertow 2000). In the case of COMPRO it refers to the system of the reuse of the waste-products of one company, such as the WW of the diary factory, that become the products for another company such as Kaumera for ChainCraft, NPSP and Bam-Infra.

The distance of the manufacturing companies of the RE-PLEX to the WWT plant as well as the company that produces the Kaumera becomes relevant when the project should be implemented in form of an Industrial Symbiosis. One expert mentions that there is a logistical and economical advantage, when the extraction facility is next to the manufacturing-company of the RE-PLEX. Therefore it would be beneficial to relocate the companies in form of an 'industrial park', as realized in Denmark, Kalundborg (Kalundborg Symbiose - 2020). The expert justifies his estimation with the fact that the sludge contains a lot of water after the extraction, which makes a transportation in the transporter very costly. He also remarks that this could become a challenge in a bigger scale [Appx. 7.4.3, E3: 129]. This fact makes a decentralized treatment more effective. He pictures that the WWTP could become a bio-refinery that would be spatially connected to the companies that use the by-products of the

WW. This scenario could be applicable to centralized as well as decentralized plants. Also other resource such as P and biogas next to Kaumera could be recovered and used by the companies in the park-region. Thereby he also refers to the vision of RR of the water-authorities in the Energie – en Grondstoffenfabriek that is explained in the theoretical framework [Appx. 7.4.3, E3: 153, 266]. With the model of Industrial Symbiosis a revenue for the water-authorities as well as for the companies could arise.

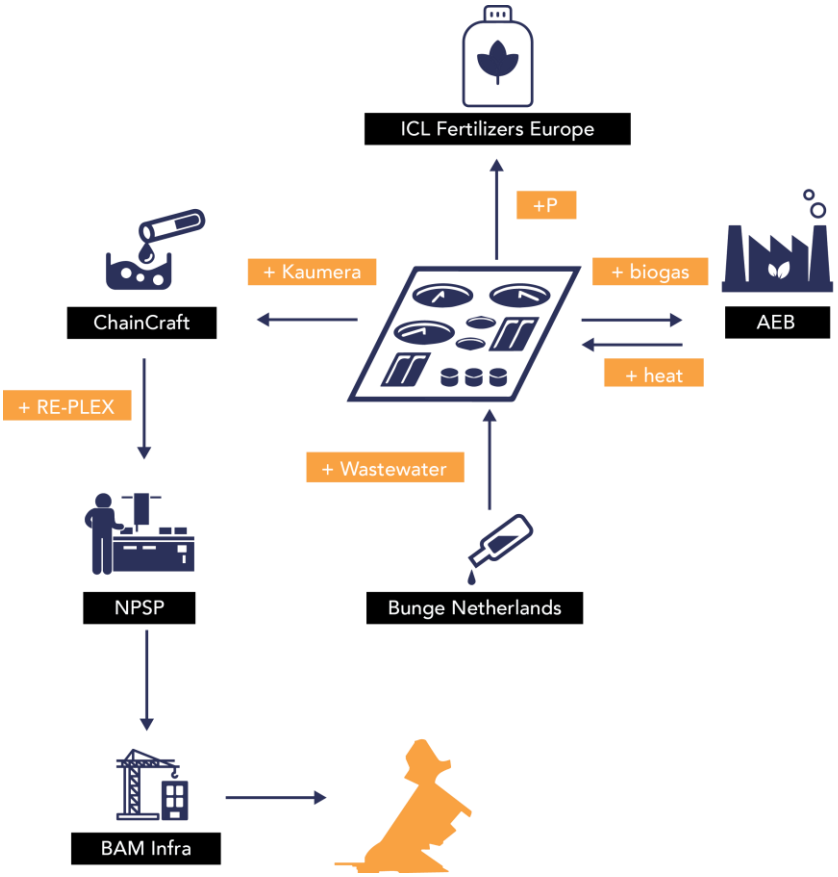

Figure 19_Industrial Symbiosis Network (own illustration)

Another expert from a manufacturer company in the region of HavenStad could also imagine to be engaged into an industrial symbiosis network [Appx. 7.4.3, E7:173].

Generally it could be examined that the integration of the concept in form of an industrial symbiosis is appreciated by the experts. As the companies should be relocated this would also fit within the vision of the strategic plans for HavenStad and therefore would be a realistic scenario, as long as more Nereda treatment plants would be connected to industrial WWs and Cellulose and Kaumera could be applied for various products such as RE-PLEX, with the prerequisite that the product properties are conveniently applicable.

To come back to the discussion of the centralized treatment it needs to be said, that a centralized treatment could also be applied in form of an industrial symbiosis. The retrofitting of the WWTP in Amsterdam West to a Nereda plant would also save a lot of space as shown in figure 20. The blue area in the picture, is the part of the Nereda technology that treats 60% of the WW, whereas the conventional plant, covered by the red area treats 40%. This shows the space effectiveness of the Nereda treatment.

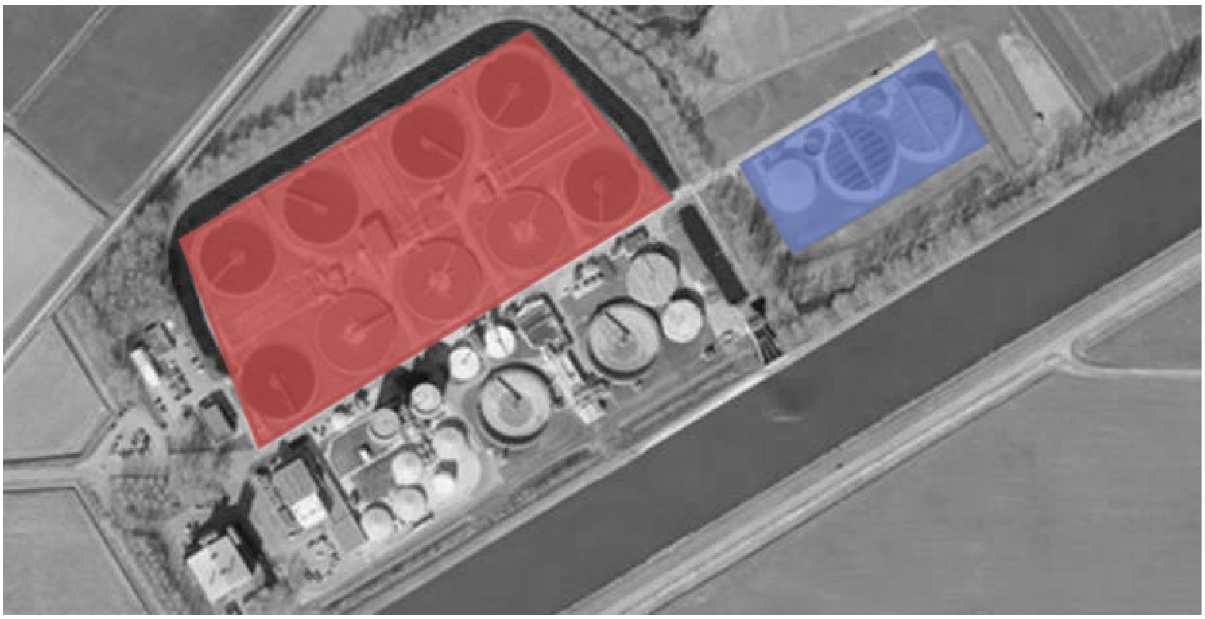

Figure 20_Footprint of a Nereda-plant (Royal Haskoning DHV 2020e)

Therefore a third scenario, to integrate the Nereda technology into the area of HavenStad in form of a decentralized treatment of the municipal WW streams it imaginable. This scenario could be imagined such as visualized in figure 21. But as the development plan for HavenStad foresees a highly dense area it is less realistic. On top, with a spatial integration into the residential area of HavenStad a higher environmental impact in form of smell and noise might occur. According to the strategy of the MoA there are certain limits for environmental influences in HavenStad. Therefore measures such as for example odour filters or extra insulation could be required. Which system configuration will be finally decided for according to Larsen et al. depend crucially on adequate assumptions about the longer term context conditions and the reliability of the implemented technologies (Larsen et al. 2013). This means that the decision for a system if centralized or decentralized will be decided through an organic process that needs time.

Figure 21_Spatial integration and advantages of the Nereda treatment (Royal Haskoning DHV 2020c)

The other form of integration addressed by this research is the integration of the RE-PLEX into HavenStad.

4.4.2 RE-PLEX integration into public space and buildings in HavenStad

The expert from the water-authority points out that for a coordinated tendering and procurement (BD Dictionary 2020) to integrate the product into HavenStad the specifications of the product need to be know [Appx. 7.4.3, E4: 142]. This is not fully given for the RE-PLEX yet. For this chapter the finished product in the future is assumed.

In the category of application different product-categories were defined that could possibly be applied in the realm of HavenStad. In the following the realization of the product integration according to the attitude of the experts as well as application-areas should exemplarily discussed. HavenStad has the right scale to serve as an experimental playground for e.g. public space furniture out of the RE-PLEX. The main responsible stakeholder when it comes to the product application in public space is the MoA.

The experts from manufacturing companies in HavenStad as well as from the MoA highlighted the difficulty to bring new products into public space in a regular way as the MoA e.g. only uses standardized materials and elements of one brand for the public space and

their maintenance system is completely organized around one brand so that elements can be reused in an efficient refurbishing process [Appx. 7.4.3, E5: 43; E7:79].

The maintenance is also a part of the product lifecycle of the RE-PLEX. So far the effort that needs to be spend for the maintenance of the RE-PLEX cannot be estimated. Concerning the product performance the MoA specifies that the design processes needs to take into account the entire construction chain which also involves the future management and maintenance requirements of the public space, which in the case of new or circular products could be higher and therefore also raise the costs [Appx. 7.4.3, E5: 95]. Furthermore is was stated that the amount of staff is limited, when it comes to the maintenance of public space [Appx. 7.4.3, E5: 99]. Accordingly it is important that in the product development of innovations the product performance of the whole life-cycle is taken into account. Therefore an integral approach such as in the COMPRO project can significantly contribute to the acceptance of products such as RE-PLEX.

To make innovative projects less risky and uncomplicated different experts indicated that pilot locations in the urban realm should be provided to innovations. There it could be tested how the product would perform in public space as well as in temporary buildings and exhibitions such as 'art-projects', where they could show new products that divert from the standards [Appx. 7.4.3, E5: 23; 27; 87; E7:91]. This offer could be very interesting for the COMPRO project when it comes to the pilot phase.

Even though, the expert remarks that there is only a limited amount of money and people to spend into the test-locations, though they cannot be provided to all projects [Appx. 7.4.3, E5: 87]. Here the competition of other innovative products on the market becomes quite obvious. However the expert recommends to also show the product to people in semi-public space or even private spaces such as gardens:

> *E5: 107: 'I would go via the urban space is not only public space of course but yeah, I would go via test locations or showcase locations where you can show it to people both in public space but also maybe in semi public or private spaces like in gardens where communities designed their own inner areas or I think you need some test projects before you can integrate it in the standards refurbishment of public space elements.'*

A further recommendation of another expert was that the neighbourhood that lives in the areas should be participatory connected to the project and should be able to give a proposal on the implementation. With the participation of citizens there is a higher certainty that the citizens feel involved and take care of the project [Appx. 7.4.3, E7:95].

The expert from the MoA emphasised that to serve as the playground for innovations would perfectly fit within the ambition of HavenStad [Appx. 7.4.3, E5:139]. These sides could for

example be parks such as the 'Westerpark' as well as waterside redevelopments [Appx. 7.4.3, E5: 143] at the Ijssel.

Especially the district Buiksloterham, which is a district in the area of HavenStad should serve as a testing-space for experimentation of research innovations in the scope of sustainability. Here innovation centres as well as product implementations can take its shape in form of local use of resources. After a test-phase in Buiksloterham the innovations can be implemented in other areas as well (Gemeente Amsterdam 2020).

The expert remarks that when it comes to installations in building sites the MoA has less influence than in public space. The application of the RE-PLEX in buildings is decided by the market parties. To have an approximation of the possibly applicable amount for the application of RE-PLEX in buildings, such as façades or insulation elements an example calculation is provided in the following:

Minervahaven was taken as an example to calculate the sum of all façade surfaces that could be newly built with RE-PLEX. The Masterplan of Minervahaven was used to get the physical values of the existing buildings. This was achieved by firstly estimating the average number of floors given the /planned/ GFA (1.162.000m2) of the zone and the sum of Building coverage area currently in Minervahaven (243.224m2).

1.162.000 m^2 / 243.224 m^2 = 4.78 Floors ~ 5 Floors

Secondly, it was estimated that with a floor height of 3 meters, the average height of a building is 15 metres. Lastly, by multiplying the existing building circumference (26.567) by 15 metres, the sum of all exterior walls was found. The sum of façade elements in Minervahaven had the following area: 398.518m2.

1.162.000 m^2 / 398.518 m^2 = 0.34.

Thererfore, it was estimated that 1m^2 GFA equals 0.34 m^2 of façade element. Therefore the *GFA in different regions in HavenStad planned to be built was multiplied by the façade-ratio to measure the total m^2 of façade elements in HavenStad:*

- Sloterdijk-Centrum en Sloterdijk Centrum – Noord - 1.058.264m2 GFA* 0,34296 = 362.942,22
- Sloterdijk I Zuid en Noord - 1.122.000m2 GFA * 0,34296 = 384.801,12 m2 façade elements
- Zaanstraat Emplacement - 182.000m2 GFA* 0,34296 = 62.418,72
- Minervahaven - 1.162.000m2 GFA* 0,34296 = 398.519,52
- Sportpark Transformatorweg en Amsterbaken - 188.000m2 * 0,34296 = 64.476,48
- Alfadriehoek 520.000m2 GFA * 0,34296 = 178.339,2
- Cornelis Douwes 2-3 - 960.000m2 GFA * 0,34296 = 329.241,6

- Cornelis Douwes 0-1 - 690.000m2 GFA* 0,34296 = 236.642,4
- Melkweg Oostzanerwerf - 146.600m2 GFA * 0,34296 = 50.277,936
- Coen- en Vlothaven - 1.540.000m2 GFA * 0,34296 = 528.158,4
- Westerpark – no houses; Noorder IJ-plas - no houses

Potential façade elements in HavenStad in total = 2.595.813m2

The calculations are based on 'approximate' data. With the realistic urban plans for HavenStad it could be calculated more precise.

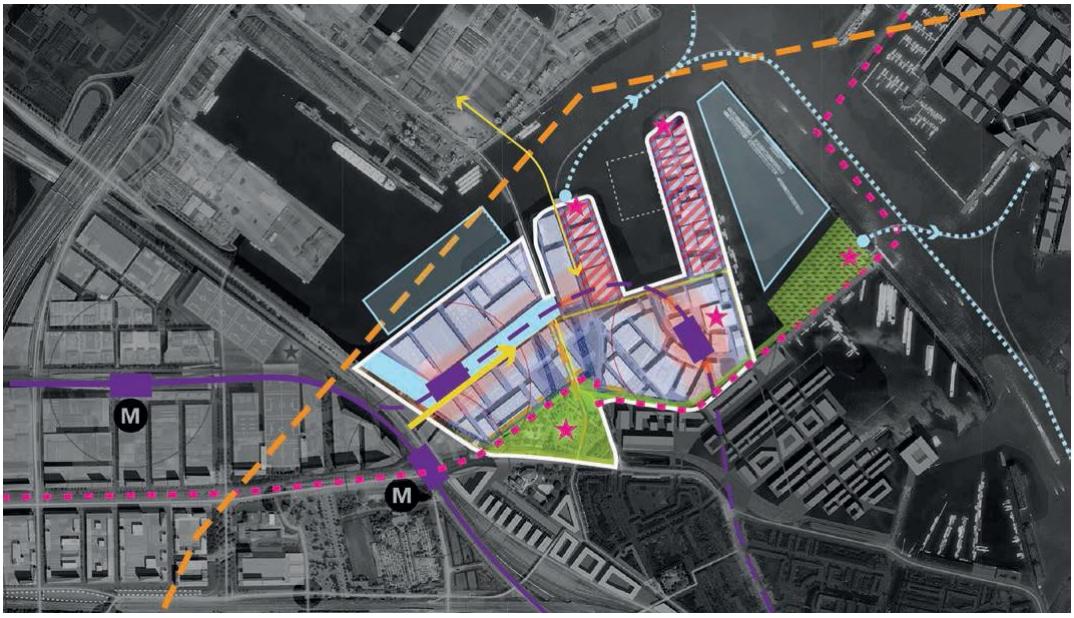

Figure 22_Proposed Masterplan Minervahaven (Gemeente Amsterdam 2017)

One vision of the MoA is also to construct flexible buildings, which can easily change their function by a partly renovation (Gemeente Amsterdam 2019). Here it could also be interesting to integrate biodegradable building-materials that could be exchanged in a transformation of the function.

As the experts mainly accepted to RE-PLEX to be used for temporary outdoor applications the fact of the transformation of HavenStad should also be considered. In the next decades the area continuously will be underpinned to construction sides. Construction sites always need temporary supporting constructions. Therefore temporary reinforcement walls or temporary ground consolidations could be a very interesting application-field that coincides with the properties of the RE-PLEX, such as biodegradability, the envisioned durability and fire-resistance. Huge amounts of conventionally produced constructions materials with large CO_2 emissions could be replaced by completely circular and biodegradable alternatives, which would essentially contribute to solve the problem of upcoming climate change.

5 CONCLUSION

This thesis aimed at investigating the potential of the COMPRO project by interviewing different experts along the value-network of the RE-PLEX in order to draw conclusions on what could be done to raise the potential of the project and thereby the acceptance in urban development projects such as HavenStad.

Insights from the interviews as well as a comprehensive literature review led to a set of conclusions that can be drawn. The conclusions can be divided into conclusions for the potential of the project in itself, as well as conclusions for the urban integration of the project into HavenStad.

5.1.1 Conclusion for the COMPRO project

For the COMPRO project in the different categories a lot of opportunities and strengths as well as threats and weaknesses could be identified.

One of the most striking opportunity is, that there is a general ambition to promote CE initiatives by the MoA, however there are still some threats in the way for an implementation. Besides all the attributes the product should accomplish in terms of the technological development, still the MoA demands high performance standards of the products combined with a high ambition of circularity. Amsterdam's governance is favouring the conditions for innovations such as COMPRO by giving incentives for circular and sustainable projects. Even though, more specific governance incentives such as financial incentives and concrete actions should be given (van Leeuwen et al. 2018).

Threats on a product-level are rather easy to be identified, but a lot more difficult to remove in a practical sense. For all defined categories barriers could be identified. The main factors that could be revealed as potential threats for the product were the *product performance*, the *competition* the product has to face in the market and the *legal regulations that are adhered to the application*. For all those factors the development-stage of the product plays a significant role. However, threats could also be detected for the other categories such as the costs in combination with the scale, or the uncertainty about environmental hazards. The barriers are highly intertwined and will need an integrated approach, where the integrated character of COMPRO project acts as the appropriate environment to find the right measures.

Especially the development stage of the product gave some limitations for this research. One of the most essential restrictions in this research concerning the product is that the RE-PLEX characteristics are not fully defined and therefore no prototype of the RE-PLEX yet exists. On the other side a potential application for a prototype should be researched to give demand-advices to the product development. The market potential obviously can be researched in

more detail, when the market parties have a product in mind and can reflect it based on the application. However, to examine the potential of the product on the way to a prototype development is also highly important.

For a further development stage a high market potential can be predicted for the RE-PLEX. On the way to the development stage of a prototype implementation, essential steps and investments especially concerning the product performance need to be taken. The COMPRO-consortium provides a great environment and puts the efforts in place for the development path. In any way, the study of the market potential of the project should be repeated in a further stage.

5.1.2 Conclusion for the acceptance in HavenStad

Consequently, also for the urban acceptance there exist limitations when it comes to the realistic application of the RE-PLEX. However, HavenStad could provide an interesting experimental ground for the realization of projects.

In order to give advices for potential directions towards the implementation in the urban realm different scenarios of centralized and decentralized treatment were illustrated. Thereby the concept of industrial symbiosis took an essential role, in both concepts. The vision of the concept would combine the concept of urban metabolism with an economic profitability for the parties involved. Therefore the market parties need to be approached as soon as a prototype exists. The cooperation between the water-boards in Amsterdam, when it comes to RR is already giving the right ground for an integration of different strategies. The transformation-strategy of HavenStad sets the right conditions for a step by step approach to find the best solutions.

A final important message is that the stakeholder integrated concept of the COMPRO project is the appropriate development-climate for the RE-PLEX. Knowledge transfer and cooperation and strategic political choices inside the business-network are highly relevant and might help to overcome some barriers. Thereby a comprehensive knowledge of the products should be available for all parties involved. However, the integration of the COMPRO-project will not be the only deciding factor of the WWT in and around HavenStad. It will always be an assessment of many different elements, which still needs a high degree of research input. In further studies the two dimensions, the urban and the product dimension of the research, also could be analysed separately to reach an even higher degree of profoundness in the analysis of both sides.

To find its leading light in an emerging CE also the in-depth analysis of the social acceptance of the concept would be one of the next research steps, as the awareness of innovations by people will always be one of the most relevant factors in innovation processes.

Personal Note

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IV. Declaration on oath

I hereby affirm that the Master thesis at hand is my own written work and that I have used no other sources and aids other than those indicated. All passages, which are quoted from publications or paraphrased from these sources, are indicated as such, i.e. cited, attributed.

This thesis was not submitted in the same or in a substantially similar version, not even partially, to another examination board and was not published elsewhere.

Date_____ Signature_____

7 APPENDIX

7.1 List of experts

Company	ID	Interview	Date	Interview duration
Manufacturer- Specialist in bio-based and circular products and materials	E1	yes	25.05.20	1:23
End-user Innovation Specialist	E2	yes	26.05.20	1:20
Gemeente Amsterdam – Urban Planner/Sustainability Advisor	E5		01.07.20	0:43
Manufacturer of the RE-PLEX	E3	yes	27.05.20	1:20
Water authority Amsterdam	E4	yes	11.06.20	0:53
End-user and retailer of construction materials	E6	Answer via mail	21.07.20	/
Architecture office and manufacturer in HavenStad	E7	yes	28.07.20	0:43
Manufacturer - Specialist in bio-based and circular products and materials	E8	yes	07.08.20	0:34

7.2 Information for experts

7.2.1 E-mail example of interview request to the experts

Dear _Team,

I am Anja Constien, a Master-student at the Bauhaus-university in Weimar, Germany and writing my Master-thesis is collaboration with the AMS Institute in Amsterdam.

The topic of my Master-thesis is the market-potential of the wastewater-recovery project Compro - and how to raise the acceptance of Compro in HavenStad.

The Compro project, initiated by the AMS-Institute is an example for the reuse of wastewater based on circular economy principles. Cellulose and the biopolymer Kaumera, two main components out of the wastewater can be turned into a bio-composite called RE-PLEX for construction.

In the presentation attached you can find some more information about the Compro-project and the product of Compro – the RE-PLEX.

I found your enterprise partly located in HavenStad and working with construction-materials which cover the potential usage-scope of the RE-PLEX. Furthermore I recognized your ambition of finding sustainable and circular solutions for the construction-industry.

I want to conduct my interviews with stakeholders along the potential value-network of the RE-PLEX product such as end-users located in the region of HavenStad.

I would like to identify the main barriers of acceptance of the Compro project and the RE-PLEX product and in a further step find measures to overcome the barriers of acceptance to examine in how far the concept could find its application in the urban development projects such as HavenStad.

Therefore I would like to ask if I could conduct an Interview with a colleague in your company connected to the 'BouwBewust'-department.

To examine the market-acceptance I use qualitative Skype-Interviews that take about approximately 1 hour.

Please do not hesitate to ask any questions concerning the format and content of the interview.

I would like to inform myself via a phone-call at the end of the week about the potentail participation of one of your colleagues in an online-interview.

Kind regards,

Anja Constien

Anja Constien

Intern - Circularity in Urban Regions

AMS Institute | Amsterdam Institute for Advanced Metropolitan Solutions

Kattenburgerstraat 5, building 027W, 1018 JA Amsterdam, the Netherlands

7.2.2 Presentation of the research for the experts

Interview Information by Anja Constien

Master Thesis at in the study-program Integrated Urban Development and Design
at the Bauhaus University Weimar and the AMS Institute in Amsterdam

Summer Semester 2020

The market-potential of the wastewater-recovery case-study Compro - and how to raise the acceptance of Compro in HavenStad

Compro

Compro is a circular wastewater-recovery-project.
The project is a collaboration between
the Delft University of Technology, ChainCraft, NPSP, Bam Infraconsult and the AMS Institute.
Cellulose and the biopolymer Kaumera, two main components out of the wastewater can be turned into a bio-composite called RE-PLEX for construction.
Compro will develop an application of the Kaumera-cellulose-composite material in the building and construction sector.

Resource: Peter Mooij, 2020

RE-PLEX

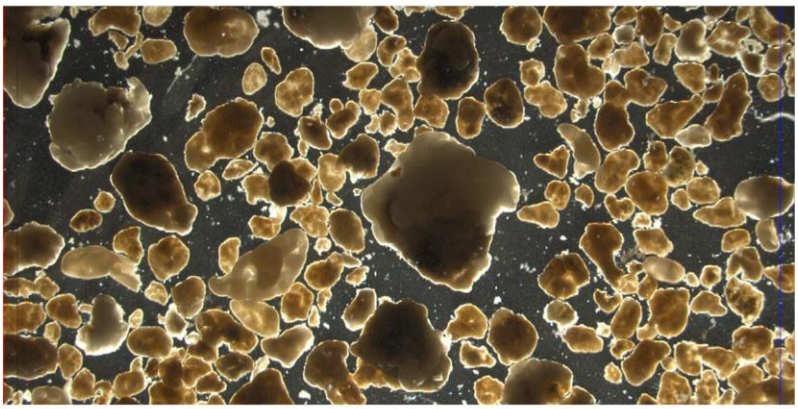


Fig.: Granular bio-polymers (Kaumera)

Kaumera + Cellulose = RE-PLEX

Sustainable

- Saves energy in comparison to conventional bio-composites
- bio-degradable

Product properties

- Lightweight and stiff
- comparable to the structure of wood

Application

- applicable in the construction sector
- alternative for fossil-based and energy-intensive composite materials such as glass-fibre-polyesters
- e.g. house insulations, temporary usages e.g. construction reinforcements or piping systems

Nereda - Wastewater-treatment-technology

- Nereda is a wastewater-treatment-technology invented by the Delft University of Technology in the 1990's.
- The granular sludge settles faster to the bottom of the tank than in conventional activated sludge-technologies.
- Therefore it is very space and cost-effective, as it requires only 25% of the area that a conventional activated sludge-technology needs.
- Aerobic granular biomass in produced in a fast-settling process.
- Phophate and bio-polymers, such as Kaumera can be recovered

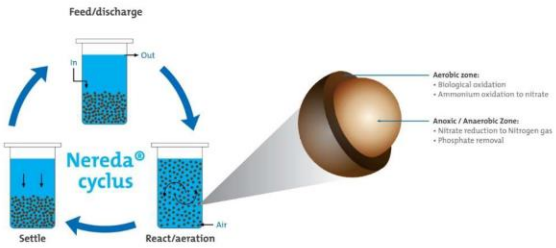
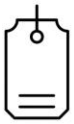


Fig.: Nereda-cycle

Fig.: setteled sludge; left: conventional plant, right: Nereda plant

Legal aspects

Products from waste-water are labeled by the **Waste-label**



- national bodies are in charge of removing it
- assessment of risks by national bodies is only possible with a prototype

- Compro aims to built a **prototype in 2021**

- after successful assessment waste-label could be removed

Facts and Figures

Scale

- potential RE-PLEX production in the Netherlands is around **250.000 ton / year**

CO2 reduction

- CO2-reduction of **15.3 ton CO2 / ton RE-PLEX** compared to the production of glass-fibre-polyesters

Energy saving

- A composite consisting of **50 % Kaumera and 50 % cellulose consumes**10.4 GJ / ton primary energy compared to 89 GJ / ton for a composite with 50% polyester and 50% glass. This is a **primary energy saving of 88%.**

Compro and HavenStad

HavenStad is the biggest urban-development-project in Amsterdam - next to 40.000 - 70.000 apartments, 45.000- 58.000 working-places are planned to be built in a high density. The big Port-area to the west and northwest of the centre of Amsterdam is planned and going to be built according to the principles of circularity. The integration of resource-reuse-strategies into urban planning is indispensable to approach the urban challenges of the near future. Projects such as Compro could be integrated into the industrial transition of the development.

The Compro-project is connected to a lot of stakeholders along the value-network of RE-PLEX (eg. Wastewater-treatment bodies, manufacturers, end-users)

- The enterprises in and around HavenStad could collaborate in the application of Compro
- The construction-sector in HavenStad is a potential end-user of RE-PLEX
- RE-PLEX products could find an application in HavenStad

Content of the interview

What are the social and economic barriers of the market-acceptance of the Compro-concept and product (RE-PLEX) - *and how to raise the acceptance of Compro in HavenStad?*

The Interview addresses the following:

Concept	Urban integration	Product
- Organization - Policies - Legal aspects - Financial performance - Urban strategy - Application to HavenStad		- Market scale - Technological feasibility - Infrastructure and Logistcs - Procurement costs - Product performance - Customer satisfaction - Environment

Thanks for your attention!

7.3 Interview Guidelines

Guideline 1

bauhaus ifex

IUDD Integrated Urban Development and Design

AMS AMSTERDAM INSTITUTE FOR ADVANCED METROPOLITAN SOLUTIONS

Interview – Manufacturer

The market-potential of the wastewater-recovery case-study Compro - and how to raise the acceptance of Compro in HavenStad

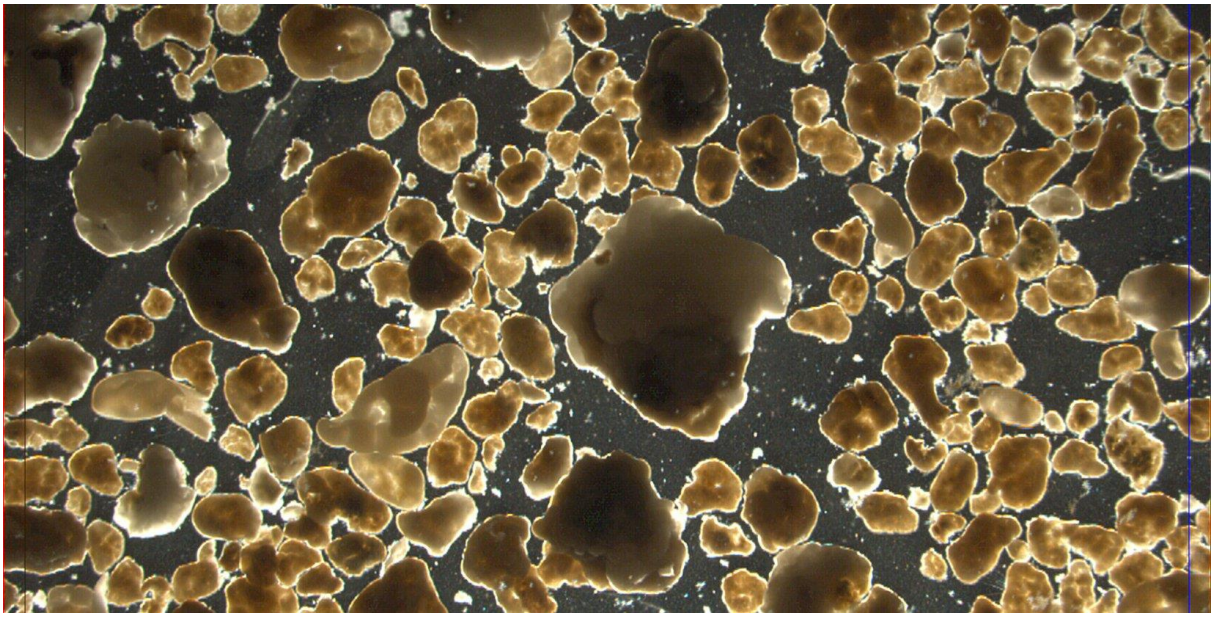


Fig.: Biopolymer-granules (Kaumera)

Dear experts,

Thanks for your attendance at this interview with the topic of 'The market-potential of the wastewater-recovery case-study Compro - and how to raise the acceptance of Compro in HavenStad'.

The aim of this interview is to gain more insights into the barriers of the market acceptance of the 'Compro'-project and the 'RE-PLEX product by the stakeholders involved.

The identification of the barriers can serve to find criteria or measures to overcome these barriers of acceptance of the Compro-project.

To guide you into the context of the project the following paragraphs shortly describe the content of the Compro-project and its possible connection to the urban development HavenStad.

The interview is twofold - a conceptual part is dedicated to the examination of the concept of Compro and how it is embedded into a network of actors. The product part examines different categories of the market-acceptance of the product ‘RE-PLEX’.

Product Compro – RE-PLEX

The Compro project, initiated by the AMS-Institute is an example for the reuse of wastewater based on circular principles. Cellulose and the biopolymer Kaumera, two main components out of the wastewater can be turned into a bio-composite called RE-PLEX for construction.

The lightweight bio-composite RE-PLEX is a viable alternative to fossil-based composite materials. Compared to conventional fossil based composite materials, RE-PLEX production consumes up to 67% less energy during the production process. The Compro-consortium aims to build a prototype from RE-PLEX for an application in 2021. So far the researchers of the Compro-consortium consider the construction-sector as the most valuable sector for the application of RE-PLEX.

Next to environmental friendly properties such as bio-degradability, energy savings and independency of fossil fuels RE-PLEX also has other useful properties that fit into the construction-market such as strength, stiffness and non-flammability.

If the properties of RE-PLEX are sufficient to compete with conventional products and if conflicts of interest can be overcome inside the stakeholder-network of the concept, so that the acceptation in the market can be raised, should be examined by this interview.

The detection of certain barriers, might also help to raise the possibility of the implementation of Compro on a bigger scale such as in urban development-projects such as HavenStad.

Potential area of application: HavenStad

Haven-Stad is the biggest urban-development-project in Amsterdam - next to 40.000 - 70.000 apartments, 45.000- 58.000 working-places are planned to be built in a high density. The big Port-area to the west and northwest of the centre of Amsterdam is planned and (going to be) built according to principles of circularity. The integration of resource-reuse-strategies into urban planning is indispensable to approach the urban challenges of the near future.

HavenStad consists to a big part of industrial areas, with companies in the construction and agricultural sector, which also could benefit by business-models connected to recovery of resources such as bio-composites from wastewater. Even though the integration of innovative technologies and projects such as Compro are not realized frequently so far.

The question that also will be addresses with this interview is in how far projects such as Compro could find its application in urban developments such as HavenStad in the future. Thereby the conceptual implementation such as the spatial configuration as well as if the products out of this concept could find its application in HavenStad is of concern.

Questions

1. Introduction

How are you?

For how long are you in your position in the company?

What is your task/position/relation to the Compro-project?

2. Questions regarding the *concept and the network*

2.1. General

What do you consider as economic **advantages** of the Compro-project?

What do you consider as social **advantages** of the Compro-project?

What are the social/economic **risks** of the Compro project?

Which barriers connected to the Compro-project did you experience so far?

2.2. Organizational aspects

What organizational difficulties have you experienced when obtaining your resources indirectly from a wastewater-treatment-plant (E.g. inconstant delivery of the granular sludge)?

Does a business model that is connected to a network of different stakeholders involve operational (e.g. communication, infrastructure) obstacles for you?

(Do you have ideas for an optimization to prevent these obstacles?)

2.3. Political guidelines

Which political guidelines do you perceive as the most preventing regulation for the Compro-concept (e.g. waste-label)?

What measures have to be taken by political bodies (e.g. Municipality of Amsterdam or Waternet) to make the symbiosis (collaboration of different enterprises) less risky and uncomplicated (e.g. subsidies, institutional framework)?

2.4. Financial performance

Are there financial risks you have to accept when depending on the by-products of a wastewater-treatment plant (e.g. supply shortfall)?

Did the production/installation-costs raise with the use of innovative technologies considered for the processing of bio-composites such as RE-PLEX?

Is the production of bio-composites out of recovered resources more costly than conventional production-routes?

2.5. Urban integration

Could you imagine COMPRO to be applied in a bigger urban scale in a symbiotic network of companies?

Would it be a relevant logistical advantage for the Compro-project if the cooperation-partners would be spatially situated next to your company?

3. Questions regarding the *product*

3.1. General

Where do you see an added value of RE-PLEX?

3.2. Market Scale

Which amounts of RE-PLEX need to be generated to make it economically valuable for your company?

3.3. Technological feasibility

Can you say something about technological difficulties in the production-process of RE-PLEX?

For which applications do you consider RE-PLEX most useful? (E.g. ceiling plates, window frames, door panels, thermal and acoustic damping plates, facing sections, scaffolding boards, bridge armrests)

Do these applications require certain properties RE-PLEX might not be able to fulfil?

Do you consider REPLEX more useful for temporary or permanent constructions?

Can you say which process-costs are connected to the production of RE-PLEX?

3.4. Product performance

Which quality criteria (e.g. durability/weight/viscosity etc.) the product needs to fulfil to be competitive with conventional products? (E.g. glass-fibre; polyester composites)

Which functions (other than e.g. biodegradability, stiffness, non-flammability) RE-PLEX does not fulfil so far but need to be fulfilled?

Do you perceive the biodegradability of RE-PLEX as an advantage or a drawback?

3.5. Customer satisfaction

What do you personally expect from a product (e.g. insulation-material in walls of a house) which consists of rest-materials (e.g. smell, safety, design etc.)?

In which product-application do you think RE-PLEX would be most accepted and why?

Are you already working on technological strategies to overcome certain safety-risks or doubts about possible RE-PLEX-products?

As a manufacturer do you feel responsible for the safety of the end-product? In how far?

3.6. Environment

RE-PLEX has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

3.7. Conclusive

Is there anything that has not been considered so far, that you would like to mention?

Is there something you want to know from me?

7.3.1 Questions guideline 2

1. *Introduction*

How are you?

For how long are you in your position in the company?

What is your task/position/relation to the Compro-project?

2. Questions regarding the *concept and the network*

a. *General*

What do you consider as social **advantages** of the Compro-project?

What do you consider as economic **advantages** of the Compro-project?

What are the social/economic **risks** of the Compro project?

Which barriers connected to the Compro-project did you experience so far?

b. *Organizational aspects*

Does a business model like Compro that is connected to a network of different stakeholders (wastewater-plant, manufacturers, end-users) involve operational (e.g. communication/infrastructure) risks/difficulties for you?

What organizational difficulties have you experienced/or could arise when depending on the by-product streams of a wastewater-treatment-plant?

c. *Political and legal guidelines*

Which political or legal guidelines do you perceive as the most preventing regulation for the Compro-concept (e.g. waste-label)?

What measures have to be taken by political bodies (e.g. Gemeente Amsterdam or Rijkswaterstaat) to make the symbiosis less risky and uncomplicated (e.g. subsidies)?

d. Financial performance

Are there financial risks you have to accept when depending on the by-products of a partner-company (e.g. supply shortfall)?

Will the production/installation-costs raise with the use of innovative technologies considered for the use of biopolymers?

e. Urban integration

How do you imagine the integration of the Compro-concept into an urban development such as HavenStad?

Could you imagine that RE-PLEX is applied in a bigger urban scale in a symbiotic network of companies?

3. Questions regarding the *product*

a. General

Where do you see an added value of RE-PLEX?

What is your motivation to consider RE-PLEX in your company?

b. Market Scale

Which amounts of RE-PLEX need to be generated to make it economically valuable for your company? (Current market-size is around 125.000 ton/year)

c. Technological feasibility

Which technological barriers prevent the implementation of Compro? Where do you see the barriers? How is it possible to overcome these barriers?

What applications the product can have in your company? For which applications other than those in your company, do you consider RE-PLEX most useful/more profitable? (E.g. ceiling plates, door panels, thermal and acoustic damping plates, facing sections, scaffolding boards, traffic signs)

Do these applications require certain properties RE-PLEX can't fulfil?

Is RE-PLEX more useful for temporary or permanent constructions?

d. Infrastructural and logistic feasibility

Are there parts of the infrastructure in your company still need to be created to integrate the RE-PLEX-composite into the standardized production-process of other products such as concrete etc.?

e. Procurement Costs

Which procurement-costs are connected to an introduction of the RE-PLEX-product?

f. Product performance

Which quality criteria (durability/weight/viscosity/resistance to water/chemicals/UV etc.) the product needs to fulfil to be competitive with conventional products? (E.g. glass-fibre; polyester composites)

Which functions (other than e.g. biodegradability, stiffness, non-flammability) RE-PLEX does not fulfil so far but need to be fulfilled?

Do you perceive the biodegradability of RE-PLEX as an advantage or a drawback?

g. Customer satisfaction

Which criteria (such as sustainability and durability) need to be fulfilled primarily to reach customer-satisfaction?

What are your doubts about a product (e.g. walls of a house) originating from residual waste (smell, safety, design etc.)?

In which product-application these properties would be most accepted?

Would it be a difference for you if the wastewater for the composite-material derives from municipalities or from the wastewater-stream of one company?

h. *Environment*

The RE-PLEX-product has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

i. *Conclusive*

Is there anything that has not been considered so far, that you would like to mention?

Is there something you want to know from me?

7.3.2 Questions guideline 3

1. ***Introduction***

How are you?

For how long are you in your position in the company?

What is your task/position/relation to the Compro-project?

2. Questions regarding the *concept and the network*

2.1. *General*

What do you consider as economic **advantages** of the Compro-project?

What do you consider as social **advantages** of the Compro-project?

What are the social/economic **risks** of the Compro project?

Which barriers connected to the Compro-project did you experience so far?

2.2. *Organizational aspects*

What organizational difficulties have you experienced when obtaining your resources from a wastewater-treatment-plant (E.g. inconstant delivery of the granular sludge)?

Does a business model that is connected to a network of different stakeholders involve operational (e.g. communication, infrastructure) obstacles for you?

Do you have ideas for an optimization to prevent these risks?

2.3. Political guidelines

Which political guidelines do you perceive as the most preventing regulation for the Compro-concept (e.g. waste-label)?

What measures have to be taken by political bodies (e.g. Gemeente Amsterdam or Waternet) to make the symbiosis (cooperation of different companies) less risky and uncomplicated (e.g. subsidies, institutional framework)?

2.4. Financial performance

Are there financial risks you have to accept when depending on the by-products of a wastewater-treatment plant (e.g. supply shortfall)?

Did the production/installation-costs raise with the use of innovative technologies considered for the processing of biopolymers?

What makes the recovery processes more costly than conventional production-routes?

2.5. Urban integration

Would it be a relevant logistical advantage for the Compro-project if the cooperation-partners would be spatially situated next to your company?

3. Questions regarding the *product*

3.1. General

Where do you see an added value of RE-PLEX?

3.2. Market Scale

In which amounts RE-PLEX needs to be generated to make it economically valuable for you?

Could you imagine COMPRO to be applied in a bigger urban scale in a symbiotic network of companies?

3.3. Technological feasibility

Are there any technological difficulties in the production-process of Kaumera/RE-PLEX? Are there already strategies to overcome these difficulties?

For which applications do you consider RE-PLEX most useful? (E.g. ceiling plates, window frames, door panels, thermal and acoustic damping plates, facing sections, scaffolding boards, bridge armrests)

Do these applications require certain properties RE-PLEX might not be able to fulfil?

Do you consider REPLEX more useful for temporary or permanent constructions?

3.4. Infrastructural and logistic feasibility

Which logistic infrastructure do you need to organize the supply of the product?

3.5. Development Costs

Which process-costs are connected to the production of RE-PLEX?

3.6. *Product performance*

Which quality criteria (durability/weight/viscosity etc.) the product needs to fulfil to be competitive with conventional products? (E.g. glass-fibre; polyester composites)

Which functions (other than e.g. biodegradability, stiffness, non-flammability) RE-PLEX does not fulfil so far but need to be fulfilled?

Do you perceive the biodegradability of RE-PLEX as an advantage or a drawback?

3.7. *Customer satisfaction*

What do you personally expect from a product (e.g. insulation-material in walls of a house) which consists of rest-materials (e.g. smell, safety, design etc.)?

In which product-application do you think RE-PLEX would be most accepted and why?

Are you already working on technological strategies to overcome certain safety-risks or doubts about possible RE-PLEX-products?

As a manufacturer do you feel responsible for the safety of the end-product? In how far?

3.8. *Environment*

RE-PLEX has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

3.9. *Conclusive*

Is there anything that has not been considered so far, that you would like to mention?

Is there something you want to know from me?

7.3.3 Questions guideline 4

1. ***Introduction***

How are you?

For how long are you in your position at Waternet?

How do you see the position of Waternet in relation to the Compro-project?

2. Questions regarding the *concept and the network*

2.1. General

What do you consider as social **advantages** of the Compro-project?

What do you consider as economic **advantages** of the Compro-project?

What are the social/economic **risks** of the Compro project?

2.2. Planning and organization

Does a wastewater-recovery-strategy like Compro that is connected to a network of different stakeholders (wastewater-plant, manufacturers, end-users) involve operational (e.g. communication/infrastructure) difficulties for you?

2.3. Political/legal regulations

Which political regulation do you perceive as the most preventing regulation for concepts such as Compro (e.g. waste-label)?

What measures Waternet or other political bodies (e.g. Rijkswaterstaat, Gemeente) could take, to make the cooperation of enterprises in these kind of resource-recovery projects less risky and uncomplicated (e.g. subsidies, institutional framework)?

2.4. Financial performance

Where do you see the financial benefits in selling a product from your wastewater-streams (E.g. household-sewage-charges)?

3. Urban integration

3.1. General

How do you imagine the urban integration of a project such as Compro?

Are there other wastewater-recovery-strategies that are competing with the project? Or in how far is the project also combinable with other recovery-strategies?

The Compro-project is connected to a centralized treatment method (Nereda) do you have doubts about this method?

3.2. HavenStad

Can you imagine the strategical integration of the Compro-concept into an urban development such as HavenStad (e.g. spatial strategy [decentralized/centralized] or conceptual symbiotic-networks)?

Do you see any financial barriers in implementing a project such as Compro into an urban development such as HavenStad (e.g. high system-installation-costs)?

4. Questions regarding the *product*

4.1. General

Where do you see an added value of RE-PLEX?

4.2. Market Scale

Is there a minimum-market-scale the Compro-project needs to reach to be valuable for Waternet to be implemented?

4.3. Technological feasibility

For which urban applications do you consider RE-PLEX most useful/reliable? (E.g. bridges, houses, street-paving, scaffolding, temporary event-halls etc.)

Do you consider RE-PLEX more useful for temporary or permanent constructions?

4.4. Product performance

Which property of a bio-composite such as RE-PLEX do you consider most important for an urban application?

4.5. Customer satisfaction

Which criteria do you think need to be fulfilled primarily to reach customer-satisfaction? (E.g. sustainability and durability)

What are your doubts about a product (e.g. walls of a house) originating from residual waste (E.g. smell, safety, design etc.)?

Would it be a difference for you if the wastewater for the composite-material derives from municipalities or from the wastewater-stream of one company?

4.6. Environment

RE-PLEX has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

4.7. Conclusive

Is there anything that has not been considered so far, that you would like to mention?

Is there something you want to know from me?

7.3.4 Questions guideline 5

1. *Introduction*

How are you?

For how long are you in your position (with the HavenStad-project) in the Gemeente?

2. Questions regarding the *concept and the network*

2.1. General

What do you consider as social **advantages** of the Compro-project?

What do you consider as economic **advantages** of the Compro-project?

What are the social/economic **risks** of the Compro project?

2.2. Planning and organization

To which extend the Gemeente can plan/influence the organization (communication/ infrastructure) of a concept that is connected to a network of different stakeholders?

2.3. Political regulations

Which political regulation do you perceive as the most preventing one for concepts such as Compro (e.g. waste-label)?

What measures the Gemeente or other political bodies (e.g. Rijkswaterstaat, Waternet) could take, to make innovative projects less risky and uncomplicated (e.g. subsidies, institutional framework)?

2.4. *Financial performance*

Do you see any financial barriers in implementing a project such as Compro into an urban development such as HavenStad (e.g. high system-installation-costs)?

3. ***Urban***

3.1. *General*

How do you imagine the urban integration of a project such as Compro?

In which way Compro can contribute to the aims of the City of Amsterdam or national urban-development goals?

Are there other wastewater-recovery-strategies that are competing with the project? Or which wastewater-treatment concept is planned for HavenStad so far?

3.2. *HavenStad*

Where do you see the benefits in applying the RE-PLEX in HavenStad?

Can you imagine to strategically integrate the Compro-concept into HavenStad (e.g. spatial strategy or conceptual symbiotic-collaboration-network)?

Do you see any barriers in implementing a Nereda wastewater-treatment plant into HavenStad (e.g. high system-installation-costs)?

4. Questions regarding the *product*

4.1. *General*

Where do you see an added value of RE-PLEX?

4.2. *Market Scale*

Is there a minimum-market-scale the Compro-project needs to reach to be valuable for a big urban development-project such as HavenStad?

4.3. *Technological feasibility*

For which urban applications do you consider RE-PLEX most useful/reliable? (E.g. bridges, façade elements, street-paving, temporary event-halls etc.)

4.4. *Product performance*

Which property of a bio-composite such as RE-PLEX do you consider most important for an urban application (E.g. stiffness, strength etc.)?

4.5. *Customer satisfaction*

Which criteria do you think RE-PLEX need to fulfil to primarily reach customer-satisfaction? (E.g. sustainability and durability)

What are your doubts about a product (e.g. walls of a house) originating from rest-materials (E.g. smell, safety, design etc.)?

In which product-application do you think RE-PLEX would be most accepted?

Would it be a difference for you if the wastewater for the composite-material derives form municipalities or from the wastewater-stream of one company?

4.6. *Environment*

RE-PLEX has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

4.7. *Conclusive*

Is there anything that has not been considered so far, that you would like to mention?

Is there something you want to know from me?

7.3.5 Questions guideline 6

1. ***Introduction***

How are you?

For how long are you in your position in the company?

What is your task/position/relation to the Compro-project?

2. Questions regarding the *concept and the network*

2.1. General

What do you consider as social **advantages** of the Compro-project?

What do you consider as economic **advantages** of the Compro-project?

What are the social/economic **risks** of the Compro project?

Which barriers connected to the Compro-project did you experience so far?

2.2. Organizational aspects

Does a business model like Compro that is connected to a network of different stakeholders (wastewater-plant, manufacturers, end-users) involve operational (e.g. communication/infrastructure) risks/difficulties for you?

What organizational difficulties have you experienced/or could arise when depending on the by-product streams of a wastewater-treatment-plant?

2.3. Political and legal guidelines

Which political or legal guidelines do you perceive as the most preventing regulation for the Compro-concept (e.g. waste-label)?

What measures have to be taken by political bodies (e.g. Gemeente Amsterdam or Rijkswaterstaat) to make the symbiosis less risky and uncomplicated (e.g. subsidies)?

2.4. Financial performance

Are there financial risks you have to accept when depending on the by-products of a partner-company (e.g. supply shortfall)?

Will the production/installation-costs raise with the use of innovative technologies considered for the use of biopolymers?

2.5. Urban integration

How do you imagine the integration of the Compro-concept into an urban development such as HavenStad?

Could you imagine that RE-PLEX is applied in a bigger urban scale in a symbiotic network of companies?

3. Questions regarding the *product*

3.1. General

Where do you see an added value of RE-PLEX?

What is your motivation to consider RE-PLEX in your company?

3.2. Market Scale

Which amounts of RE-PLEX need to be generated to make it economically valuable for your company? (Current market-size is around 125.000 ton/year)

3.3. Technological feasibility

Which technological barriers prevent the implementation of Compro? Where do you see the barriers? How is it possible to overcome these barriers?

What applications the product can have in your company? For which applications other than those in your company, do you consider RE-PLEX most useful/more profitable? (E.g. ceiling plates, door panels, thermal and acoustic damping plates, facing sections, scaffolding boards, traffic signs)

Do these applications require certain properties RE-PLEX can't fulfil?

Is RE-PLEX more useful for temporary or permanent constructions?

3.4. Infrastructural and logistic feasibility

Are there parts of the infrastructure in your company still need to be created to integrate the RE-PLEX-composite into the standardized production-process of other products such as concrete etc.?

3.5. Procurement Costs

Which procurement-costs are connected to an introduction of the RE-PLEX-product?

3.6. Product performance

Which quality criteria (durability/weight/viscosity/resistance to water/chemicals/UV etc.) the product needs to fulfil to be competitive with conventional products? (E.g. glass-fibre; polyester composites)

Which functions (other than e.g. biodegradability, stiffness, non-flammability) RE-PLEX does not fulfil so far but need to be fulfilled?

Do you perceive the biodegradability of RE-PLEX as an advantage or a drawback?

3.7. Customer satisfaction

Which criteria (such as sustainability and durability) need to be fulfilled primarily to reach customer-satisfaction?

What are your doubts about a product (e.g. walls of a house) originating from residual waste (smell, safety, design etc.)?

In which product-application these properties would be most accepted?

Would it be a difference for you if the wastewater for the composite-material derives from municipalities or from the wastewater-stream of one company?

3.8. Environment

The RE-PLEX-product has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

3.9. Conclusive

Is there anything that has not been considered so far, that you would like to mention?

Is there something you want to know from me?

7.3.6 Questions guideline 7

1. Introduction

What is your main work and responsibility in you company?

For how long are you in your position in the company?

2. Questions regarding the *concept and the network*

2.1. General

What do you consider as social **advantages** of the Compro-project?

What do you consider as economic **advantages** of the Compro-project?

2.2. Organizational aspects

Does an integrated project like Compro that is connected to a network of different stakeholders (wastewater-plant, manufacturers, end-users) involve operational (e.g. communication/infrastructure) difficulties for you?

What organizational difficulties could arise when depending on the by-product streams of a wastewater-treatment-plant?

2.3. Political and legal guidelines

Which political or legal guidelines do you perceive as the most preventing regulation for the Compro-concept (e.g. waste-label)?

What measures have to be taken by political bodies (e.g. Gemeente Amsterdam or Rijkswaterstaat) to make innovative projects less risky and uncomplicated (e.g. subsidies)?

2.4. Financial performance

Are there financial risks you have to accept when depending on the by-products of a wastewater-treatment plant (e.g. supply shortfall)?

Will the production/installation-costs raise with the use of innovative technologies considered for the use of biocomposites?

3. Urban integration

How do you imagine the integration of the RE-PLEX into an urban development such as HavenStad?

Could you imagine that RE-PLEX is applied in a bigger urban scale in a symbiotic network of companies? (where the waste-streams of one enterprise become another enterprises products)

Which material properties do you consider important in an application in public space?

Which material properties do you consider important for an indoor application (façade elements/isolation)?

4. Questions regarding the *product*

4.1. General

Where do you see an added value of RE-PLEX?

What would be your motivation to consider RE-PLEX in your company?

4.2. Market Scale

Which amounts of RE-PLEX need to be available to make it economically valuable for your company? (Current market-size is around 125.000 ton/year)

4.3. Technological feasibility

Which technological barriers prevent the implementation of Compro? How is it possible to overcome these barriers?

What applications the product can have in your company? For which applications other than those in your company, do you consider RE-PLEX most useful/more profitable? (E.g. ceiling plates, door panels, thermal and acoustic damping plates, facing sections, scaffolding boards, traffic signs)

Is RE-PLEX more useful for temporary or permanent constructions?

4.4. Infrastructural and logistic feasibility

Are there parts of the infrastructure in your company that still need to be created to integrate the RE-PLEX-composite into the standardized production-process of other products, such as insulation or façade elements?

4.5. Product performance

Which quality criteria (durability/weight/viscosity/resistance to water/chemicals/UV etc.) the product needs to fulfil to be competitive with conventional products? (E.g. glass-fibre; polyester composites)

Which other circular construction-materials are competing with the RE-PLEX?

Do you perceive the biodegradability of RE-PLEX as an advantage or a drawback?

4.6. Customer satisfaction

Which criteria (such as sustainability and durability) need to be fulfilled primarily to reach customer-satisfaction?

What are your doubts about a product (e.g. walls of a house) originating from residual waste (smell, safety, design etc.)?

In which product-application these properties would be most accepted?

4.7. Environment

The RE-PLEX-product has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

4.8. Conclusive

Is there anything that has not been considered so far, that you would like to mention?

Is there something you want to know from me?

7.3.7 Questions guideline 8

1. *Introduction*

What is your task/position/relation to the COMPRO-project?

2. Questions regarding the *concept and the network*

2.1. General

What do you consider as economic **advantages** of the COMPRO-project?

What do you consider as social **advantages** of the COMPRO-project?

Which barriers connected to the COMPRO-project did you experience so far?

2.2. Organizational aspects

Does a business model that is connected to a network of different stakeholders involve operational (e.g. communication, infrastructure) obstacles for you?

2.3. Political guidelines

Which political or legal regulations do you perceive as preventing for COMPRO?

What measures have to be taken by political bodies (e.g. Municipality of Amsterdam or Waternet) to make innovations such as COMPRO less risky and uncomplicated?

2.4. Financial performance

Do you think that the production/installation-costs raise with the use of innovative technologies considered for the processing of bio-composites such as RE-PLEX?

2.5. Urban integration

Could you imagine COMPRO to be applied in a bigger urban scale in a symbiotic network of companies (Where one enterprises waste-water-streams become another enterprises products)?

Would it be a relevant logistical advantage for the COMPRO-project if the cooperation-partners would be spatially situated next to your company?

3. Questions regarding the *product*

3.1. General

Where do you see an added value of RE-PLEX?

3.2. Scale

Can you give an estimation about how much of the RE-PLEX is approximately needed for 1 m² of façade-element?

3.3. Technological feasibility

Can you say something about technological difficulties in the production-process of RE-PLEX?

Which properties for the RE-PLEX are certain? (Lightweight, fire-resistance)

Which functions (other than e.g. biodegradability, stiffness, non-flammability, and lightweight) RE-PLEX does not fulfil so far but need to be fulfilled?

Which material is comparable to the RE-PLEX? (wood or compositions-materials like high density fibre-boards)

Do you know competing products that currently exist on the market (other epoxy-resins)?

For which applications do you consider RE-PLEX most useful? (E.g. ceiling plates, façade-elements, urban furniture, thermal and acoustic isolation)

Do you consider REPLEX more useful for temporary or permanent constructions (or indoor or outdoor)?

Do these applications require certain properties RE-PLEX might not be able to fulfil (e.g. dealing with moisture)?

Can you say something about the pace of the biodegradability of the RE-PLEX?

Might the maintenance of the product be higher than for conventional products (e.g. for an application in public space)?

Might the RE-PLEX be reusable after its use-phase?

3.4. Customer satisfaction

What do you personally expect from a product (e.g. insulation-material in walls of a house) which consists of rest-materials (e.g. smell, safety, design etc.)?

As a manufacturer do you feel responsible for the safety of the end-product? In how far?

3.5. Environment

RE-PLEX has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

3.6. Conclusive

Is there anything that has not been considered so far, that you would like to mention?

Is there something you want to know from me?

7.4 Data extraction

7.4.1 Rules of transcription

I	interviewer
…	there was a break
[…?]	the expression was not understandable

Repeated words were just written once

Expressions such as ‘ehm’ and ‘ehhh’ are let out

7.4.2 Reduction of inductive categories

Uncertainty (+)

Dokument	Paraphrasen	Paraphrasiertes Segment
E8, Pos. 67-68	the required thickness is unclear	E8 11:20 This is very hard to answer this question because you need different things are. You know what is important is, for example, we don't know anything about the thickness required yet.
E8, Pos. 68	the application is not defined yet	So if we need a very, you know, or if we use the material in a sandwich panel, for example, like we have it's light core, and we have the two layers of the material, the compro material on top and both sides. It's all very different values depends on because we still don't know much about what kind of material is like we know that we want to use it for construction and for building but we still don't know which thickness. We still don't know if we use it as layer on top of something else or as in a sandwich panel, you know, just on both sides of some, some lighter material.
E8, Pos. 68	the materials to work with aren't fully defined	So it's, I think at this stage its very difficult to answer this question. I don't know if there's a estimations to who work in building and construction because we still don't know even the which fibers we're using.
E8, Pos. 144	the content of the Kaumera is changing; bio-based materials are changing a lot	So, I suppose they have enough information about that or they did you know the thing is that is also changing every time it is you see that in for example, even in by in fibres we use natural fibers, depending on the season, depending on the harvest, depending on the region, you have different results. So, it's always with bio based materials. I think the idea is that every time you get you start producing, RE-PLEX or not, we've not the composite but you get the waste stream you have to do all these tests there is no maybe you have this value now but next year you have other values because of industry you know there are different industry different pollution.

E7, Pos. 50	the inconstancy of the wastestream puts a high uncertainty on the ingredients of the product	Well of course, the problem is constancy. So, you are having it from a waste stream you never know hundred percent sure what the ingredients will be for your product. So, that will be the most the biggest issue I think, Hmm.
E5, Pos. 191	the project is to early in development to estimate the disadvantages	No, not yet. I think the main disadvantage for me now is that, yeah, I have not enough feeling for what it really is and how far it really is in development. So the disadvantages mainly did is too early in the development to really know that. Okay, yeah, sounds really good, but it's super-early.
E4, Pos. 46	people have to know what COMPRO is	No, I don't think that is specific rule. We have that's not a problem. I think the most important thing is that people have to know what, what Compro is and what they can do there has to be an urgency without stakeholders.
E4, Pos. 198	if viscosity is an important property of the product depends on the application	Yeah. Okay. Yes that depends on the... and I know viscosity from more liquid products, but that depends on the purpose if sometimes you need a very flexible material and sometimes you need other perspective. Yeah, I don't know what yeah, that depends.
E3, Pos. 53-55	dependencies and organizational hurdels are just to be found out	are there any organizational hurdles? E3 Yeah, this is something we are only starting to just to find out.
E3, Pos. 197	the quality criteria and competition with conventional materials of the RE-PLEX highly depend on the application	Okay, yeah, I think this is also highly depending on the application you are looking for and what is the reference-material there, ehm, but at this point NPSP and BAM have a better idea.
E3, Pos. 209	if the biodegradabilty of the RE-PLEX is an advantage depends on the application; therefore it should be found a prototype where the biodegradability is useful	[…] yeah I think it depends on the appication, if you can use it as an advantage, and otherwise, if you want to build a bridge it's a drawback obviously but maybe for that reason we don't want to build a bridge, but something else where the biodegradability is not […] I think the whole bio-degradability in the end is about how fast it bio-degrades and how long the product […]

E1, Pos. 165	risk that the quality of the material is changing	as always in a circular economy, if you will work with waste based materials that there is the risk of changing quality of the material. Okay, I'm not sure about the sewage waste, maybe it's quite constant. But I can imagine, I don't know. Maybe the chemical substance changes in the seasons and summer it's warmer than a winter so I can imagine that there is some difference in chemical or biological built up of this waste stream.
E6, Pos. 31	same poduct quality cannot be guaranteed for products out of wastewater	It may be difficult to guaranty the same quality for every product developed out of waste-based materials. However it is very important that quality is constant, so there can be a risk of failure.
E2, Pos. 112	the urban integration totally depends on the application of the material but it is still not sure for what it will be applied	[…] I think it totally depends on your material. So are you using it as an isolation or as a flame-retardant material or are you using it as a building-material, that is what you need if you, how to apply it in an urban project like HavenStad. But I am not sure if its used for housing or if its used for other stuff. Could be both or not at all. […] maybe its something that is not so much for the construction-industry but might be possible that you apply it in the automotive industry.
E2, Pos. 152	uncertainty about the properties of the RE-PLEX	I don’t know, I don’t know. But I am not sure about RE-PLEX in pretty much detail and I am also not sure about the requirements for the applications and things like that. So, probably there are certain properties […]
E2, Pos. 168	first the application of the RE-PLEX needs to be certain to if it can compete with conventional materials	Again, we need to find out what the application is and then all these questions come easily.

Application

Dokument	Paraphrasen	Paraphrasiertes Segment
E4, Pos. 198	if viscosity is an important property of the product depends on the application	Yeah. Okay. Yes that depends on the... and I know viscosity from more liquid products, but that depends on the purpose if sometimes you need a very flexible

		material and sometimes you need other perspective. Yeah, I don't know what yeah, that depends.
E3, Pos. 197	the quality criteria and competition with conventional materials of the RE-PLEX highly depend on the application	Okay, yeah, I think this is also highly depending on the application you are looking for and what is the reference-material there, ehm, but at this point NPSP and BAM have a better idea.
E3, Pos. 209	if the biodegradabilty of the RE-PLEX is an advantage depends on the application; therefore it should be found a prototype where the biodegradability is useful	[…] yeah I think it depends on the appication, if you can use it as an advantage, and otherwise, if you want to build a bridge it's a drawback obviously but maybe for that reason we don't want to build a bridge, but something else where the biodegradability is not […] I think the whole bio-degradability in the end is about how fast it bio-degrades and how long the product […]
E8, Pos. 107-108	the RE-PLEX is more suitable for outdoor applications; but maybe because of the biodegradability it would need a coating	E8 22:29 Yeah, I think it's if we get again good results with the properties I think it's more an outdoor material and about yeah you have the next you had the next question I was reading like you can use it in buildings outdoor or you know, as a layer maybe between two other layers in the building outside the building because it's, it's biodegradable and it's quite I think it's also if we didn't do the tests with humidity, and in environmental terms but it might be if you, if you expose it directly to weathering it might not be very strong. So probably I can imagine if you use it in panel or you have a coating on top of it, maybe it can be used outside.
E8, Pos. 115-116	because of the biodegradability the RE-PLEX is more suitable for temporary applications	E8 24:35 I think more temporary, but maybe it is possible to have a longer life cycle. So like temporary, not maybe two, three months, maybe a bit longer, but I think it will, because it's biodegradable it's more suitable for temporary application. Okay.
E8, Pos. 139-140	the smell can be more or less, depending on the application	E8 27:42 Yeah, um, we still have we do have there, we have to think of a solution for the smell yet. Because in the form that we have, we still have some smell. If you use it in, maybe inside between two layers or again,

		cavities are in sandwich maybe this smell is less or disappeared.
E5, Pos. 159	the RE-PLEX could find an application in public space elements; but also in buildings but this is not so the decision of the municipality	Yeah. Yeah. It could be, I think in public space elements basically, mostly, would also be in buildings, but that's not so much up to us.
E5, Pos. 179	elements in public space out of RE-PLEX could be replaced after e.g. 20 years	I just replace it and reuse the part that you take out in a good way or if the lifecycle on the whole process is still good, than might be an option, but I think you have to keep in mind sort of the refurbishment circles of public space.
E4, Pos. 204-206	non flammability is important but it depends on the purpose within an urban application	Okay? And the non flammability E4 43:33 It's most of the time also very important. It depends also on the purpose within an urban application. I think this is an important one.
E3, Pos. 177	RE-PLEX more useful for temporary constructions; permanent constructions would come with time	For this moment in time – temporary. I think that permanent is something that can […] over time. But I would start with temporary constructions.
E1, Pos. 289	start with temporary applications; then go to interior applications with a high added value; then standard interior; at the end the highly developed material can be applied outside as well	So yeah so I think we start with temporary applications then we go to interior application with high value then you go to standard interior applications and then in the end we have developed the material so far we can go to outside applications something like that will be interesting. So, that's one strategy.
E1, Pos. 321	the biodegrability can be an advantage when the product biodegrades after 20 years; or if you use it in temporary applications	So if you make a facade penal that falls apart after one year, then it's not an advantage. But a drawback, if I use a painted facade or coated facade element that will last for 20 years and then I break it apart and it falls apart or it biodegrades, then it's an advantage. If we use a temporary application, it's an advantage, etc. So it depends on the application you use it for.
E1, Pos. 337	the smell would be a problem in interior applications	Design we can solve of course, smell I hope we can solve it. Yeah, but not all applications are for not so if

		we use it for interior applications, the smell will be a problem.
E1, Pos. 341	the smell problem needs to be solved but for temporary constructions in the open air it would not be a problem	We have to solve it of course. But for temporary applications in the open air, then I think the smell is not really a problem.
E1, Pos. 349	the Re-PLEX would be good for temporary outdoor applications; it can be made very cheap; e.g. for grounds, consolidations, reinforcements	It depends on at this point. I think it's for temporary, outdoor applications. Because I also think it's, I think we can make it relatively cheap in a way at some point so you can make it for really for grounds, consolidations. Or reinforcements of yeah, and especially temporary reinforcements could be interesting.
E6, Pos. 55	the RE-PLEX could be applied in cavity walls as it is able to deal with moisture. ceiling plates and elements could also be interesting	As mentioned earlier, in the cavity wall as an insulation. There are many other 'new' circular insulations, but none of them are suited to be applicable in the cavity wall where you have to deal with moisture. But there are multiple options, ceiling plates and elements may also be interesting. Alternatives for current 'fossil' materials are always interesting.
E6, Pos. 80	the RE-PLEX should be used for non-constructive purposes	In which product-application these properties would be most accepted? Only non-constructive.
E2, Pos. 144	the scale depends on the application	Sure, it depends on the partner.. […] for incidence the current production-limits. If it's for example […5000 tons??] the production could be […] it really depends on the amounts of production we are talking about. […] how many houses are built in a year, how many isolations you need in a year, yeah, sometimes these types of calculations you can make.[…]
E2, Pos. 172	heavy has a different meaning in the construction-world; lightweigth can mean different things; non-flammability is clear for everyone	Because you will not pay for […] it will be to heavy in the construction world, so my heavy is different from your heavy probably. So, if you say lightweight it probably is […] but non-flammability is one of the more interesting aspects. That is the gut-feeling that we have.

Circularity

Dokument	Paraphrasen	Paraphrasiertes Segment
E8, Pos. 20	circularity is the main advantage of the project	Yeah. Yeah, because I thought okay, I think circularity is the most important aspect of Kaumera. Otherwise, you know, you can use that the I think that's the advantage of this project. That's one of the main advantages of this project that it's circular.
E7, Pos. 159	manufacturer is interested when the material has a circular approach	But we we also do a lot of combinations of 3d printed elements with other kinds of materials. So could also be that the plate or as long as its going into sustainability and circular approach, we are interested in it.
E7, Pos. 227	the circularity is a trend	Well, I think the waste streams and circularity and ehm are very trending at the moment it must be possible to create a product which is interesting. Yeah, it can be anywhere. Almost. But if you can say its a plate, it could also make wardrobes for IKEA for example. Why not?
E4, Pos. 62	procurement for renewable products	In our procurement we see that there's also a benefit for renewable products more than for the projects we will waste a lot.
E4, Pos. 158	if products have a high score on circularity it is a high added value	Yeah, but yeah, To start with the product, I think in general, if it's if it's renewable if it's the pollution index is very low if you look at the lifecycle analyzes and RE-PLEX is scoring a high value on circularity than I think there is a big added value.
E3, Pos. 221	besides circularity the product should only fulfil its function	I don’t expect too much other than the product to fulfil its function – that’s what I am buying it for. If I know that the bio-degradable product is the offer if it has multiple environmental issues associated I am willing to accept less performance, to a certain extent.
E1, Pos. 20	RE-PLEX is 100% waste based and 100% biobased at the same time	Yeah, so maybe I'm moving ahead, but, you know, for us, it's the holy grail to make 100% or high end material that is hundred percent bio based and hundred percent waste based together. So Compro has the promise of combining these So it's being bio based and it's waste based at the same time.
E1, Pos. 243	Circularity is the holy grail	Well, I think I see mostly the two advantages. One is the holy grail or the commercial one, and that really everybody loves a story. That is bio-based, it's local, it's circular is waste based etc. So that's really, really good.

E6, Pos. 10	demand for circular building materials will grow a lot	Sooner or later the demand of circular/sustainable materials in the building material market will grow rapidly. Whether or not instigated by the government.
E6, Pos. 44	a waste based material is a very appealing story	I think the 'product out of waste materials' is a very strong story. This is a powerful USP. Sustainability-wise this is very appealing.
E2, Pos. 136	The biggest added value of the RE-PLEX is that it is a completely circular building-material	So, it's a completely circular building-material. So that's the biggest added value.

Development stage

Dokument	Paraphrasen	Paraphrasiertes Segment
E8, Pos. 32	the product still need a lot of time for development	So We still have a long way to go. Not even I don't think it's realistic to think about three years from now. I think even longer.
E8, Pos. 99-100	innovations need time	E8 20:02 Yeah with time, we need time definitely yeah.
E5, Pos. 191	the project is to early in development to estimate the disadvantages	No, not yet. I think the main disadvantage for me now is that, yeah, I have not enough feeling for what it really is and how far it really is in development. So the disadvantages mainly did is too early in the development to really know that. Okay, yeah, sounds really good, but it's super-early.
E4, Pos. 126	structural changes in wastewater treatment take many decades	At the moment it is not it's just not in our strategy to build a new decentralized wastewater treatment plant in HavenStad but I can imagine that we are not only looking on only 20 years but also for 50 and 100 years that we are designing the concept of HavenStad that it can also be in the end in let's say 30 or 40 years, it can be a decentralized system.
E3, Pos. 137	a lot to be discovered about the material in time	Eh, hm, for Chaincraft? I think it is a very interesting material, there is also a lot to be discovered about the material in general. But that can open in a time a lot for Chaincraft, so that is very interesting.

E1, Pos. 60	valley of death is a difficult development phase	So that's more for all innovations and so you always have the so called valley of death. So you are you go from research to series production and in between you're out of research and research funds in but you're not upscaling yet. are relatively expensive and how can you get through this fase?
E1, Pos. 203	the valley of death is defined by the step of low investments and inefficient production to high investment and efficient production	So, this does also display what I said with this valley of death between innovation we go from research so we have no investments, or low machine investments but inefficient production to high investments but efficient production.
E1, Pos. 247	plastic is optimized since about 100 years; hopefully the RE-PLEX needs less	So for instance, plastics already exist for about 100 years now, a bit more, and it has been optimized all these time. And we have lots of yeah, advantages. And yeah, so I don't hope we need a hundred years of optimization to beat them.
E1, Pos. 345	moving further to have better material properties	So again, that depends really on. So I think we should move a bit further to have it a stiffer stable material, which is not too brittle, and then see what we got and then see where we can use it.
E1, Pos. 353	in the longer term the RE-PLEX should be used for interior products	For the short term and on the longer term I think we should go for more interior products. Because then we also have because temporary products are of course it may not cost too much. So it should be cheap.
E2, Pos. 37	time is a barrier; especially in the corona situation, time is limited	Well, I think time is a barrier in one sense that all our time is limited and I think there is a big stress at the moment to get enough power on what yeah, especially in these Corona times of course.
E2, Pos. 140	until the product is valuable in an economic sense it can take 30 years	I am not sure of the market value the material is using up. […] If you think about […] or the isolation or if you think about coting it is interesting […] than you talk about 30 years then it might be interesting

7.4.3 Transcripts

1 Interview E1

2 _____

3 E1

4 I think Yeah, yeah, I think I see it. Yeah.

5 I1 0:11

6 Okay. Perfect. Yeah. Okay, good.

7 I1 0:15

8 Well, yeah, we start with general questions for how long are you in your position in the company?

9 E1 0:24

10 Well, I joined a company. It was really small in 2003. And then we build it up to quite large to 30 people. And then we close the factory and decided to do the production somewhere else. And now we are with eight again. I am well owner and managing director or one of the three year we do it with the Willem and another guy, and I'm responsible for product development mostly

11 I1 1:01

12 Okay,

13 E1 1:01

14 so we have three guys. So one is vilem is doing r&d and material research and stuff like that help. And then we have another guy, he's doing business development or sales. And I'm a bit in the middle, try to translate all the material inventions into products that can be sold or demonstrated or put into pilot projects. But I do a lot of sales as well. I do a lot of finance as well. So it's a bit the small company. Okay, mostly product development. And it's been like that for ya ehwhile we started really small, so I was responsible for everything and then we grew and then at one point, I was only responsible for sales. But I've been responsible finance, etc. So there's a lot of shifts. If a company develops through its lifetime

15 I1 2:01

16 Okay yeah. Oh yeah your position in relation to the Compro project is partly explained already I would say

17 E1 2:15

18 It's comparable so but Compro is a bit complicated because on one hand, it's still we need to do a lot of material research. So it's a bit before product development on the other hand we have some results already it's already good to think about products to the market.

19 E1 2:40

Circularity

20 Yeah, so maybe I'm moving ahead, but, you know, for us, it's the holy grail to make 100% or high end material that is hundred percent bio based and hundred percent waste based together. So Compro has the promise of combining these So it's being bio based and it's waste based at the same time.

21 E1 3:05

22 That's sick if you can make out of waste, a high end material. So so that's the holy grail in the future the dot on the horizon where we're moving to. But it's not very easy. So we still have to solve a lot of problems. We already made some material that has potential of being used to make products. So that's, that's really good.

23 E1 3:34

Applicatic

24 So we proved that in the pre processor project of wascom. And so now we want to move to the market. But of course, material still has to be developed. So you can think of let's build a bridge out of it but that's I think, at this point a bit ambitious. We do think we can think of applications that can be used already or on a really or quite short term. That could be interesting.

25 I1 4:16
26 Okay. And just some general questions. What do you consider as a general economic advantage of the Compro project?

27 E1 4:29
28 Well, it's mostly commercial. So what we can we do is what I said we can make a holy grail that we make them a material that is bio based and waste based. So this will there's a, you say, political demand for it. So not so most people don't care of which material something is made or not too much. Mm hmm. So if somebody buys a chair, he loves to see it and he's not really interested in, in, in the LCA of the material, etc, etc. So most people so we operate a lot in niches. But if you look at the targets of the municipality of Amsterdam, for instance, if you can make material for to build the city out of waste from the city, that would be great. So I set the holy grail is that it's bio based and waste based, but the real holy grail is that it's local bio based and waste based.

Product pe

Policies

29 I1 5:38
30 Okay,

31 E1 5:39
32 so that would be really a sustainable solution for the future if you can use that as a building material would be fantastic for us.

33 I1 5:48
34 Yeah. So it can be very big, but we still need some time. And

35 E1 5:55
36 economic advantage and social advantage are combined. I don't think If so, as I said, so we can build houses of concrete and bricks and glass and aluminium, etc. So people, most people think it's okay. They love the buildings they have now. So they don't really care about it. But of course, there is a policy of going to a circular economy, especially donut economy from the city of Amsterdam. So, yeah, so I think in the future it will be forced to build smarter and more local and more waste based and bio based or more renewable.

Product pe

Circularity

37 E1 6:47
38 yeah, so this. So at this point, it's still a social advantage here because it's policy and so half of the people think it's wise to do other half of the people say, well, it's exaggerated. I don't want to pay any cent more for it and eh and I want it to be as it used to be more conservative view of life and so the economic advantages, but I think the potential is really big. And of course, if you can make a low cost material, because it's waste based, so if you optimize it and increase the how to say the amount or the number of kilos of material, then maybe you can have economies of scales and you have a really cheap product

Pro

Sca

39 I1 7:34
40 mhm

41 E1 7:35
42 in potential could also be really cheap.

43 I1 7:37
44 Okay. And do you see general any risks already connected to the Compro project?

45 I1 7:45
46 Well, the risk, there are some risks. We have some technical problems. So one of the risks is we cannot solve technical problems. Mm hmm. And then we have to find other applications.

47 E1 8:00
Environme
48 So that's a bit of a risk. The other risk is, is we, it's so it's coming from a waste stream. So there's some level of biohazard maybe involved or, you know, I don't know exactly how the material will be appreciated in the future. Also the idea it's also a limitation and because it's from the sewage, which is considered really dirty by most people. So this may be a problem for some for some products. so the products you touch or or are close to or Yeah, I wouldn't start with the coffee mark of this material or something like that, because people already think it's, yeah, it says social limitation, I think.

49 I1 8:56
50 Yeah. Okay.

51 E1 9:00
Competiti
52 So also the thing is economic risk is that there's a lot of competition in the material country. And companies who are hundred years old or a little less or a little more, that have been optimizing their processes for hundreds and hundreds or dozens of years, at least, your heart to beat them on price and quality because they have a really, really optimized factories. So it's really hard to answer if you want to, for instance, if you want to start a car company now, well, Tesla did it. But for most, most companies, it's really hard to to get to the same quality level as more older factories.

53 I1 9:48
54 Mm hmm. Yeah. Okay. Um, yeah. Did you experience any barriers already connected to the compro project, or do you think it's to recent that there are technological you already mentioned

55 E1 10:08
56 yeah I think what I already mentioned so some technical stuff and some acceptance stuff of the of the of the material acceptance issues some technical issues and yeah and strategic issue like can we upscale it fast enough?

57 I1 10:32
58 Okay yeah I think I will have more detailed questions

59 I1 10:37
Developm
60 So that's more for all innovations and so you always have the so called valley of death. So you are you go from research to series production and in between you're out of research and research funds in but you're not upscaling yet. are relatively expensive and how can you get through this fase?

61 I1 10:58
62 Mm hmm. Okay. Yep. Ehm well organizational aspects what organizational difficulties Have you experienced when obtaining your resources indirectly from a wastewater treatment plant? Like any transfer or logistical challenges?

63 E1 11:25
64 Yeah, not really, I think the wastewater of course, it goes from wastewater treatment and then it goes to Chaincraft. And they make a semi-finished product and then we have

to dry it so that it comes to us. So, I think that's, that's okay.

I1 11:45
Mm hmm. And how does it come to your company the Kaumera?

I1 11:51
in well we wanted to dry it in a pouderous form, so we get it just in a small bottle or barrel sent to us. No, not really a problem.

I1 12:03
Okay, and might it become a problem when there's a bigger amount?

E1 12:11
Well, yeah, well, if you have hundred grams of 100 kilos, euro per kilo and it's 10 euros, so it's not really a problem. But if we have to build a house, and we get raw material for hundred euros per kilo and a competition costs 50 cents or less, than the price will become so the upscaling is always we have to take into account from the start. And I think that's what we do or we think at least think about well, so. So I think the project is set up in a good, good way. So everybody involved knows where to go but the risk is Of course, if we're depending on one wastewater treatment plant and one processor like Chaincraft. So the risk is if we have if one of them decides not to supply anymore, then we have a problem, of course, for whatever reason.

Dependei

I1 13:19
Yeah, so the more stakeholders are kind of in the network, the higher the risk gets at the end.

E1 13:27
Well, if you have more suppliers risk go down, of course. So if you only have one supplier and there's a risk on the other hand, we know each other and we can protect everything. So it makes all sort of project a bit more. Yeah. More a bit, you have a better overview of what's happening. So for now, I think it's good and good innovation settled one company there's only one company supplying in the beginning. Hmm. So

I1 14:03
yeah, I mean, there's the wastewater treatment plant, and then there's ChainCraft, and the main suppliers, the wastewater treatment plan, right. So that is where the source is.

E1 14:17
Yeah, that's a source. That's right.

I1 14:18
And then there's Chaincraft, and then the more players are in the line, the more kind of risk exists, but I think because of the close collaboration

E1
it will increase costs as well because they all want to make some money.

I1 14:38
Okay, oh, yeah. And but generally, you think because of the close collaboration with the other stakeholders in the project is not such a high risk, or there's kind of a security that the different stakeholders are connected and bound to the project.

E1 15:02
Um, Yeah, I think it's quite simple and yeah.

I1 15:18
Yeah, so I think it's relatively simple because there are only two steps before the raw material to the semi-finished products we can process it. There's only well there's actually three steps because we have the wastewater treatment plant and we have Chaincraft and then we have a drying facility. Okay, if it comes to us, okay. So they have this third step in between kind of the drying facility.
Yeah, a what also we can optimize further because we now do because it's small quantities, we can mix it with the other chemicals or chemicals. But other ingredients to make a semi-finished material that we can process into products. So, there will be but we cannot or we will not do that in the future for large amounts of that we need a company to. So maybe we can be done by Chaincraft. Mm hmm oh by the drying company or by another company in between the drying company and us.

I1 16:25
Okay.

I1 16:28
But now it is a limited amount of partners, but I'm not sure if that's yeah. So on one hand the less partners the better the less risks but on the other hand, the more partners, the more the risk is spread. And also the more use of optimization you can do.

E1 16:53
Because we can do drying, because ChainCraft can do drying in the lab, but that's really expensive. So that's why we look for a company that can dry more efficient, but they have big machinery to do so, or advanced machinery, and sometimes it's better to let it be done by a specialized company. This will decrease the risk and increase efficiency. But yeah, there's also a bigger if you have 20 partners in between and if somewhat something happens to one partner, which is important, then we have a problem, of course. So that's another risk if you have more parties.

I1 17:39
Yeah, sure. Okay, um, so far to the organizational aspects. Now, the political guidelines. Which political guidelines do you perceive as most preventing regulation for the compro concept is their one? Yeah, any legal

E1 18:00
do you mean preventing as an obstacle or being an obstacle?

I1 18:04
mm hmm

E1 18:08
yeah, you have to go well, the material has to go from waste status to resource status not sure the English word for that.

I1 18:19
Well, there's the waste label but a product status probably or

I1 18:26
product-status yeah something like that. I think it's illegal to sell waste to a certain extent.

I1 18:35
Okay.

E1 18:38

But I'm looking if I can find a translation. Yeah, it's called in Dutch afvalstoffestatus.

I1 19:09
afvalstoffestatus, Okay, so it's kind of the waste label.

I1 19:23
Yeah, probably. I don't know what a waste label is. Maybe it's the same thing. We have to see what the translation is.

I1 19:32
Mm hmm. Okay.

E1 19:36
Yeah, because you need that to be able to transport the material import or export it or, or sell it. So I think it's important legislation.

I1 19:53
Yeah. So if it has the waste-label, or the avfalstatus. You can't sell the product in a big scale or you can't sell the product at all.

I1 20:09
Okay.

I1 20:11
I think at all or but, I don't know exactly. You have to ask someone else.

I1 20:18
yeah, I can research as well. Okay. And do you think or what measures have to be taken by political bodies like the Gemeente or Waternet to make the symbiosis less risky and uncomplicated, like? Well, there's the product, and there's the collaboration of the enterprises. Is there anything that the municipality can do to make it more easy?

I1 20:55
puuhh

E1 21:05
Policies
That's a good one. Well, we always are more to the market situation. So what we notice in municipalities is that policymakers really want to have a circular economy. But the guys or the ladies buying materials and products and use the products in municipality itself, they are not so enthusiastic about innovative new materials, because they cost more the risk profile is higher. So, I would well would be good if the these these political bodies or governmental bodies are a bit more behave more as a partner.

E1 21:55
Mm hmm.

E1 21:55
Policies
Because at one point we see they say, Oh, we want to have circular economy. And I say, Okay, we have lots of regulations and you have to fulfill all the regulations, you have to do all the investments, then you come with a perfect product. And then maybe we buy it if it is the cheapest only. Mm hmm. It's, it's another very collaborative position they have. Yeah, but it's also because it's a we call it a multi headed monster. All these, even the municipality of Amsterdam is quite large. So we have the rational people and the policymakers. And there's a big gap between them. I think that this is a problem in lots of places in the government and not only about circular materials. Mm hmm. So if Yeah, so it will be great if they would close this gap themselves out, leave it to the market risk etc.

I1 23:01
Okay,

E1 23:03
so we noticed that it's really, so the policymakers are really enthusiastic about what we do. But the municipality never buys a product of us. Okay, it's too expensive or too risky or there's some legislation thingy you don't fulfill yet or whatever. And this can be done, I think a bit stronger, more entrepreneurial, as if they wanted to have to take some risk. Or for instance, a shell great. You have a new material. Yes, it's circular. Yes, it's local. It's made out of waste, okay, but you have to give a guarantee of 30 years. Otherwise we don't buy it because we're used to work with aluminium and aluminium has a guarantee of 30 years or we know it lasts for 30 years. And we say okay, the least you can do is act as a partner and say, okay, we buy it and if it the or we accept less the guarantee or we say we buy the pilot project and if it fails and it fails, so they have to take some risk in there as well.

Policies

I1 24:16
Okay. So it's rather like case by case they put another regulation on certain products or but there is no like general legal legislation they would have to change or.

Legal regi

E1 24:40
Well, of course that I think the tender procedures can be adapted. Mm hmm. So would help if they say it's really important that So, so maybe if they say well, if you make something that is local waste based circular bio waste, whatever, then you may be 50% more expensive and don't have to give a guarantee of something like that.

Legal regi

I1 25:03
Okay,

E1 25:04
Or say, okay from all public money we use for operations. I heard this morning it's about 250 million in the Municipality of Amsterdam. So maybe we spend 10% of that on bio based local waste based. So make get some money going which can be spent dedicated. And of course that has to be fitted in the tender, tender legislation European tender legislation. But I always wonder is that the municipality of Amsterdam says we cannot buy or we cannot force people or we cannot promote too much that we use bio based or waste based or local materials. But on the other hand, I don't see ICE train running in France or TGV running in Germany or somewhere in these countries. Yeah, they can buy local. I don't know how they do it, because I think it's not legal but or think it's legal but sometimes the Dutch governmental bodies are a bit over-formal, let's say.

Policies

Policies

I1 26:28
Okay, more formal than Germany.

E1 26:31
Yeah. Yeah, I think if they want they can think of something to promote local companies or whatever.

Policies

I1 26:39
Okay.

E1 26:40
So it's amazing. Sometimes it's even harder to sell something in Amsterdam than in any other city.

158 I1 26:49
159 Okay. Um, so the final we are already in financial issues. Are there any financial risks you have to accept when depending on the by-products of a wastewater treatment plant, like some instability issues.

160 E1 27:10
161 or instability of the organization. So,

162 I1 27:14
163 like, of the supply, for example,

164 E1 27:18
165 as always in a circular economy, if you will work with waste based materials that there is the risk of changing quality of the material. Okay, I'm not sure about the sewage waste, maybe it's quite constant. But I can imagine, I don't know. Maybe the chemical substance changes in the seasons and summer it's warmer than a winter so I can imagine that there is some difference in chemical or biological built up of this waste stream. We work for instance with waste clothing as well as fibers and denim for instance, so the colours are different. So in the end of the summer we have lots of light colored denim and end of the winter, it's more dark colored. If skinny jeans are hot, then there's more Elastan in it and less cotton, etc. So it's really hard to sit certify the material because the waste streams are a bit. There's a bigger variation in quality. So, so the problem with all waste based products, because it's really, it can be very expensive to bring everything to specification. But in many cases, the specifications are not really necessary. They're more cause or it's more habits based that when some people say oh we want every material to be fireproof which is okay because the less fire catching materials the safer our buildings will be. So, I can imagine that everybody wants fire safe material on the other end this has a consequence. So, if you do say materials are not may not burn then you cannot use any bio based material or you cannot so, everything is made out of concrete steel and glass. If you want to have a comfortable chair, which is un-burnable then it also can be made but we have to lots add lots of chemicals.

Uncertain

166 I1 29:43
167 Okay,

168 E1 29:44
169 so it doesn't burn, but it's poisonous or hazardous to a certain extent or hazardous in not in use, but in the production.

170 I1 29:57
171 Okay,

172 E1 29:58
173 so there's always a downside or so it's really easy to think of our we will have requirements of this and that because we're used to it. But yeah, there's always a consequence of the choice.

174 E1 30:12
175 Mm hmm okay,

176 E1 30:14
177 so this so now all designers and people buying materials and people make safety codes etc. They're really used to that they can buy wherever whenever in all available quantities any material to specification, but in a circular economy if we have waste based materials, then we have to, to either or reprocess it a lot. So, for instance, we can bring plastics down to the chemical building blocks and then separating chemical building

Competiti

blocks and make new materials out of them. Then it will be too spect. But they will be more expensive than have it virgin. Yeah, or we accept that we can always get a so there's some color difference in between plastics or there's some quality difference. And so sometimes people say we want material to specification. And then they it's, so it's pure, three notes or three numbers, we add the comma. So it's really pure material. And then they make a product and they put in a safety factor of two, just in case.

I1 31:41
Okay?

E1 31:42
So say, well, okay, then it's a bit exaggerated. Why? Why do we need to help your material for that function? Mm hmm. So it's a different way of thinking. So that's the biggest, I'm not sure if its own it's in a way financial risk because if everybody keeps to the habits that every material should be to spec and they want circular material then this may have cost consequences large cost consequences for the for the waste based economy or circular materials.

Leg

Cos

I1 32:23
Yeah. Um

I1 32:27
Okay. Yeah, did the production or installation costs raise with the use of innovative technologies considered for the processing of bio-composites or especially RE-PLEX?

E1 32:44
What do you mean production of making the products you mean, right?

I1 32:48
Yeah, like the installation costs for the technologies to make the products for example. Or were there or did there need to be installed any new technologies?

E1 33:03
Ah, okay, To process RE-PLEX? We don't really know yet.

I1 33:10
Okay.

E1 33:15
Oh yeah, we're still optimizing. So we can imagine that we don't really need new machinery. But if you optimize, you may have to change the machinery. So you can imagine that if you have to fill bottles with beer for instance, you can use very simple standard equipment to fill bottles with beer. Mm hmm. You have I don't know how you call it but you can put holes in the bottle and then fill it and then but then half of it spills and takes 10 minutes and you put a cap on you dry, you turn it, it takes maybe 10 minutes to fill the bottle.

I1 34:01
Yeah.

E1 34:03
But now always so of course production lines that you can fill the bottle within a second or something like that and close put a ticket on it and etc. But then you have very optimized machinery to do this. Yeah, it's optimized for filling bottles with beer for instance in beer bottles with the weight of beer bottle and the size of beer bottle etc. So it's all very, so Coca Cola is filled differently in plastic bottles than beer in glass bottles,

which are smaller. So, so the more optimized it is, the more adaptions have to be made. So we can do so I can imagine the weight so the technology is used to make a RE-PLEX material. We don't have a high cost because we can use standard equipment to make plate material, but if we want to optimize the further we optimize the further it will be specific for this material for this product

I1 35:15
Okay,

E1 35:15
So this will shift in time, so we can do demonstration products, but inefficiently with standard machines. So, we can make facade elements with standard machines, but they cause but it takes us two hours per square meter. Or we can make facade-elements in 10 minutes per square meter, but then we have optimized machine which for which we have to do a investments. So, this does also display what I said with this valley of death between innovation we go from research so we have no investments, or low machine investments but inefficient production to high investments but efficient production. Yeah, something in between. So I always we always struggle with that. So we can make one prototype for 10,000 euros. That's no problem. If we have a big factory who wants to process it, we can make a million square meters for 10 euro per square meters also no problem. But the problem is, after one prototype people say, okay, we want to have a demonstration project with 10 square meters, or 10 prototypes that we say okay, we make 10 prototypes, but this is 10 times the prototype costs. But there's always a client who says, Okay, now I want 1000 square meters. But I don't want to pay prototype costs, because it's too expensive for 1000 square meters. Yeah, but if I want to make it more efficient and markets cool, or with market prices, I have to make 1 million square meters. So then, this 1000 square meters is not interesting for me because I need to have a client for a million square meters or at least 1000 square meters or not 1000 square meters. So this always scale related. Yeah, this upscaling is really complicated in this way. So not only with RE-PLEX, it's also at this point, and we can make prototypes and we can make demonstration. So we probably don't need high machine investments, but the product costs will be relatively high. So, if we want to do market introduction, we have to decrease market costs, but we will have increased investments.

Developm

Costs

I1 37:37
Okay. So everything works with a conventional machineries, but it could work better, or especially for biocomposites.

E1 37:49
yeah, so we can do things with standard machinery. But if we have to, if we want to upscale we have to optimize it and make optimize machines for RE-PLEX and then we have we will have bigger investments.

I1 38:02
Yeah. Okay.

I1 38:05
Um, yeah, so far so good. The Urban integration of the COMPRO project, could you imagine COMPRO to be applied in a bigger urban scale in a symbiotic network of companies? For example in HavenStad?

E1 38:27
Yeah, I think local production always has an advantage. I think socially because you have less environmental impact and you use your so also the idea that you use your local waste to build your local your city. That's a great idea. So I think socially and emotionally it works really well. And also, economically if could also be interesting because well, you

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save on transport costs, but at this point, it's cheaper. To produce something in China, and yeah, transport here.

I1 39:07
Mm hmm. Okay.

E1 39:10
Yeah. Yeah, it's always there's a nice now with Corona now you see this discussion of bringing back production to Europe. So besides the economic and environmental impact, we also have now a strategic impact. So I think it's interesting discussion to see what will happen, but I think the movement will be more and more towards local but we have to take into account that it's less optimal. Because, you know, if you build a factory in China, you can do whatever you want. You have cheap labor. If I build a factory in Amsterdam, I have a very high costs for building and pay space for labor for legislation and all the rules and laws we have.

E1 0:02
These higher costs will beat the cost for transport or will be higher than the cost for transport from China to here. Okay, so that's why we have also recycled plastics for instance. So we recycle plastic [...] that tender that's more expensive to collect used plastic, clean it a little bit and melt it again into a new product that is more expensive than bring oil from Saudi Arabia to China. Make plastic out of it, make products out of it and send it to the Netherlands that's cheaper than use, use plastic which is for free. You have to collect it, wash it and remelt it that's more expensive. So I think it's a logistical advantage but only social and environmental and not economical. It's really at this point if we, if we keep transport really cheap and labor really expensive, then it's going to be a problem.

I1 1:19
Okay, but do you see the compro project connected to international pathes? Like, could you imagine that the RE-PLEX is also processed by Chinese companies, for example?

E1 1:38
Yes, it could be but, but I think you should use a local waste stream as well. Yeah. Because otherwise what we do is we transport our waste to China, make a product out of it, bring it back.

I1 1:55
Yeah,

E1 1:57
So environmentally it's really rediciulous to send ships with shit from Amsterdam to China? I don't know. Yeah, I think its a lot of shit in China as well but then we don't have the local for local thought anymore.

I1 2:13
Okay.

E1 2:15
But I can imagine that we will I can imagine it will happen and because yeah what you start to see is that we, yeah if you if you optimize everything in economic way then this might happen. Okay. So I can imagine that it happens, but on the other ends, I would think it would be ridiculous to do so.

I1 2:39
So all these logistical and transfer to have it locally is not so economic. It's not such a big

economic advantage. And yeah, that's why it's still possible that things would be outsourced to the international market.

234 E1 3:01
235 Its a risk. Yeah.

236 I1 3:02
237 Okay.

238 E1 3:04
239 On the other hand, if you want to upscale the material, and it's adopted by Chinese companies, and they will upscale it to 1 million square meters a year, well, we can only do 1000. Yeah, maybe it's good to do so.

240 I1 3:20
241 Okay. And now the product questions. A bit more direct, I would say. First, where do you see the added value of RE-PLEX? Maybe especially for your company as well, or in general and then for your company?

242 E1 3:45
243 Well, I think I see mostly the two advantages. One is the holy grail or the commercial one, and that really everybody loves a story. That is bio-based, it's local, it's circular is waste based etc. So that's really, really good. But so that's the added value. And we have maybe a cheaper resource. It's a, I don't know, at this point. But it potentially can be really cheap as a resource. So yeah, that's a great added value. So you have something that has a negative added value, which is waste or really sore sewage based waste. So aluminium waste still as a value, but this waste is only cost money to get rid of. So we don't really get rid of it. We make something out of it with the positive added value. So that's, that's great. I think that's the biggest advantage. But still you have to compete with other materials and alternative materials. On price and on quality? If you have other materials that are better and cheaper, then you have a problem.

244 I1 5:06
245 Yeah, of course. Well, ehm, the market scale, which amounts of RE-PLEX need to be generated to make it economically valuable for your company. Can you say this already?

246 E1 5:20
247 Yeah, for us, I think we need between five and 10 tonnes a year at least, to be able to scale it up somehow. That's still for projects on a pilot scale. And in the end, of course, the bigger the better we can compete with any other material. So for instance, plastics already exist for about 100 years now, a bit more, and it has been optimized all these time. And we have lots of yeah, advantages. And yeah, so I don't hope we need a hundred years of optimization to beat them. So, but yeah, for us, it will be interesting if we could get about 10 tonns at least five to 10 tonnes to start with and then the bigger the amounts, the bigger or the bigger the market.

248 I1 6:28
249 Okay. Um, yeah, technological feasibility. Can you say something about technological difficulties in the production process of RE-PLEX?

250 E1 6:49
251 Well, there are two issues. One is to make a good impregnation and a good mix of fibers and resin of Compro material and fiber to make a good composite out of it. I think we solved it mostly I think that's okay because the solvent they use is water and we don't want to have water in and we have curing at 140 degrees so we get boiling water and mold under pressure so we don't want that. And another issue now is very recent is that

the the COMPRO material damages the natural fibers somehow we don't know how yet.

I1 7:38
Okay, so Kaumera damages.

E1 7:41
Yeah. But we're investigating this and if we solve these two issues, then we can yeah, well, we can optimize. Yeah, we don't know exactly where we are now because we had a good hart sample or first we had so first we had samples that were a bit too flexible, and also not stable. So they would become softer in time because of the, the moisture in the air. So it would degrade too fast. Which could be interesting for applications for a short time. That's something else. And the newest recipe looks stable, but it's very brittle. And it's like, it looks like it's damaging the natural fibers.

Product pe

I1 8:38
Okay, what do you mean by brittle?

E1 8:43
Brittle is that if you if I dropp this pen it's still at one piece so it can take the impact. If it's brittle, it would break very easy. So if I have a glass for instance also very brittle. So if I have a piece of glass and I drop it like this, it will break into pieces.

I1 9:04
Okay.

E1 9:05
So that's what we call brittle. It's opposite of tough.

I1 9:10
Okay. Thanks.

E1 9:13
Yeah.

I1 9:15
Yeah.

I1 9:20
Yeah, okay. Yeah, I think this water boiling thing is maybe too in depth I think. Maybe I can't reach it now with the interview. Oh, well, it's it's too technological.

E1 9:37
Yeah, that's okay. But we don't want to sound so. Yeah. So the dried powders form we get it now is optimal for for curing but we don't have any flow in a mold so we have to think about, yeah, it's a very technical stuff really.

I1 10:00
I think its maybe not so needed.

Product pe

E1 10:02
No, but it can be overcome with some technology. So so there are processes to make a good diversion of powder through fibrous environments stop. We can solve it.

I1 10:18
Okay. Yeah. Um, and for which applications in the construction sector do you consider RE-PLEX most useful?

Apl

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280 E1 10:28
281 Um, yeah, well depends also in the timescale. So so what we have now is a material that degrades quite fast, is biodegradable as well. So it's really optimal for timely or short time applications. Okay, temporary. That's the word I was looking for. Yeah, so it's really good for temporary applications. So it could be interesting in building sites. For instance, they have wiring and the building site, they put it under the ground. And to take it out again, is a lot of work but they have to because they can leave it. So what if you make piping out of Compro material, you take out the wires and then you can leave the piping. So it will disappear in half a year, or in an infrastructure you have lots of projects. If you build a new highway, as little of a dike, you put a highway on top and this is really sandy in new build highways.

282 I1 12:40
283 Okay.

284 E1 12:41
285 So this could be interesting applications on the short term, on a longer term, I would think we would go for interior products. Because of the hydro-philic character so it will take up water. So we have to make relatively dry applications and then in beginning of course with quite high added value, because yeah, we still make it a small quantity. So for ceiling plates could be interesting only they cost nothing and comply to all codes you can think of and they are save a etc, etc. And then they're really cheap. So it's really hard to beat so what we were thinking it has good fire properties for instance. So we use it as a file in fire safe doors or something like that. So so we Yeah, so what we try is we try to find niches where we are for good application and then move increase the amount so we can optimize and go to more wider bigger uptake of the material.

286 I1 14:01
287 Okay. Yeah. Are there certain properties that RE-PLEX might not be able to fulfill? Well depends very much on the application.

288 E1 14:18
289 So yeah so I think we start with temporary applications then we go to interior application with high value then you go to standard interior applications and then in the end we have developed the material so far we can go to outside applications something like that will be interesting. So, that's one strategy.

290 I1 14:42
291 Okay. Um, you already said now for temporary.

292 E1 14:48
293 Oh, um, yeah, so it's a question of the timing.

294 I1 14:53
295 Yeah. Okay. Um, yeah, can you say which process costs are connected to the production of RE-PLEX?

296 E1 15:07
297 No. So we need to do some material stuff with Chaincraft, then we have to dry it, then we can process it quite standardly. So the process costs are not really with us, but more. So we only have the economy of scales. And so we don't have optimized machinery for this material to process so we do it with general machinery. That's why it's less efficient its more labor time and less efficiency and then. But the process costs are more with the company's bit more upstream. So I think this is a good question for Chaincraft mostly for us. It's quite yeah. Comparable to conventional alternatives.

298 I1 16:08
299 Okay. Um, yeah. Well, I could now ask for the connection like different types of process costs, but maybe it's too confidential.

300 E1 16:24
301 Or, yeah, well, eh what we are still looking for is a continuous process. So, what we do now is that we put it in a mold, close the mold, leave it there for a while and open it again take out as a product, but you also have continuous production lines from role to role, if we could reach that that would be optimal. Okay.

Product pe

302 I1 16:55
303 And about the product performance which quality criteria the product needs to fulfill to be competitive with conventional products. Like, for example, glass fiber, or what we said.

304 E1 17:09
305 Yeah. I think this is really application based so it depends on the application, what quality would need. Competitive. So I think we should start with the look what is the characterization of the material itself because there's always a combination. So for instance, imagine that I would make a table out of glass fiber polyester, so maybe I can make the table three millimeters thick and it will fulfill. That is really thin, but it's really strong, so it's no problem and it's really in a stiff enough etc. And it's really lightweight. If we use our material, which is half as strong and half as stiff, maybe I need six millimeters of material or nine millimeters of material to do the same application, but maybe the density is lower. So we have a table, which is six millimeters instead of three millimeters, but it's half the weight. [...] is half, so the weight is the same. Okay, well, but than its only a design issue, and it's not really a problem and then we have a more environmentally friendly table. So depends on what requirements you will have for a certain application. Maybe maybe the sewage waste beer factory has glass fiber reinforced composite products, but they want to have something out of their own waste, then maybe they have a different program requirements than another than a boat builder. For instance. Its hard to say.

Applicatic

306 I1 19:03
307 Yeah, sure. But is there any aspect that for example, glass fibers have that Compro or RE-PLEX doesn't have?

308 E1 19:13
309 That's a totally different material, so it's not really comparable. So glass fiber is waterproof it's easy to process it's fast to process it's really strong. It's really stiff and dirty or chemical and poisonous and not good for you. Yeah. So okay the poisonous this and it's not good for you. We can beat but all the other issues are not so easy to beat.

Competiti

310 I1 19:44
311 Yeah. Okay. Good.

312 E1 19:51
313 Yeah, I think at this point the brittleness of the RE-PLEX material is the biggest problem.

Product pe

314 I1 19:57
315 Okay. So this needs to be overcome.

316 E1 20:00
317 Okay, so that's the first thing and this, because the issue is that we use natural fiber to reinforce the plastic because polyester, it's also very brittle. Mm hmm. If I drop a

Product pe

polyester bar like this will break as well. Mm hmm. Maybe not that fast, but it will break. But if we put glass fiber in it, it's really strong. And the same goes for a RE-PLEX material. But at this point, it damages the fiber reinforcement. So, whatever issue there.

I1 20:34
Okay. yes. Do you perceive the biodegradability of RE-PLEX as a as an advantage or drawback in that sense?

E1 20:50
Well, yeah, what I would like to have is, it can be an advantage if you can control it. Mm hmm. So if you make a facade penal that falls apart after one year, then it's not an advantage. But a drawback, if I use a painted facade or coated facade element that will last for 20 years and then I break it apart and it falls apart or it biodegrades, then it's an advantage. If we use a temporary application, it's an advantage, etc. So it depends on the application you use it for.

Applicatic

I1 21:32
Okay. Ehm, what do you personally expect from the product which consists of rest materials? Like what maybe are also your doubts about the product?

E1 21:51
Yeah, actually, that's very funny because I'm doing a lot of work and innovation and stuff, but personally, I'm quite conservative so I drive very old cars and I started I just my first I was the last to ever mobile phone etc. So ah yeah I would like to I want it to be as as another natural material like maybe like wood or something like that.

Product pe

I1 22:31
Okay.

E1 22:32
So yeah, you know if I buy a house myself I want it to be safe to look nice and not being smelly.

I1 22:44
Yeah, of course.

E1 22:45
Yeah. So insulation material you may be already different, but smell is may be still a problem. Don't know. Yeah. So it's hard to Yeah. So I would expect it but yeah, it will have to meet high standards of course. I think we shouldn't make half. We shouldn't go for a product that is not safe, smelly and ugly.

Product pe

I1 23:18
Okay, of course, yeah. But you think you can overcome or that could be overcome with more research and more investment.

E1 23:30
Well, they say it's very fire safe or it's at least not very lightly inflammable. So that, that's okay. Design we can solve of course, smell I hope we can solve it. Yeah, but not all applications are for not so if we use it for interior applications, the smell will be a problem.

Applicatic

I1 23:51
Mm hmm.Yeah.

E1 23:52

Applicatic

We have to solve it of course. But for temporary applications in the open air, then I think the smell is not really a problem.

I1 24:02
Yeah. Okay.

E1 24:03
So again, that depends really on. So I think we should move a bit further to have it a stiffer stable material, which is not too brittle, and then see what we got and then see where we can use it.

I1 24:19
Okay. So first, we need to know exactly. Yeah, which properties it has? And then you could think about the product application. Which, yeah, or which? Well, the question is, in which product application do you think RE-PLEX would be most accepted?

E1 24:41
It depends on at this point. I think it's for temporary, outdoor applications. Because I also think it's, I think we can make it relatively cheap in a way at some point so you can make it for really for grounds, consolidations. Or reinforcements of yeah, and especially temporary reinforcements could be interesting.

I1 25:09
Okay.

E1 25:11
For the short term and on the longer term I think we should go for more interior products. Because then we also have because temporary products are of course it may not cost too much. So it should be cheap.

I1 25:25
Yes

E1 25:25
So, because you will always have to find a balance. So if we can make a temporary application that's really cheap, it's biodegradable and we can make it now then we should do it and if we make something that is stiff and really strong, etc., but 10 times as expensive as all the competitive materials, then you shouldn't do it. I think, wait, my chairs falling apart. I take a different one. Good quality.

I1 26:00
Made by Npsp. Hopefully not.

E1 26:04
We rent is building.

I1 26:06
Okay.

E1 26:07
I think its a Chinese copy of a Vitra-chair.

I1 26:15
Good design at least.

E1 26:18

Yeah.

I1 26:22
Yeah, are you already working on technological strategies to overcome certain safety risks? About the product?

E1 26:31
Not specifically only well what we do as a technical a lot what we do is do a lot of research projects and hope on different solutions. So we work to 100% bio-based and waste-based material and Compro or RE-PLEX is one option for us. So we have different options.

I1 26:54
Okay.

E1 26:54
So that's already some kind of technical logical strategy because all the other options we or not all but some other. So, we have a line of products of composite products that behave totally different.

I1 27:11
Mm hmm. Okay. And yeah, as a manufacturer, do you feel responsible for the safety of the end product?

E1 27:22
Yeah. Because if something happens, they will call us. Okay. So, no, but I always feel some responsibility of course otherwise, so I wouldn't go through the hassle of making sustainable products. Yeah, we are in that way very responsible company. And also for the safety of course, because you also have a rebound effect. So we put a lot of effort in a new product. And we know it's really lightly and flammable for instance, and something happens then your business is gone as well. And your investments lost.

Dependei

I1 28:02
Yeah. Okay.

E1 28:04
So, yeah, morally and rationally, it's both necessary to be responsible for your safety.

I1 28:12
Mm hmm. Okay, last but not least, the RE-PLEX, as we already mentioned, has a lot of environmental advantages. And do you also see any disadvantages?

E1 28:28
Yeah, I'm not sure if we can save energy with it. I'm not sure about that. How do you what do you think? Why do you think that we have energy saving potential?

I1 28:40
Well, in the production process there are some energy savings and also because the product is very lightweight. They say that the transportation costs or the energy for transport gets lower because the longer term if we have to transfer lighter products of course.

E1 29:06
Yeah, I think you mean potential. It's okay. But um, I don't think we researched it really thoroughly yet. But okay. Yeah, so we have environmental, do I see environmental risks. Now well for us now this Kaumera stuff is also a bit of a black box. So we don't know it's

Product pe

wastewater we don't know exactly what's in it.

I1 29:34
Yeah. Okay. So there always could be as well some pathogens that could still be relieved. For example.

E1 29:46
Yeah. You don't know exactly what's in it so people and companies throw lots of waste in sewage. So it is even, cocaine in it probably. So yeah, yeah. It's not easy to know what's in there and what's not. So that's a, that can be a risk. Because it's really hard to, to make an invitarisation of all the materials which are in because it can be so many you don't know what you're looking for.

Product pe

I1 30:23
Okay. So it's difficult in the laboratory to really see every substance.

E1 30:32
I think they already made a list at ChainCraft of all kinds of materials that could be in there. I think it will be good if you were last meeting. You were not there.

I1 30:46
Yeah, I think it was the technical meeting. And I'm actually not so much.

E1 30:51
Oh, no, of course. Yeah, I think it was technical meeting. But these are the most interesting of course.

I1 30:59
Yeah. Well.

E1 31:01
Okay, here's I think. Yeah, so there's all kinds of elements that are in it.

I1 31:09
But this can also fluctuate, right? I mean, it's always the same. So this is probably high risk somehow.

E1 31:20
Yeah. So we find all kinds of elements. So I don't know. Can you read this? Maybe I made a picture of the screen?

I1 31:31
Yeah, I see. Natrium-phosphorus

E1 31:37
Oh, yeah. Steel or iran. So there's lots of there are quite some metals in it.

I1 31:43
Yeah. Okay. Yeah, I think if I if I need it, I can still ask for it for the list by Peter, but good to know that it is there.

E1 31:56
Yeah. I'm not sure if it's 100% complete. Because I can't see the cocaine in here. So only chemical isolated chemical elements.

I1 32:15

No. Well, eh good. So is there anything that you would like to mention that wasn't considered so far?

E1 32:28
Uh no. What was your role again? Exactly.

I1 32:40
Um, well, I am student still writing my master's thesis and

E1 32:48
Oh, you look at the market potential. Oh, yeah.

I1 32:50
Yeah.

E1 32:51
Circularity
Product pe
Okay. Yeah, first was really. The thing is, is that if we are in this sustainable material business and circular economy stuff its really we call it a technology push so we have something and you have to buy it. And all the marketeers say this doesn't work. So you have to see what people want and then supply it but people don't want so they're not wait. So there are already a lot of materials in the world and we can make everything we think of so if you would ask somebody would you like to have a telephone that's made out of sewage water then nobody will say yeah, that's exactly what I want. I want to pay 50 euros extra for it. There's no market for that.

I1 33:43
Yeah.

E1 33:44
But we want you to buy it because it's good for the environment and that's I think it's a bad strategy of force people into it. May be some niche people but even myself, you know, I I'm in the business. But still I want to have a cheap car and that's the work I don't know. Yeah.

I1 34:08
Yeah, it's difficult to catch people in this yeah. I see it by myself as well.

E1 34:14
Developm
So we are really look for strategies to get these necessary implementations into the market. And we don't want to force everybody with law to do so. But up to now, that's the most effective. Sometimes it just takes long. So I started in solar energy in the 1990s. And it was really hard to buy a solar panel because it's cost money and you don't, it doesn't make any sound you don't see it. Or well maybe you see it if you look at it on your roof, but on a flat roof, you don't see it. It see in the energy, because at that time we sold very small systems because otherwise was too expensive. Or it's really hard to sell something like that. But now it's a good investment because interest rates on the bank are low. And here you have a return on investment 7% or something like that. So it's really, it's a good investment, it's good for the environment, and it's not so cheap or expensive anymore. So it's really more interesting to invest in solar energy, but it has been well since the 1990s. It's 25 years ago. So there's a lot of time and a lot of money invested to make it to where it is now. But I would really like to see with a market point of view, what would be a good strategy to implement these materials. Yeah, because the material is, in a way, it's a low interest product for people. So for instance, this telephone, you want to make that its smooth to touch that it doesn't it's not sticky. It's not smelly or will last long. It's strong. If you drop it a may, no break. For the rest. People won't care less of which it's made of interested in chemical ingredients of the paint that

is used. If somebody say, oh, it's cancerous material, then okay, people may be interested, but not really. So, so low interest products, so it's always hard to sell. So we should look for strategy where we go from niche products to mainstream products in 20 years, and where should we start?

I1 36:59
Yeah.

E1 37:01
And that's always the difficulty to start. Because what will be we'll be interesting question is, they also say don't combine too many innovations. So don't use a new material for a new product.

I1 37:17
Mm hmm. Yeah.

E1 37:21
But for our new material for a new product and a new market, so there's always we have to find a combination of so we have existing market with a new product, new material or a new material, a new market on existing products. So we should find strategic combinations with which are easiest to do, or, yeah, where to how to approach the market in time. Yeah. So yeah, finding this route is really complex.

I1 37:57
Yeah, I see.

E1 37:59
This one I want to know from you come up with a good strategy and I'm happy to come up with a good market approach strategy and I'm happy.

I1 38:11
Okay, we'll see what I can do. I think maybe at the end of my thesis, there's no strategy. This sense no complete strategy, but maybe I can contribute my part somehow. Who knows, would be great.

E1 38:30
Yeah, I will also be interested to have some German because we are working with German companies. So they produce for us products sell mainly on the Dutch markets. And we don't really know the German market only a little bit. So I would be interested if you would ask some German market. So not only ask the Amsterdam municipality but also the municipality of Weimar or Dresden or whatever, so also other so also German counterparts of the Dutch people you talk to.

I1 39:16
Okay. Well, I think this I would have to communicate still with Peter and with Arjan, huh. But it could be indeed interesting to.

E1 39:33
Yeah. To see how I if the or maybe maybe what you can do is do a research on with the Dutch people but do the evaluation with German people or something like that.

I1 39:47
Which evaluation you mean.

E1 39:49
Of your results. So you have some results based on the interviews you do now. And then

you will test or evaluate these results not only with your tutors, but also with some german counterparts.

Transcribed by https://otter.ai

Interview E2

I1 0:03

I think I will just read them for you if it's okay. I could share as well, somehow I changed them a bit and I don't know I did it like this so far, but. Okay, so let's start. For how long are you in the position in the company yet.

E2 0:32

Yeah, I started in 2017 so almost a little bit over three years now. And I work as an innovation-manager something. Yes, I think. Yeah, the general idea is that innovation is considered to be a new business, it's not just investing. It's also about creating something new in the end creating new ways of doing business. And one of the themes one of the bigger themes is that we set it up as a goal for the coming years I would say is to become more circular. So I think that fits really well into the whole topic where you come from to build these things from wastewater.

I1 1:42

Okay. And what is your relation to the Compro project or your position?

E2 1:49

Yeah we joined in last year at the end of september or something we had a discussion with the Peter and the team and I really didn't no I hoped but I think that we would win any grants so I learn that [...] yeah, I think at the moment we are still not to much involved I would say because its more about the research and more about we will be later on I think when we start talking about what kind of aspects do you need for any given certain sense for a building project. And so we will participate in the market side things to create a set of specifications and then also to help with getting the files organized. And in the end we mark it as well[...] So hopefully that will happen in the coming period.

I1 3:19

And do you already have partners in mind? In that sense like other construction companies or?

E2 3:32

Well, I think it's to early for that so as far we are here the companies mostly is Europe and I think it depends on where you are and what you want in what kind of partnership you need. So we do a lot of partnering but a with several construction-companies but also with big [...] or sometimes with logical customers I think it depends on what location which area you are in to be able to define what kind of partnership is needed. Of course at the moment I think part of our partners are technological so the two start-ups and the TU so its more research-based and later on we might need people that scale the technology or we might need to [...] market. The other type is also the more people you get to deal with it more difficult it becomes. Most people are too many people to make partners there are to many interest and then it becomes slower and slower. So we need to have some balance between speed and agility and also power to get it done.

Dependei

I1 5:21

yeah

E2 5:33

so I think it depends on in a later stage maybe you need more [...] and finance so there's a company within a [...] and they create finance models for building projects. So it can be from the market it can be from the technological site it can be from any side where you would need partnerships. So I think it depends.

I1 6:15

19 Ok. Yeah. Now some questions regarding Compro and the network also. First some general questions to get an quick overview. What do you consider as social advantages of the Compro project?

20 E2 6:39
21 With Compro-project you mean creating a new staff new from wastewater. Is that what you mean?

22 I1 6:47
23 Yes, and also the cooperation with different partners. Yeah, this network of stakeholders that is connected to the project? Yeah, basically this.

24 E2 7:03
25 I think in terms of the efficiencies, it could be a huge benefit to be able to reduce our waste more but also be more circular that has so many advantages you can think about environmental impact you can think about economic impact because, when you create something from nothing it so for example, it would mean that we could use it as an insulation material and the cost for the current insulation-material is x and with this material you have to produce it [...]. So it costs is also basically the grounds to make is worth nothing or less than nothing so it cost more money. So the huge model in everything you buy to get technology working. So it has a strategical advantage I would say to reduce the environmental impact. As we are one of the bigger eh CO2 and waste producers in the world the construction industry. And it goes from helping against the harder part the concrete part but it also has something where you are being a [...] for others. So, there is also an advantage by doing this in a new way we can prove that these kind of stuff can happen is technology relevant and its also this can inspire other people so thats more in the structure. [...] Yeah, and I think it is very important indeed because as we are as I said one of our goals is to be more circular that means that you need to think differently how do I design something, how do I build something what kind of material can I use/ to not use. So you can inspire people to think differently than learn and thats their way of working and you can create an impact and take steps toward making economy less dependet on fossil fuels or or other material that you use. So it's a very wide and big but it could have this kind of impact.

Environme

Environme

26 I1 10:48
27 Eh. And the economic advantages of the project?

28 E2 10:55
29 I think the team is working well I think it's also interesting to the process of being together with a bigger cooperate besides ourselfes together with regional facilities its a really interesting mix and what you see is that within the process you have a lot of [...] from universities. One of the bigger struggles that we have as I think the Dutch, Europe country is that a lot of universities are not very stay within the institution, so you have this very nice knowledge and people publish a paper and that's it. So, this should also be a way of learning on how that works and how that could be proof. And then you see in the US it becomes more successful there in getting research out into the field and somehow you have these universities that are top of the [...] if you then think about how much how many innovations are really coming out the features are applied is very minimal. So that also a local advantage because if you do that better in Europe or in Holland then you could be you could be have a competitive advantage compared to the US and China. So it's really important that there is a link with research but concerns that there is a way to apply it make it something that is useful [...]

Dependei

30 I1 13:46
31 Okay. What do you think are the risks of the Compro-project? In a social and economical sense?

Uncertain

32 E2 14:02
33 Risks yeah, there is always the risk of eh, failing so there is not guaranteed that it will happen. And that you make something useful out of it so you could say that eh, one of the bigger risks is that you spend a lot of time together and it doesn't work. Or that there is a negative effect that you have some kind of side-effect where you are going to the other direction of being less [...] that it's actually worse but yeah both of the risks I know Yeah. Its difficult to manage Yeah. If you are on the other side if you want to have different results you should just you should go with the risks if you want to do something new it's not like another risk could be that if you make a bridge out of it the bridge could collapse so you should think about structural integrity. As we are not there yet. [...]

34 I1 15:55
35 Okay, and are there any barriers connected to the Compro-project that you experienced so far?

Developm

36 E2 15:57
37 Well, I think time is a barrier in one sense that all our time is limited and I think there is a big stress at the moment to get enough power on what yeah, especially in these Corona times of course. Another barriers is that there is an because of the economic climate there is not.. I really need to make an effort to be involved here. [...] The first, the first three attempts to participate[...]

38 I1 17:09
39 Okay, from inside the company.

Costs

40 E2 17:12
41 Yah, there is control on all cost-flows so everything that is costing money is eh being cut. Although [...] its adding to our own wish to be more circular. You still are in this economic climate where its pretty difficult to get [...] attention.

42 I1 17:51
43 Okay. Some organizational questions. Does a business model that's connected to different stakeholders involve operational risks for you? I think you already mentioned some so conflicts of interest.

44 E2 18:16
45 Yeah, but what do you mean by the business-model?

46 I1 18:22
47 Yeah, I mean, the Compro-project or the RE-PLEX could be a business model or more the Compro-project and I mean the connection to the different stakeholders basically. It is not very [...] but there are many different players that are involved somehow.

Dependei

48 E2 18:50
49 Yeah so there are different stakeholders with different interests so the university or research should have a different outlock than a commercial company or even a company that is also linked to the financially [...] We are not a start-up we cannot. So there is you could choose to be first and foremost, we cannot innovate within our own company. So I don't believe in doing the stuff just ourselves

Dependei

50 E2 19:56
51 I think it comes from the realization that actually everything in the world is connected and everything will is the developments are going to fast. So it's not that you can do the things just by yourself so if there is the mindset that you are ahead already than partnering is not the only way to go. But then it becomes important who you are

working with. So, is there is there any quality on value and on believes share trust within partnerships and if that's not the case than you should not than you're missing out [...]. In the end it is not [...] Maybe something that you could do short-term but the partnership for years to come is something that you should [...] week or days. So you should have stakeholders or partners. Stakeholders are something different that partnership is. So what do you say to be sure the you want to make it happen? And we at BAM also want to be more circular so. No one saying that we have different goals. So we also need to make money and the university not, not so much they need to create research and make knowledge that's different goal that's something that you should realize. But it coud help eachother not so much, help each other not so much. Compete with each other, it becomes even more difficult if you have similar companies with the same goals. So if you have for example another construction-company its not so [...] if you want to create the same business model than it becomes difficult. And then it could also happen that you say ok eh for example we invite our partners because we have a dinner [...] we will [...] so there is a habbit of [...] So everything is possible. I also have a partnership with another construction company where we have divided the buying, we said okay we have the new infrastructure and you guys have the new housing part although BAM also doing the housing business.

Dependei

I1 23:14
Can you say which company it is?

E2 23:18
Its a company a producer of concrete and the company is called van [...meien??]

I1 23:24
Van Mayen ok.

E2 23:25
I think the construction industry is used to partnering and collaboration because the projects that we do are enormous to enormous for wascom and compro[...] so to a building project which we are doing and two or three [...]. So we are used to working like this. But it takes also, concurrency and trust is key to make it happen and durable otherwise, you will fail in one point in time.

I1 24:21
Okay. What organizational difficulties have you experienced or could arise when depending on the by-product of a wastewater treatment plant?

E2 24:43
Well, that's not a big thing but at the moment we are in the process of getting the name registered. So it's a really easy process you say this is the name we want to, but if you think about it what I said if you are in some kind of a collaboration like this you need to prevent that there will be conflicts in the future. So, [...] which is [...] one of the difficulties is that you need to find commercial grounds as well and not just technological grounds. Everybody wants to make these machines that's the easy part, but when it comes to who has the role or in the modelmaking it becomes conflics and you need to prevent that. So if you are you can talk about it and you can [...] For example if you this compro BAM [...] and then they go to the supplier [...and they say they want to have a prototype] and the supplier says, yes of course we can make a prototype and then from there they create the prototype and then they say ok now yeah, this is what we wanted and then the supplier says, well you can just pay me all the knowledge you can have a share on that okay yeah

Dependei

I1 27:01
The name is related to the patent of course. Yeah.

66 E2 27:06
67 So I think you, you need to prevent those kind of stuff because then you could end up in some kind of conflict you don't want at all and in the end it doesn't help either because you're already fighting and all that energy is lost. So I don't think that it will help to market this. So that's the thing to do I would say.

68 I1 27:42
69 To share the parts of the name to have...

70 E2 27:47
71 Yeah, that we have some kind of a model. One partie should register the name and than have some kind of agreement that, that agreement needs to be at least [...] before you enter in kind of these difficulties [...] and that doesn't really help.

72 I1 28:33
73 Okay. But you see no logistical problems or organizational problems that the source is the wastewater-treatment-plant, of the product?

74 E2 28:45
75 Oh that. Yeah Okay. [...] And if you apply it to wood the scaling up is a difficult thing [...] this could be that you say ok, we will [...] another waste-treatment-plant to apply that technology and they feed you for the knowledge [...] so you licence the knowledge to them. I think those kind of [...] the interesting part still because what you want is that you I don't even in one of these projects where Kaumera will be applied as a material that is, it won't work. It will work for a small amount but if you go to a certain level it needs to be centralized somehow.

76 I1 30:23
77 So there would be that would be more smaller wastewater-treatment-plants to deliver the sludge.

78 E2 30:38
Applicatic
79 I'm not sure about [...] if there are certain test that can not do the wastewater-treatment facilities work do if the wastewater-treatment-plants cover you would have one in every city for example in every city there are these water-companies in every city there are different stations, so you would maybe have one station per city and then [...] in Holland. So yours will be de-centralized in a region [...] quality if you apply [...]how the stack it and you can just ship it everywhere you want. I think it depends on what you want to finally do with it. It is like timber, you cut it in peaces and send it everywhere. That's really easy if it's like asphalt you need to have some kind of decentralized cutting facility and in most cases in Europe[...] travel but if you go oversees so to other parts of the world, only one or two people yeah. So maybe there are some faces to discover. In one face and then in some point of time the quantity [...] ok now we are you say now we are scaling up within Europe and than we scale up within the world or something like that.

80 I1 33:15
81 Okay. Some legal questions or political questions. Which political or legal guidelines do you perceive as the most preventing regulation for the Compro-concept?

82 E2 33:28
Legal regu
83 [...] Everything you do as a construction company has to comply with some rule or regulation. So the construction-code I would say. The problem would be that this is something that this is not [...] use at all So you can not say it complies with the norms because the norms doesn't exists for this stuff. So we need to find a certain way to tackle that depending on what you want to do with it. So if it's just some [...] you probably with

Legal regu

some plastic and some property's you could proof that its worth it that it works if you are really creating constructions out of it. […] So you design something and then you test it and then you produce it in a way you have designed it. And then you have to comply with some legal framework. So you have to comply to this construction code […] And if you then go to another country [… in another country the legislation is different]

84 I1 35:28
85 Okay. So it not only just needs to overcome some waste-label but also certain construction regulations […]

86 E2 36:24
87 […] Wherever environment difficult applies first time where the legal and technological I think all that […] and it starts with learning a bit more about what can I do and then finally figure out a good application for it. Isolation is something different from fire to fire. […] Yeah and then there are. Everything that has a value is okay. And there are, so it depends on the functionality where we are with and then we can ask this question about the legal framework where we have to comply with. Okay.

Legal regu

88 I1 37:56
89 So what measures have been taken by political bodies to make the symbiosis less risky and uncomplicated so it means.. the symbiosis is the network of companies that work together and nourish each other. And is there something that the Gemeente can do to make this symbiotic relationships easier?

90 E2 38:39
91 Yeah in the end eh, who is eh.. yeah it can happen either way.[…] It depends on who is the one that is legally resposible for that. So if BAM is responsible than we make sure that the bridge it doesn't collapse. So than its the responsibility of BAM that that will not happen. And strangely when the government was responsible for making sure that is didn't collapse and than the who process it is much more difficult. And that's a very strange thing because you would think there is less risk because when the government says ok I will take the risk of 'Wascom' that would speed up. And, of course, if that is the case that the Gemeente really wanting to help here and then think about who owns the risk it probably the way forward but its also about trust again that there is not a […]

Dependei

92 Transcribed by https://otter.ai
93 Anja 41:00
94 Mhmm.

95 E2 41:01
96 So you need to be sure about what your goals are and also allow others to have their own goals and to reach them that is something that is very important in a in these kind of inventions […] So, in the other way you could also say well, by giving the risk to somebody else and […] that could be one way to manage it. So BAM […] but you are the risk owner, which means that we will need to do stuff and we will do stuff to make it happen but also we will, if you have a risk you also want the reward for it. So that´s also how it works. So, what is the reward in that case? And with the other project […] where the government was takes all the risk but not allowing to reward […] which made the process really slow because we only did what we were asked to do and not something else and in these types of innovations you always come to the knowledge that […] yeah you don't know what you don't know. That's the basic […] and if you then organize it in a way that you say here is the paper I want you to do everything on it, that people will only do what is on the paper. But nothing else what will be needed because we don't know what we don't know as I already said. […] if you organize it that you say […] and it is also your reward […] there is a responsibility and stuff will be aligned people will manage it people will be aware of it, I think that would help. In eh, that would be more facilitating

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giving the space for other companies to prosperate and not try to do it themselves. In most of the cases although the intention is good, we will take the risk and you will have no problem with it, the intention is good, but you are coping with a buffer.

97 Anja 45:33
98 Mhmm. Okay hmm. So financial performance. What financial risk you have to accept when depending on the by-products of a wastewater-treatment-company?

99 E2 46:00
100 I am not sure about the difference between a by-product and a normal product.

101 Anja 46:16
102 Ehm, the by-product is the is the waste-product it's the its not the product created for a certain purpose but the product that is ehm something that's coming out of waste.

103 E2 46:30
104 Oh I get hmm, well if you think about the quality that you that you. So normally you buy something and you I don't know I buy soil […] make sure it happens and if its not happening I won't take it. It is probably more difficult if you do it like this if you have a but in the end yeah, I don't know is depends if you, on its technological meaning maybe it isn't even a problem, so eh so I think the quality it should be kind of a quality-control […] Chaincraft independent from your waste-water. So I think that is more interesting than a supply-shortfall or something like that.

Developm

105 Anja 47:46
106 Okay, ehm, will the production costs raise with the use of innovative technologies, considered for the use of bio-polymers? So, do you need any new technologies for the production of RE-PLEX or the usage of RE-PLEX inside your products?
107 E2 48:14
108 Yeah, I don't know. You know, I don't know. Could be if you are creating something new. For now I don't know. […] At these point, if you ask these questions there might be no answer.

109 Anja 48:41
110 No, that's fine. Now the urban dimension. How you imagine the integration of the Compro concept into an urban development such as HavenStad for example?
111 E2 49:00

Uncertain

112 […] I think it totally depends on your material. So are you using it as an isolation or as a flame-retardant material or are you using it as a building-material, that is what you need if you, how to apply it in an urban project like HavenStad. But I am not sure if its used for housing or if its used for other stuff. Could be both or not at all. […] maybe its something that is not so much for the construction-industry but might be possible that you apply it in the automotive industry.

113 Anja 49:49
114 Okay.
115 E2

Applicatic

116 Yeah, who wants to check it. Again, we will this needs to be researched. I think what we need to do is to take some kind of a step forward. I really like the idea to take it as an example it you dig a big whole and that could be really much of a possibility. Or isolation is also if we could […] the current isolation yeah, is not very environmentally friendly so that also has an impact.

117 I1

Applicatic

118 Okay. And could you imagine that RE-PLEX is applied in a bigger urban scale in a Symbiotic network of companies? I mean Compro. For example, that a wastewater-treatment-plant is located next to Chaincraft and Chaincraft is located next to a drying

Applicatic

facility. And the drying facility is located next to BAM Infra.

119 E2
120 Hm. Yeah, so for me it doesn't really matter where we are.

121 I1 51:42
122 Okay.

123 E2 51:50
124 The only report to apply it in sensible ways they didn't make it […] really use […] applicable to a lot of stuff and independent from. I could imagine that […] so it's really independent form Chaincraft or NPSP it should be… so we organize it in a way that […] yeah, you can do that in different forms […]or producing it yourself and others can apply it or. You can even set up a different company so.. everything is yeah, I think it depends on […]

125 I1 52:53
126 Okay, so this spatial dimension is not so important.

127 Speaker 53:00
128 Where we are not. But there also need to be some finance and the technical part, if you need to have some, eh, if you have a limited time for […] I think the kind of application still […] everything. And if you apply it as asphalt than you need to apply it within a certain amount of time […] than it makes sense that you apply it with production companies or Chaincraft and NPSP or whatever. But yeah, if that doesn't apply, if it's just like timber, than you yeah. You go from there to the first question, you need to think of the advantage. And then we can think about testing and thinking about the prototype from there.

129 I1 54:12
130 Okay, and now we are in the product-part. What do you think is the added value of RE-PLEX in your company?

131 E2 54:24
132 Sry, but I look at my diary, eh, okay, so we have half an hour still.

133 I1
134 Okay, maybe we go through the second part a bit faster. So, where do you see the added value of the RE-PLEX?

Circularity

135 E2 55:05
136 So, it's a completely circular building-material. So that's the biggest added value.

137 I1
138 Mhmm. Which amount of the RE-PLEX needs to be generated to make it economically valuable for your company?

Developm

139 E2 55:21
140 […] it really depends on ehh.. […] I am not sure of the market value the material is using up. […] If you think about […] or the isolation or if you think about coting it is interesting […] than you talk about 30 years then it might be interesting […] the housings are older but the economic value is more and more, if this costs millions and millions of euros than, it's a really easy business case, so you need some more information to really answer this question. When you really know where we are applying it […] market size […] [very bad quality!]

141 I1 57:19
142 Ehm, for example what's the total amount […] that's coming out of the wastewater-treatment-plant per year […]

143 E2
144 Sure, it depends on the partner.. […] for incidence the current production-limits. If it's for example […5000 tons??] the production could be […] it really depends on the amounts of production we are talking about. […] how many houses are built in a year, how many isolations you need in a year, yeah, sometimes these types of calculations you can make. […] what's your […] that you are creating something out of nothing. This will automatically will be more economically viable than […] but the problem is that you need to create more than 25.000 a year probably. So than you will make that happen, than it comes to higher costs […] not understandable.

145 I1 59:51
146 So, some economical questions, which technological barriers prevent the implementation of Compro?

147 E2 60:08
148 So, we need to figure out what is the technological possibility and what is the application for it. So I think the barrier would be […] so you need to create a prototype of something, […] there are different stages in the creation-process, this is all text-book stuff, but basically you create a prototype, a prototype that you deliver and you do something in the delivery-phase and in every phase there are different types of technological problems to solve but the biggest but the big issue probably is to do eh.. […] [59:31] Than you have the prototype and the second is that then from the prototype can you make something that is really actually a product? […] perhaps or I don't know. If it becomes, that's the difficult one to create from a prototype a product. And then from the working product you need a final way to […] and then you come over to the technological problems, how do I create it […] how do I […] logistically but that stuff is in the end, so normally you take about […] six month per stage, so the challenge is to go from one stage to another in six month time. So you have six month for the product and six month to figure out a working product and then six month to figure out […]

149 I1 1:00:45
150 Okay, and what are the applications the product can have in your company? I think you already mentioned the tunnel, this is maybe a product which maybe.. yeah. Do these applications require certain properties the RE-PLEX can't fulfil so far?

151 E2 1:01:09
152 I don't know, I don't know. But I am not sure about RE-PLEX in pretty much detail and I am also not sure about the requirements for the applications and things like that. So, probably there are certain properties […]

153 I1 1:01:37
154 And do you think the RE-PLEX is more useful for temporary or permanent constructions?

155 Speaker 1:01:58
156 So, I think our goal is to go for permanent constructions. Because temporary works are not, well they are used more, but they are also discarded very early, eh […] could work, but they might be better in permanent constructions as in temporary there are higher impact to get less effect on the environment.

157 I1 1:02:46
158 But temporary constructions can also be very big applications right?

159 E2
160 Yeah, of course.

161 I1 1:03:00
162 Ehm, yeah, can the RE-PLEX or Kaumera be integrated into into the standardized production-process of some products in your company?

163 E2
164 […] 1:03:39 [….] and then you have to test it, that it works and it doesn't have a negative effect, so you could probably do it. But I would think twice if you would like to do it in this stage. For example I would make the first step to create something of it and then see if it can be applicable in other fields or stuff, so you also have to ask for the reason why, why we should do this, can we take a reward of it? I am not sure, if it is the case, that would help […bigger part] etc. etc.

165 I1 1:05:13
166 Which quality-criteria the product need to fulfil to be competitive with these conventional products?

Uncertain

167 E2 1:05:35
168 Again, we need to find out what the application is and then all these questions come easily.

169 I1
170 Okay.

Applicatic

171 E2
172 Because you will not pay for […] it will be to heavy in the construction world, so my heavy is different from your heavy probably. So, if you say lightweight it probably is […] but non-flammability is one of the more interesting aspects. That is the god-feeling that we have.

173 I1 1:06:54
174 Do you perceive the bio-degradability of the RE-PLEX as an advantage or a drawback?

175 E2 1:07:07
176 It can be both. I think the story about it is cool.

177 I1 1:07:36
178 Which criteria the product need to fulfil primarily to reach customer-satisfaction?

179 E2 1:07:50
180 Yeah, […] you begin by creating a identify a need for us. So, ehm, sustainability, durability could be also […] in particular but we are doing a lot of investments aiming to reach the climate-goals. And they are really.. […] so one of the needs is to be to understand […] it could be the need to [… a lot] but it should not be to expensive. So if you have that than you are… yeah.

181 I1 1:09:38
182 What are your doubts about a product originating from residual waste?

183 E2 1:09:48
184 I think […] will be always with a higher quality. Eh, design is always important but, that is something that needs to be tackeled, well it doesn't needs to be beautiful, but […]
185 We should figure out to cover the demand. […]

I1 1:11:38

187 Would it be a difference for you if the wastewater for the composite-material derives from municipalities or from the wastewater-stream of one company? So from different sources or facilities or if it is just one stream?

188 E2 1:12:16

189 I can imagine that if it is just from one company […] different sources […] if you have a common facility […]

190 I1 1:13:12

191 The RE-PLEX-product has a lot of environmental advantages such as the degradability, energy savings and independency of fossil fuels. Do you also see environmental risks connected to RE-PLEX?

192 E2 1:13:30

Environme 

193 So one could be that. .. I don't know how that works but you take something out, than you create something new with it and then we add stuff and the stuff that we add is even worse than that what we trying to pretend than it doesn't really, yeah, it makes sense. So we should find out how it works and what exactly is the case but, for example with concrete I know that yeah, if you add cement its not so environmentally friendly, so that that doesn't happen. […] for nothing, so we need to do something with it. So I think that is a big environmental disadvantage

194 I1 1:14:43

195 Is there anything that has not been considered so far, that you would like to mention?

196 E2 1:15:10

197 Ehm, I think maybe who is the customer? Is it the government or is it the municipality? […]

198 I think in a later stage this is something that is really needs to be considered I would say. Than from the market-side you could think about how to communicate and the message that you need to get across. This will fly when […] because of the environment etc. etc. People will be […] so the whole communication will be from your city in your city or something.. […] the communication of the technology is very important. This will give a technological push

Applicatic 

199 I1 1:17:48

200 Yeah, thank you very much for your time and openness to participate.

201 Speaker 1:15:52

202 Yeah, I think you will create kind of a report.

203 I1 1:17:56

204 Yea, I will use it for as data and in the discussion of my Master-thesis of course, and if something is published, it stays anonym – maybe important to mention. Yeah, I hope I can somehow contribute to the project.

205 E2 1: 18:32

206 I would like to have the report if that is possible.

207 I1 1:18:35

208 Yeah, sure

Interview E3

I1
Well yeah, the first question, a more introductory one, for how long are you in the company now?

E3
For 5 years more or less – three years working on the Kaumera.

I1
Ah ok. And what is your task? Or position in relation to the Compro-project?

E3
I am the innovaty-manager for Kaumera at Chaincraft. But, do you know the consortium of the Kaumera – which companies are in it, and the roles of the separate companies?

I1
I know the parties involved but maybe I don't know all the different companies. It would be interesting to know who is meant to have which job.

E3
Well, I think it's the easiest if I just show you a little presentation.
There are the waterauthorities Rijn and Ijssel and Vallei en Veluwe [6:46]
I don't know if you know them or have heard of them?

I1
I just know about Waternet.
[In the following part the expert is giving a presentation]
[about:
who is involved in the project
showing the material
explaining the manufacturing-process
other extraction-possibilties]

I1: [24:44]
What do you consider as an economic advantage of the Compro-project?

E3:
Ehm, for Chaincraft specifically?

I1
Mhm, yes, I would say for Chaincarft specifically.

E3
We are looking for outlets for the Kaumera. We are always looking for applications – and the RE-PLEX is very promising.

I1
And what are the social advantages of the project?

E3
But this would be more general right?

I1
yeah.

E3

39 I think the social advantage. I think we should see it more in a bigger picture. Moving towards environmental [two words not understandable] I think obviously the name might… [not understandable] but I think we should defenitly see it in a bigger picture.

40 I1
41 So, the circular.. promoting the Circular Economy. And are there already social or economic risk you can mention?

42 E3
43 yeah , I don't see I mean people talk about social risks of the Kaumera. Economic risk, of course there is an economic risk for all the parties involved that invested in.. Chaincraft, NPSP and BAM infra, yeah, but especially Chaincaft and NPSP we have invested lots of people and resources and that is the economic risk I think that comes with it.

44 I1
45 Yeah, and are there already barriers that you have experienced so far with the Compro project?

46 E3
47 Of course there are technical hurdles.

48 I1
49 yeah, so you think this is the biggest barrier – the technical issues.

50 E3
51 yeah, this is the biggest barrier but of course there are other barriers as well. Another barriers may be as well, because this is a new material, of course there needs to be enough of supply to build the demand.

52 I1
53 Yeah, this was just for the general introduction. Organizational Questions: What organizational difficulties have you experienced when obtaining your resources from a wastewater-treatment-plant? Like for example in inconstant delivery or yeah, are there any organizational hurdles?

54 E3
55 Yeah, this is something we are only starting to just to find out. For that particular plant in Zutphen is probably operational within a couple of weeks– the wastewater is form a diary-factory and therefore it highly depends on the amounts of wastewater that produces the factory and that fluctuates a lot [28:30] but for the municipal wastewater-treatment this is much more balanced out.

56 I3
57 Okay, ehm does a business model, that is connected to a business-network of different stakeholders involve operational obstacles for you? Which is mainly concerned to that there are different interests and ehm yeah, different stakeholders combined.

58 E3
59 Can you explain, hm I don't know what you mean with the business model?

60 I1
61 Ehm. The business model is Compro itself or eh the product RE-PLEX what I see as yeah, the centre of the business model and around it there are the different stakeholders like the end-users, BAM-Infra and eh yeah Chaincraft, NPSP and Waternet like many different stakeholders are kind of connected to the project and which can be ehm yeah, organizationally difficult.

Dependei

Dependei

62 E3
63 But these kind of collaborations between universities and industries are possibly needed and are still to be developed this time [not understandable] because this is a very new product. [30:30]
64 So you need universities that critically intervene and the freedom to investigate these type of things but you also need the companies to bring these market inventions into practice.

65 I1
66 So you don't see difficulties at the moment.

67 E3
68 yeah ehm, obviously there are difficulties in these collaborations but I think this is the way to go. If you say Compro is the business-model I think the business model should follow the Compro-project and the Compro-project is not a business-model in itself.

69 I1
70 Okay, but it can become right, kind of a business-model in the future?

71 E3
72 But, for the RE-PEX you mean?

73 I1
74 mhm

75 E3
76 I don't know but this question will be dependent on the project.

77 I1
78 Okay, [laughing]

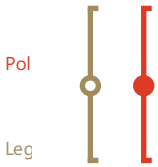
79 E3
80 Yeah, I think the business-model is that Chaincarft is supplying the material to NPSP and they make a product of it and they sell it.

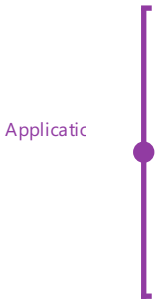
81 I1
82 okay. Ehm, yeah, ehm let's come to the political guidelines which political guidelines do you perceive as the most preventing regulation of the Compro-concept?

83 E3
84 yeah, you already have mentioned the waste-label. [32][not understandable] I think I can give an own presentation just about the waste-label.

85 I1
86 Okay.

87 E3
88 You have to understand […] in the past there was no such thing as waste. And now we move to a circular economy and we want to use our waste and put it back into the economy as a resource and that complex is a very strict law which prevents the waste to go anywhere except to an incinerator or something and this is an issue in legislation, a big issue and I think. And eh, exactly what needs to happen is something that is waste needs to become 'end of waste' and therefore it needs certain bacteria and these bacteria can be developed on a European -level […] but there is hardly any examples of than but these bacteria can be developed on a national level there are some examples





for that.

89 Only local authorities can define, if something is waste or not but that also means that local authorities can disagree on that. Ehm and that means the final 'end of waste' for example in Amsterdam [..] they can disagree, but that probably won't happen. But that doesn't allow me and that is today my problem in the EU, in the free trading-zone in the EU that it is not generally accepted in the EU. But yeah, that's a bit.. yeah.

90 I1

91 So for every local parcel it needs to be decided again or ehm and only if there is a prototype you can actually do something against the waste-label right?

92 E3

93 Mhm. No and yeah, ehm, it is a type of framework that you have to comply with. So what you need to do is have. You need kind of a stereotype [not understandable] because you have the development but it's hard to generalize this because you have waste and this creates kind of a loop [35:30] which makes it a difficult situation […] it is easier when you make something […]when it's this product and when everybody knows how it's working and when it is save to use.

94 I1

95 Okay, what political measures could be taken by political bodies to make the cooperation that you have with different stakeholders or companies less risky?

96 E3

97 [36:05] Eh, yeah I think the subsidies are very important, that support by the government eh, but it is also the political bodies that can help with […]?

98 I1

99 That's fine. Financial aspects- are there financial risk you have to accept, when depending on the by-products of a wastewater-treatment-plant?

100 E3

101 Ehm so, but in this case you mean not necessariliy the development but the process of a dwelling […] what is the financial risk? Because you are depending on a wastewater-treatment as a supplier.

102 I1

103 Yeah

104 E3

105 Ehm so, I think you should distinguish two types of wastewater industrial wastewater and the municipal wastewater, in industrial wastewater you have a wastewater treatment supplied by a factory and you get the wastewater from that factory in that scenario you are dependent on the supply from that factory. But the wastewater is a lot […] you have much less risk than in municipal waste-water. In the municipal wastewater you don't have so much control about what is in the wastewater, so some contaminations can have the end-product and therefore yeah. [39:16]

106 I1

107 So in the municipal water you have a more constant supply but in the one-stream-wastewater you have the risk that there is not, okay. Ehm. Did the production or installation-cost raise with the use of innovative technologies considered for the processing of RE-PLEX? Or bio-polymers?

108 E3

109 That I don't know. That might be a question for NPSP.

I1
Also not for Kaumera?

E3
[39:15] But for Kaumera that is the only – there is no reference-process there for the process to make Kaumera. So we have one process but nobody else. There is a dedicated process for Kaumera so it is difficult to compare.

I1
Ah, okay. But you needed to install new technologies for this?

E3
Everything is just for Kaumera so, yes.

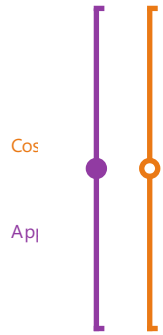
I1
Ehm, and what makes this recovery –process more costly, or is it more costly than conventional production-routes? And for glass-fibre-polymers, do you think it is comparable?

E3
I don't know that I am sorry.

I1
ok

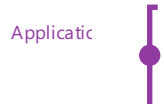
E3
What would be comparable is the resin of the RE-PLEX because Kaumera is not the resin, so you better compare a polyester or epoxy – that's the better comparison – the market price to these Resins.

I1
Ehm, the Urban Integration, would it be a relevant spatial advantage for the Compro-project, if the cooperation-partners would be situated spatially situated next to eachother?



E3
Yeah, ehm yeah, for the Kaumera there is always an advantage when you keep it next to the wastewater-treatment plant and that is because eh, there is a during the extraction of Kaumera, so the sludge and the wastewater […][42:14] and that contains a lot of water ehm and most of that water is removed during the extraction-process eh that means that the total amount of sludge is larger than Kaumera so transporting it in a transporter is costly so you want to be near to the supplier, so near to the wastewater-treatment-plant. Ehm. This creates kind of a challenge because there is a lot of small-scale wastewater-treatment-plants and Chaincraft is not able to have extraction-operations next to [42:50] each plant, but generally speaking because you don't want to carry so much water around you want to be near your supplier.

I1
And this is for the step between the wastewater-treatment plant and Chaincraft and do you think it's the same for the step between Chaincraft and the drying-factory for example? Or is it especially that huge amount of water that makes it so ehm.



E3
yeah, there is still a huge amount of water in the Kaumera ehm and there is a cost of transportation that we need to carry but Chaincraft may yeah, to the drying company

but yeah, I think the scenario would be much more […43:50] that Chaincraft is also drying. So we hopefully dry ourselves. Basically we dry on the Kaumera-site.

134 I1
135 So ehm, now the product-questions, which maybe are more direct. Where do you see an added value of the RE-PLEX for Chaincraft?

136 E3
Developm
137 Eh, hm, for Chaincraft? I think it is a very interesting material, there is also a lot to be discovered about the material in general. But that can open in a time a lot for Chaincraft, so that is very interesting.

138 I1
139 Ok, thanks, eh, the market-scale, in which amounts RE-PLEX needs to be generated to make it economically valuable for you for Chaincraft?

140 E3
Scale
141 45:00 Ehm, well I don't […?] but yeah, to give you examples, the installation in Zutphen at the water-authority Rijn en IJssel that generates around 300 tons of Kaumera.

142 I1
143 Per year.

144 E3
145 per year, yeah.

146 I1
147 Ehmm, yeah, ehm, could you imagine, because we already talked about this connection of different companies and ehm could you imagine Compro to be applied in a bigger urban scale, in a symbiotic network of companies?

148 E3
149 I am not so sure if I got the question.

150 I1
151 Ehm, because this is kind of a symbiotic relationship between the wastewater-treatment-plant and Chaincraft and then NPSP and could you imagine for example that a wastewater-treatment-plant is the center, and then the companies are located around it or in a bigger urban scale for example in HavenStad or… [46:30]

152 E3
Applicatic
153 Yeah, so it's almost like the wastewater-treatment plants becomes like a bio-refinery, yeah I think definitely this is also like a way we should move, because there is a lot of resources extracted from a wastewater-treatment-plant. [47:00] and maybe we have to extract that.

154 I1
155 mhmm okay. Thanks, ehm – technological aspects – are there any technological difficulties in the production-process of Kaumera? Or RE-PLEX?

156 E3
Cos
Env
157 Ehh.. are there any technological difficulties in the production-process? Yeah, for the RE-PLEX I think there are but I leave it to answer that to Npsp, eh, Kaumera […47:45] yeah, there is always technological difficulties, yeah, but we also when we put is more into a more economical perspective there is a lot of water in Kaumera, so that is the main cost I think. And the chemical use in the extraction is high.

158 I1
159 Or the most important for now for which applications do you consider the RE-PLEX most useful?

160 E3
161 [48:40] Ehm, yeah, I think eh we should understand the added value of the RE-PLEX to the consistent […], – I think with the biodegradability it ends pretty fast. So we should use it in applications where that is an added value. I am not sure about something concrete in that sense […] but you also could dig them out. And if it stays in the soil it degrades over time, I think that could be of added value.

Applicatic

162 I1
163 Ok, so the bio-degradability, yeah is

164 E3
165 Yeah, then the durability is something I am not to aware.. [...50:00] where you can have an added value. Where your performance for that particular property is better than the current.

Product pe

166 I1
167 Ok, thanks, ehm do these applications require certain properties RE-PLEX might not be able to fulfil?

168 E3
169 Applications?

170 I1
171 Yeah, the applications meant by ehm well, you mentioned the applications underground ehm yeah, maybe there is something that RE-PLEX might not be able to fulfil so far?

172 E3
173 ehm, yeah, [laughing] there is a lot of questions where we want to find the RE-PLEX there is a lot of opportunities where the RE-PLEX is not yet being able to fulfil […51:40] because the strength or the durability. I think it may attrackt water, but I am not sure. My main concern is the combination of the RE-PLEX and moist. […] I think that will all decide on what kind of applications to use it for.

Product pe

174 I1
175 Yeah, of course and do you consider RE-PLEX more useful for temporary or permanent constructions so far?

176 E3
177 For this moment in time – temporary. I think that permanent is something that can […] over time. But I would start with temporary constructions.

Applicatic

178 I1
179 Okay, thanks eh, for those insights ehm, which logistic infrastructure do you need to organize to supply the Kaumera, I would say.

180 E3
181 Ehm, the recovery has to be mentioned so the wastewater-facility is becoming a supplier of the product ... to Npsp for this some facility […53:00] there is nothing that is pretty straight-forward.

182 I1

183 And ehm yeah, it's transported by trucks, or…

184 E3
185 yeah, so typically for the scale we are thinking about big packs – so it's a bag like 1m x 1m.

186 I1
187 A: Okay, ehm, maybe this is a bit difficult questions, or easy to ask, difficult to answer. Which process-costs are connected to the production of RE-PLEX.

188 E3
189 Yeah, materials and energy, and labour, […] [53:55] a bit of maintenance, these kind of things but yeah.

190 I1
191 Mhmm. Ehm, which quality criteria the product needs to fulfil to be competitive with conventional products for example glass-fibre?

192 E3
193 And there we are talking about Kaumera or the RE-PLEX?

194 I1
195 Mhm.. more about the RE-PLEX, because there in the product-performance it is more about the end-product I would say.

196 E3
197 Okay, yeah, I think this is also highly depending on the application you are looking for and what is the reference-material there, ehm, but at this point NPSP and BAM have a better idea.

Apl
Uncertainty (+)

198 I1
199 Okay, and if you think for example of a bridge or… but this is more probably can be said by NPSP yeah, or more even BAM Infra.

200 E3
201 Yeah, personally I would tell you there opinions a bit more than my opinion because of their perspective.

202 I1
203 Okay, which functions the RE-PLEX does not fulfil so far but need to be fulfilled?

204 E3
205 […56:00] I am not so sure what to say but I think it is the strength.

206 I1
207 And do you perceive the bio-degradability of the RE-PLEX more as an advantage or a drawback or it depends on the application as well right?

208 E3
209 […] yeah I think it depends on the appication, if you can use it as an advantage, and otherwise, if you want to build a bridge it's a drawback obviously but maybe for that reason we don't want to build a bridge, but something else where the biodegradability is not […] I think the whole bio-degradability in the end is about how fast it bio-degrades and how long the product […]

Unc
Apl

210 I1

211 Now, we are quite fast, the customer-satisfaction, what do you personally expect from a product ehm, which consists of rest-materials?

212 E3
213 What do I expect?

214 I1
215 Is there something that you ehm, that you would expect, when you wouldn't have so much knowledge already?

216 E3
217 I think that's the bias.

218 I1
219 yeah.

220 E3
Circularity
221 I don't expect too much other than the product to fulfil its function – that's what I am buying it for. If I know that the bio-degradable product is the offer if it has multiple environmental issues associated I am willing to accept less performance, to a certain extent.

222 I1
223 Okay, in which product-application do you think RE-PLEX would be most accepted and why?

224 E3
Applicatic
225 Ehm, yeah, that is a very specific question. Yeah I think ehm, it's easiest to […59:40] but maybe something that is not very visible?

226 I1
227 What did you say? Visible?

228 E3
229 but this is not necessarily but generally we are doing some work in the building-sector, outside from Compro, outside from RE-PLEX. […01h] Also not for this material. Cause this type of polymers is mostly B to B. So there is not of sales procurement directly.

230 I1
231 But what is B to B?

232 E3
233 Business to business.

234 I1
235 ah ok

236 E3
Product pe
237 I mean in the building-sector people are very conservative but also very willing to try. But then try it somewhere where it's save there is not such a big construction like some wall so if it falls over of nobody cares. So indeed it really depends on the kind of application the requirements I would say […]

238 I1
239 Ehm, is Chaincraft working on technological strategies to overcome certain safety-risk or doubts about the RE-PLEX?

240 E3
241 Sry, what did you say?

242 I1
243 Ehm, if you as Chaincraft are working on strategies to overcome certain safety-risks about the RE-PLEX connected to Kaumera?

244 E3
245 Ah, if we are working on these issues? Ehm, yes, I would say yes, but I think most of the risks that are associated with sludge they deal within the extraction-process, which is performed by the […]? 1:01:50] so we are involved also in designing the management of the processes which we do with our partners so Royal Huskoning, TU-Delft, […] but it totally depends on the application on every case. So we have to investigate how we can control these in the Kaumera.

Uncertain

246 I1
247 Ok, thanks and as a manufacturer do you feel responsible for the safety of the end-product and if so, in how far?

248 E3
249 Yeah, so definitely in respect to Kaumera, so I would answer this question for Kaumera, so we definitely feel responsible for that. In what way the responsibility? […] I feel responsible for the guarantee that this product is […]

Dependei

250 I1
251 yeah, and there are also always different impurities right in the wastewater-streams?

252 E3
253 yeah, the impurities, that everybody agrees with they […]

254 I1
255 Ok so you can somehow proof if those with high risks are there or not?

256 E3
257 yeah, so the wastewater-treatment is already a barrier in the line because in the wastewater-treatment most of the bacteria are already degraded. In that sense the specialist say that the material with heavy metals they cannot accumulate some stuff. […] and that's not always the same but [...]

Product pe

258 I1
259 Ok, thanks, last but not least, there are a lot of environmental advantages of the RE-PLEX and do you also see any environmental risks connected to the RE-PLEX?

260 E3
261 Ehm, not necessarily, I think that they suspect a little bit to the question about the regulation of what is waste […] there is a risk of an accumulation of certain toxic components. And it's exactly this accumulation that they want to prevent. I do not necessarily see the risk of RE-PLEX also because the source is very defined because it comes from a wastewater-treatment where everybody can see where the wastewater […]
262 This is much more an issue for example when you recycle plastic-bottles, you have the same plastic-material […] but in the RE-PLEX that is not the case so I think it would fully degrade by the wastewater and by the biomass so the cellulose fibres the risk is not there necessarily. [...] And then at the same time we have to prevent this kind of...

Product pe

Applicatic

I1
Ehm, cool, thanks so far, is there anything that has not been considered so far, that you would like to mention?

E3
Nothing that comes to my mind. […][1:07:15] concerning this question of acceptance of Kaumera in the market, we are facing this question a lot… but my experience is[…] Yeah, you had this one question about the bigger urban scale? […] but this is more of my personal vison that I think […] you have a central plant in all kind of regions […] so you can recover the carbon before Kaumera and you can transform the phosphor into struvite and than you can recover the phosphor. This is also a vision I know from the water-authorities themselves. And they have organized themselves of what they call Energie- en Grondstoffenfabriek I don't know if you have heard about that?

I1
No, maybe because its Dutch but would be interesting to see.

E3
I will quickly send you the link to the website. You are german right?

I1
yes, I can translate it as well in google-translate that's no problem.

E3
That works well?

I1
yeah, that always works I mean, it's similar, so it does the job quite well.

E3
I send the link in the chat as well.

I1
Cool

E3
To the water-authorities and do you know how the water-treatment in the Netherlands works?

I1
Well, I know that it is quite centrally organized through Waternet.

E3
So you have Waternet which is a bit of an exception because they do both the wastewater and the drinking water and they are the only organization in the Netherlands who does that and the drinking water I think they are… and the water-authorities are under the government – so they are governmental bodies. I think it is slightly different from the biggest part of the world. And they are actually the oldest governmental bodies in the Netherlands. And they do everything related to water, almost everything.

I1
And is there anywhere a list where I can find them? I think I can google them I wasn't sure about it actually.

Interview E4

Did physics at the at the University of Twente in Ensredde day after this I went to Eindhoven Technology Management, then I worked in the energy sector with eco fiets, renewable energy and assessment studies on this, then became a director of the in Amsterdam under the municipality to stimulate energy renewable energy within the municipality and from 2005 on I work, I'm now working at Waternet, as a strategic advisor and in the field of sustainability, social responsibility, co2 emission reduction and also I coordinated the innovation program of Waternet and at the moment I am focusing on thermal energy, circular economy aspects and international possibilities for cooperation with New York, Berlin, Copenhagen and Paris and Singapore.

I1 1:17
And

E4 1:18
yeah. And so yeah, and now I am working in the field, just had a call with Stowa. I don't know if you know what that is. It's the research. They are coordinating the research of the water boards. And I'm also involved in this same program on circular economy for the drinking water sector. And so yeah, that's what I'm basically doing at the moment.

I1 1:52
Yeah, seems to be very comprehensive. Yeah. Good fitting for this information, interview. And yeah, and how do you see the position of Waternet in relation to the Compro-project?

E4 2:15
Yeah, during the time I was, was coordinating the innovation program of Waternet on circular economy and on co2 emission reduction. What I saw was that the water sector and also Waternet itself was doing a lot of research. But there was no focus on the outcome of the of this research. And what I started to do was more thinking in the perspective of innovation-tunnel, that means that you can do in the in the beginning, you can do a lot of research, but you have to focus on what kind of outcome you're working on. And that's why I also stimulated If you start with research, bring in also the knowledge sector that can be a university, but it can also be a research centre. But also think on on the market. So also work, bring in market parties. And that's all why we went also working on biomass and biomass upgrading. From that perspective, I also know NPSP, we also looked together with Npsp, what they need for, for producing products, and what we can deliver as a resource. So if this perspective, you see, that's also the people from Waternet, they not think eh say okay, we have biomass. So, if you want it you can you can have it, but we are more thinking market party or Npsp if you want to make a product, what quality do you need and what quantity and when do you need it and by answering these questions, you see that also our focus was becoming more different and related to the Compro project or better the Wascom-project and before there we had also some eh or what was the name of it more this also bio products from Npsp. We saw that we can bring in cellulose and but we are not very close to this project and that's now called the Compro-project because cellulose is not a core resource or waste material we collect. You have some problems with the cellulose collection, which still think biomass is is interesting and one of the top five focus areas of the energy factory resource factory. Maybe that's sounds familiar to you the energy factory research factory?

I1 5:32
Not exactly this, but I Well, I am familiar to this prioritization of which, yeah, which sources to recover or which resources to recover. And so it would be interesting to know what what are the highest priorities right now for Waternet to recover resources?

Applicatic

Product pe

Competiti

E4 5:58
that's also the top five. All the water the regional Water authorities to work together in the energy factory research factory and they have a privatized the top five of waste streams which we'd like to upgrade to resources and biomass is one of them. But also phosphorus is an interesting product and now we also focused on nitrogen as a big problem for co2 emission reduction or, and also possibility and there's there we also work together with the University of Delft to see if you can also make or energy or other products out of it. So these are the focus points.

I1 6:54
Yeah. And yeah, I think this is very specific by maybe also meant should be mentioned at another point of the interview. But maybe we can come back to it with the Yeah. competition of phosphorus against for example alginate or something. But yeah, I think phosphorus is not competing with the Compro-product, right? So you can also filter phosphorus or struvite. Yeah. Next to alginic acid.

Competiti

E4 7:33
We are not focusing on alginic acid. So for us, it's no problem at all you need the. I think you need a Nereda wastewater treatment for this, right?

I1 7:48
Yes, yeah. Oh,

E4 7:49
yeah. We don't have a Nereda facility at the moment.

I1 7:54
Okay. Um, yeah. What do you consider as social advantages of the Compro-project?

E4 8:01
a lot of social advantages, I think, if you look at the possibilities and the quality of the product and what you can do with it, then I think there are only advantages of this project. I don't see really some disadvantages.

I1 8:34
Okay. And, economic advantages of the Compro project.

E4 8:43
Yeah, that depends on what the price will be of the products of course. Maybe you can mention it here, if you look at the website of the municipality of Amsterdam, they have a very ambitious programm on circular economy I don't know if you if you've seen this but if you're looking at these ambitions and these ambitions are also ambitions which are which are the ambitions of Waternet and the Regional Water Authority of the region of Amsterdam with I think in a in coming years also the ambitions of the all the water authorities in the Netherlands then I think there will be there will be a kind of price indicator or also the damages of materials will also be taken into account in the price of a product. And then I think this will help the Compro project or the material which is produced let's say RE-PLEX will help to make it easier to come to the market. So, yeah, if I have to say more about the economic advantages, yeah than I have to know more about the quality of the product and also Yeah. More about the aspects of this of this project. What I see is that less primary energy consumption but I think all the, the advantages on on the aspects of yeah, climate change, but also on sustainability this will help to make it a more interesting product.

Costs

I1 10:41
Okay. I will skip the risk question.

Scale

Competiti

Uncertain

Legal regu

33 E4 10:46
34 Okay about risk question. I can tell you a few things about this. The risk is probably what is needed is that it's people have to know the products and they have to know the disadvantages and they have to know, what are their hazards. So are there people have to trust the product, they have to know where it's coming from a risk can be that you have to be sure that you can produce enough of this product. And so that's a risk. And at the moment, yeah. You if you work in a chain at the moment that the market party asks for, for products from out of biomass, you have to produce it.

35 I1 11:43
36 Yeah.

37 E4 11:45
38 And people have to accept it. So this is also a social aspect as well.

39 I1 11:50
40 Yeah. Okay, thanks. Yeah, does a wastewater recovery strategy like Compro, that is connected to a network of different stakeholders involve any operational difficulties for you?

41 E4 12:13
42 Operational communication, what do you mean by this by operational difficulties? The people in the wastewater treatment plant they have to know what where it is needed for. For Waternet, the focus will be on celluose I think. And what we see is that at the moment it's not a trigger another yeah not a focus point to catch all the cellulose out of the wastewater. So what is needed is that there has to be a believe that the cellulose is needed for this product or if it's another waste stream and it has to fit in the total overview of what kind of waste do we need? And why is this specific waste product? Is it that you feel that we have to focus on this waste product instead of other waste products?

43 I1 13:30
44 Okay, but like there is not such a big difficulty that there are so many stakeholders connected to this project. Do you think that other for example, recovery strategies also are connected to a network of stakeholders? So, it's not the special risk for for Compro?

45 E4 13:52
46 No, I don't think that is specific rule. We have that's not a problem. I think the most important thing is that people have to know what, what Compro is and what they can do there has to be an urgency without stakeholders.

47 I1 14:14
48 Yeah. Okay. And yeah, is there any political regulation that is preventing the Compro-project or which political regulation is the most preventing one for Compro?

49 E4 14:33
50 Yeah. At the moment. I think it is important that our what we need is and that's what we see also with phosphorus. There has to be a legislation which says that makes it easier for waste materials to upgrade to materials, and that's a big problem at the moment if you have the label of waste, and it's very difficult to make materials out of it.

51 I1 15:22
52 Okay. And is there anything that Waternet could do to make this yeah or like any political guidelines that make more or less risky, the whole project.

Policies

53 E4 15:41
54 I think you have to use the municipality of Amsterdam because for the municipality of Amsterdam, it's important that circular economies is going to work and therefore they can do a lot in this lobby tryact and also the connection with the regional Water authorities they have and within this energy factory research factory. There are probably you can use the knowledge which is which was gained by under the phosphorus project.

55 I1 16:25
56 Okay. Um thanks. And yeah where do you see the financial benefits in selling a product from your wastewater streams or the wastewater streams of Waternet?

Costs

57 E4 16:39
58 Eh financial benefits, ehm the financial benefits yeah, in the end it would be great if we can say that from our waste streams a lot of products are produced or it is again used as a resource in the most beautiful dream is that people have to pay less for their wastewater because a lot of this waste it gives us a financial benefit so we can lower the tarrifs of wastewater. But in the end, eh I think we have to come to an other financial mechanism in which we also incorporate the, the disadvantages of our products. And so that's more the pollution of a product, bring this into account in the price.

59 I1 18:10
60 Okay, so integrate,

Circularity

61 E4 18:13
62 Integrade yeah do integrate cost price or you have a lot of differences and a lot of different price mechanisms. The you have to I think this is maybe a lifecycle analyses helps in this. But I think this is one of the important things. And what we see now at Waternet and also at the municipality of Amsterdam. In our procurement we see that there's also a benefit for renewable products more than for the projects we will waste a lot.

63 I1 19:01
64 Okay, um, yeah, okay. Ehm the urban integration is the second bigger part of the interview. How do you imagine the urban integration of a project such as Compro?

Applicatic

65 E4 19:23
66 Yeah. The urban integration is I think it depends on the, if it's known, if the product is known, and it helps that it's known by the people of the.. but yeah you can say the buyers or of the those who by the product they have to know that this is a project and they have to know the benefits so they can bring it into the procurement aspects and then it will make it easier when for this kind of projects when it's tendered or whatever.

67 I1 20:32
68 Okay.

Circularity

69 E4 20:33
70 I think Yeah. Eh if you if you see a project and it is known, and you know the aspects of this product, then I don't see why it will not be used. And what can help is there is a kind of a system that you not only selling a product and people are buying it. But there can be a kind of a cycle brought into it. So if the product is not needed anymore, it can still be reused again. So look at the nine R's and it's part of this nine R's and it'll help a lot.

71 I1 21:27
72 Okay. Yeah. So for example, if you have a bank constructed out of RE-PLEX, you can digrate it or put it back into the cycle.

Applicatic

E4 21:39
Yeah, if you use it in houses or whatever, if it's easy, if it's not if the Compro or RE-PLEX, but what's the name of the product is if it's not polluted with other materials so it can be easy to reuse again, then I think it helps a lot to for the urban integration.

I1 22:06
Yeah. And the next question I think I can answer by myself. Yeah. Are there other wastewater recovery strategies that are competing with a project? I partly can also answer it by myself, but it's good to have your opinion.

E4 22:33
That depends on what we have to do for this project at the moment. If you look at the streams, which are needed to produce a Compro then Waternet at the moment can only deliver cellulose I think right? So what is needed that is that in the end, we just tendered a new wastewater treatment plant and what we saw was that the Nereda was not the one where which was chosen for. So there was chosen for another wastewater treatment concept. So what is needed if you if the Nereda or the products out of Nereda are used for Compro, then yeah, we should all use the Nereda concept, right?

I1 23:30
Mm hmm. Yes. Was it a special tender selection or where was it deselected the Nereda technology?

Costs

E4 23:42
It was a I think in the top three, but at the end. There are a lot of advantages for the Nereda project. But in the end, it was too expensive, I think.

I1 23:54
And was it for a specific product or?

E4 23:58
Eh, it's a wastewater treatment project in Weesp that's close to Amsterdam and it's for I think 40 50,000 people inhabitants.

I1 24:12
Okay. And which was selected then?

E4 24:17
I have to look at the website. I'm not in this wastewater treatment fields but i think it's on the Dutch website somewhere I shall look at wastewater treatment waste.

I1 24:36
Okay. Yeah, if you find it you could send me maybe the link would be interesting. Yeah.

E4 24:47
Are you familiar with Dutch or maybe you can translate it very easy to, to English I think eh?

I1 24:57
Yeah, and I can and also to German. I mean, yeah, it's I understand Dutch a bit, but it takes me some time.

Competiti

E4 25:09
Yeah, I will ask my colleague if he has a presentation or some slides with you because you want to know why it was choosing for. It's called the ICEAS system. I don't know if you're familiar with that. Yes.

99 I1 25:33
100 ICEAS. I think I'm not familiar yet. But

101 E4 25:39
102 I will send you some, some, some links on this.

103 I1 25:46
104 Thanks.

Competiti

105 E4 25:47
106 And and is it competing? Yes, if it's a we are looking at not only the last year we were looking at the co2 emission reduction. So this was the most primary focus area but now we are also focusing on what are the what are other polluting aspects? So it's not I don't think it's competing with something.

107 I1 26:16
108 Okay. Yeah, do you know and how far the project is combinable with other recovery strategies?

Pro

Developm

Competiti

109 E4 26:29
110 It is combinable. What you need is the time to market what you need is. If you want to make a product out of it, you need the right quality with the and the right amount on the right time. And so then a market party knows what they can produce but also the buyers of the product they know when they have a product. So I think if you are sure about this. Yeah, I don't know what other kind of products are becoming more interesting. They can be becoming more interesting because they are cheaper or it's easier to get in. It's easier in use or. Yeah, it's easier to to make other products out of it. These are the most interesting, important things.

111 I1 27:38
112 Okay. Thanks. Um, yeah, and then the Nereda technology is a centralized method. And is there a tendency somehow to decentralize more. Eventually, the wastewater treatment or is there any tendency towards decentralization or centralization?

113 E4 28:04
114 Within Waternet, you mean?

115 I1 28:06
116 Yeah.

Applicatic

117 E4 28:08
118 Yeah, at the moment we have a centralized system and the wastewater treatment plant of Amsterdam for 1 million inhabitants. We are now also focusing if it's possible to make more decentralized wastewater treatment systems. Maybe if you have heard about Strandeiland, it's an island in IJburg in the water and for 8000 houses and what we trying to do is see if it's possible to install a new sanitation system in which we separate the waste the black water from the grey water. So we separate the water from the toilet and also maybe the food waste the grinder and then buy a vacuum system we can concentrate it and we can we can treat it locally.

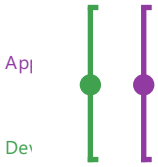
119 I1 29:08
120 And vacuum toilet system, right?

Applicatic

121 E4 29:10
122 Yeah, vacuum toilet system. Okay. You have to concentrate waste and if you have

concentrated waste, maybe it's easier to upgrade to water stress or to energy or to other valuable products. And so if you're asking it's not a strategy at the moment, but we are working on some projects. So we on an innovative scale of 8000 people and supposed this is going to work then this can this means that there will become more and more decentralized wastewater treatment plants.

I1 29:59
okay. So also if there's a new urban development like for example HavenStad and then you would probably prefer decentralization if you built new



E4 30:14
At the moment it is not it's just not in our strategy to build a new decentralized wastewater treatment plant in HavenStad but I can imagine that we are not only looking on only 20 years but also for 50 and 100 years that we are designing the concept of HavenStad that it can also be in the end in let's say 30 or 40 years, it can be a decentralized system.

I1 30:51
Okay, and could you also imagine that Compro finds its application? Sorry. Did you understand?

E4 30:59
What do you mean? By this.. can you can you ask the question again?

I1 31:04
If Compro can somehow be applied in this strategy or in HavenStad.

E4 31:11
yeah I think the more the more promising Compro is and then it helps in our decision making for building wastewater treatment plants, which can also produce Compro. Is that what you meant? Or do you meant Compro also to be used to build the wastewater treatment plant?

I1 31:43
Um, no, I meant more like the urban integration like, yeah, to implement the project or to Yeah, apply the project to the urban realm somehow like how you would imagine this. Yeah,

E4 32:02
What is Compro? Compro is a material or is Compro is also the is Compro also that you need kind of a wastewater treatment plant which produces materials or resources which can be use for making Compro or.

I1 32:32
Yeah, well it's on the one side it's the product the RE-PLEX like applying the product to the buildings, for example, in the urban realm. This is more the practical side of Compro. And then there's this. Yeah, this. I mean, it's a project where many stakeholders are involved and this like yeah, there's the wastewater treatment plant and then there's the Chaincraft who develops the Kaumera the glue and then there's Npsp that combines the cellulose with a glue. And then there's the BAM Infra like an end user which produces the end product. And this could also be kind of cooperation symbiotic cooperation in the urban real. Yeah. This is a very like this is more the abstract. Yeah, kind of application to the urban realm of the project itself. That Yeah, maybe a bit too early as well.

E4 33:45
yeah, what I can say about this is that we need to know of people need to know people

Uncertain

who are the coordinate procurement or the coordinated tendering within HavenStad they have to know what are the what are the specs of this Compro product? Is it about this? Yeah, what is it? It's the the bio-composite it's light, it's a fire resistant and a couple of specs onther specs. If you know what these are, then it's easier for people to use it. And if you if people know what it is then within the tendering there you can you can describe it in a way that the Compro product can be one of the top three or five products which have to be used.

I1 34:59
Okay,

E4 35:00
Therefore, if you look at the strategy of the circular economy of Amsterdam, maybe you have some you see some connections with this question. Yeah.

I1 35:09
Okay. Yeah, we already in this product-realm. So, now we come to the product part. Yeah. A bit more maybe more concrete. And where do you see the added value of RE-PLEX?

E4 35:25
The added value, ehm...Is there a list of what are the

I1 35:33
Yeah, we can jump

E4 35:35
Ah, durability, weight, viscosity, resistance to water, UV, chemicals, not flammability and biodegradability. Is this is?

I1 35:44
Yeah, that's, like some product properties. And when we answer this question, we can already maybe fill it out. Yeah. How do you perceive the importance of the different properties?

Circularity

E4 35:58
Yeah, but yeah, To start with the product, I think in general, if it's if it's renewable if it's the pollution index is very low if you look at the lifecycle analyzes and RE-PLEX is scoring a high value on circularity than I think there is a big added value.

I1 36:29
Okay. And is there a mini minimum market scale that the RE-PLEX or Compro needs to reach to be valuable for

E4 36:39
I don't know, I don't know how it is produced I don't know what quality is and where you can use it for so what the price will be. But I think also you have to look at the back side of this, of this project, how much resources do you have how much materials can you deliver? So, RE-PLEX can be produced.

I1 37:08
Okay.

Applicatic

E4 37:10
And yeah and if Nereda is the core aspect yeah then you have to look at this point and then yeah, we have to build more Nereda installations. Waternet is, is better said I told you working together with other bigger water organizations in metropolitan cities. So

Applicatic

what we can do is if you are not only talking about Nereda, but we are talking also about products which are which are produced out of a Nereda wastewater treatment plant, it becomes more and more interesting for water organizations to build Nereda plants

I1 38:03
Okay, yeah

Scale

E4 38:04
And it and it becomes more interesting if you also have it on a bigger scale but also on a more decentralized scale.

I1 38:11
Yeah. Okay. Good, thanks. And yeah, for which urban applications do you consider RE-PLEX more or most useful? There I think you already asked what possible applications are there they would be for example, facade-elements of buildings or Yeah, the piping system because it's biodegradable. So, if you are constructing something and you need a temporary piping system, you can keep it in the ground and degrades itself so you don't have to get it all out of the ground again. Or you also could use it for temporary constructions. Yeah. Do you see any application that is makes more sense for you in that way.

Scale

E4 39:19
That depends on the characteristics of RE-PLEX? Yeah. And if you can be more specific on what the characteristics are then we can see what connections we can make. Yeah, what kind of products?

I1 39:39
Yeah, I think maybe it's a bit too spontaneous when I tell you know, what are the exact properties but it's it is biodegradable and non flammable. And yeah, it's very lightweight and durable as well.

Uncertain

E4 40:01
Yeah. And what do you mean by bio-degradable? If it's biodegradable within 20 years, then it means to be it's just not it cannot be used as, as in a sewage system because the sewage system has a lifetime of 50 or maybe 100 years. Yeah, so that has to be clear.

I1 40:22
Yeah. Yeah, I think this is filled up with the unclear how, durable in that sense it is. At this time. And yeah. And now we are at this table. Maybe we can quickly fill it out together. So, which property of the RE-PLEX do you consider most important for an urban application? Like, first, durability? Is it more important or unimportant for you?

Uncertain

E4 41:00
Of course, durability is very important, but that depends on what kind of lifetime are you looking at? Is it a 10 year lifetime or 20 or 30 years? Yeah, that's that depends on the specific purpose of this of this project.

I1 41:21
Okay. But you would say it's important,

E4 41:24
it is important. Yes. Yeah.

I1 41:26
The weight more.

189 E4 41:30
190 Yeah. that most of the time, the weight is very, very important aspect, especially if we look at the urban environment. And if you use it in the, in the transport sector, then weight is a very important thing. If you want to use it, in the building perspective. If weight is also Yeah, it's important and looking at your schedule. It's I think it's yeah. So depends on the purpose it's important or very important.

191 I1 42:14
192 Mm hmm. Okay. And the viscosity?

193 E4 42:19
194 What do you mean by the viscosity? In what perspective?

195 I1 42:26
196 Ehm if yeah, the the product is more brittle like breaks or is very expandable and like, yeah,

197 E4 42:39
198 Yeah. Okay. Yes that depends on the... and I know viscosity from more liquid products, but that depends on the purpose if sometimes you need a very flexible material and sometimes you need other perspective. Yeah, I don't know what yeah, that depends.

Application (+)

199 I1 43:10
200 Okay. And the is resistance to water, solar or chemicals.

201 E4 43:18
202 Yes. in our, in our branch in our sector, it's these are very important aspects.

203 I1 43:27
204 Okay? And the non flammability

205 E4 43:33
206 It's most of the time also very important. It depends also on the purpose within an urban application. I think this is an important one.

207 I1 43:43
208 Yeah. Okay. And the biodegradability

209 E4 43:50
210 I'm neutral in this what does it say biodegradable if you can recycle it than biodegradability is not that important. If you look at, what time scale are you thinking of if biodegradable means you don't have to get it out of the ground again. So you don't have to ditch it. You have to know what the time period is. So sometimes it's not that important but in there are cases where in which it's very important.

211 I1 44:24
212 Okay. Yeah, thanks for the estimation. Now. We are at the customer satisfaction. Which criteria do you think need to be fulfilled primarily to reach customer satisfaction? If you for example, have a wall made out of the product and what are the criteria you think are very important?

213 E4 44:49
214 Just be strong material it has to be maybe flexible, easy in use it has to be, if you have to look at it has to be designed in an inspiring way. And an interesting design. Yeah. Maybe if it's easy, if you look at generations and you think of a period of 30 or 50 years, if it's easy to change things because of this material or to rebuild things or to renovate or to

whatever, then I think it's, it's it has a high customer satisfaction.

I1 45:42
Okay. Okay, thanks. And what are your doubts about the product originating from waste, or waste water?

E4 45:56
It has to be sexy. So if you if it's not sexy, then it's difficult to get it to bring it into the market, I think because people who are using this material. And yeah, they are not using the traditional material. So they have to be proud of the product. So it has to be a look at wooden buildings, it's still very difficult to to get them built because there's a lot of conservatism in the market and you see that only concrete is used and so you have to make it you have to make it very attractive, interesting product to use. Yeah. And yeah, if you look at the building market or the yeah, talk to the people of BAM, they are very traditional, very conservative. So, you have to you have to inspire this whole sector not only the BAM persons but also the installation sector as well to use this product, okay. And what can help is that consultancy firms like copper eight or who are the frontrunners in this field and look at architects who want to work with new products, they can help in the starting period to to bring this and if it's if it's if you're not using these kind of stakeholders, then I think it will be difficult to to bring this product to the to the market.

Product pe

I1 48:02
Okay. Um, so.

E4 48:04
Yeah, and smell of course is a very important one. Smell safety design. Yeah that these are products that will be easy and flexible and working. Mm hmm.

Product pe

I1 48:16
Okay. And yeah. Would it be different for you if the wastewater for this material would be from one waste stream like from a company for example, or from various waste streams from a municipality.

E4 48:35
For me as a as a customer, as a customer, and no more specific I hear where it's coming from, the more I'm maybe willing to pay but I think in the end, the most important thing it's that it is a sustainable material which is not wasting the environment. I think they are polluting the environment is more important than to hear to be specific. But I can think in the start if we if if Amsterdam or Waternet is can can be a front runner because they say we have a Amsterdam product, then it's sounds good and maybe this is an extra advantage to for this product.

Circularity

I1 49:36
Okay. Thanks. And they are we already mentioned some environmental advantages of the product and but do you also see environmental disadvantages of the RE-PLEX?

E4 49:56
Yeah, it is. It's coming from waste so the first step, what you have to do is that it's not waste, but it's a product. So it doesn't have to people don't if they see the material or the product, they they don't have to think hey, this is waste. Now, they have to know that this is a quality product, which is used for the right purpose and which is not damaging the environment, that it's recyclable. So you don't but you said before, you don't have to smell it. You don't have to see it. You have to be sure that you're not polluting the environment extra. And so if in your business model, it is accepted that it can be reused again, or upgraded and then I don't think don't think there are big disadvantages for the

product.

I1 51:08
Okay. Okay, thanks so far, and is there anything that hasn't been considered that you would like to mention?

E4 51:18
I think the more specific you know about the type of products and the qualities and the, then the more specific I can answer the questions and then I can also give more specific answers also on what kind of stakeholders can be involved or what Waternet as a, water-organization can, can do to help and to bring this further.

I1 51:54
Yeah. Okay. Yeah, that's always the thing of okay the product is not in this stage now that we exactly know everything. Yeah, we already need to have opinions and yeah.

E4 52:11
Yeah. That yeah if the more specific you are then it's if you know more about the product can also be very interesting to talk to urban designers of the municipality of Amsterdam to talk to architects to talk to maybe we have in the water sector, we have Aqua minerals, and what they are doing is maybe you have heard about Aqua minerals. I think Peter Mooij knows them as well. And they are helping to bring the waste streams to the market. I think this is also an interesting interesting party to interview.

I1 53:00
Okay, thanks. Oh, yeah, that's nice. Yeah, I think I would now finish the recording. Yes, it worked for me.

Interview E5

Municipality of Amsterdam

I1 00:11
Okay, now it's recording and you see me, but I don't see you, but that's fine. And so I would start.

E5 00:24
I think it helps the connection if I shut down the camera.

I1 00:28
Yeah. Yeah. Perfect. Um, so you are there still right? Yes. And yeah for how long are you in your position within the HavenStad project in the Gemeente? Now,

E5 00:50
I think a little bit more than a year like 1.5 years. Mm hmm.

I1 01:00
Yeah, we just start with a conceptual part and some general questions. What do you consider as social advantages of the Compro-project? Oh, yeah.

E5 01:18
Circularity
As far as I know, the product which is very limited, is that you make better use of residual products like we consider now residual. And maybe if it's also visible again, in the public space or in interiors or in materials that people experience every day, and they know what is made from then it also adds up to the consciousness about a more circular society. Mm hmm.

I1 01:51
Okay, and do you also see any economic advantages of the project?

E5 02:02
Maybe it's an example of how we can I have no insights in the business case of getting something out of the waste flow and making something of it. So I cannot it could be an advantage for yeah, for Waternet, if they have business cases on not only treating water and making sure it's not a purifying but also that they can widen their amount of activities to producing products producing energy. So they have multiple sources of income. But I cannot say anything about the business case of that because I have no insight into their money flows.

I1 02:54
Yeah. And so you feel like this is more question that Waternet could answer and you are you don't know exactly you would need the scale for example or other parameters to answer this question probably. Okay. And then I continue with the planning and organizations. To which extent the Gemeente can plan or influence the organization of a concept that is connected to a network of different stakeholders like the Compro project.

E5 03:42
Pol
Apl
I'm not sure if I understand the question well, but in the current phase of the ideas and the products that you could make of it I see the Gemeente, probably as a launching customer, because we have no role at this moment in the purifying cycle so all the assembling of the raw material and the processing it's into new products that's out of our scope. So to say I think we can stimulate it with Yeah, providing maybe some subsidies or help to start up that process but it's mainly the process of Waternet that it's concerned that. We could for example if the products have been tested or need to be tested, we could provide like pilot

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locations to, to use them in a public space. Because what we use in public space because what I understood from your story before it's thinking about like making benches or tables or furniture for public space, for example.

I1 05:00
Yeah, that's one possibility. But yeah, it's kind of like now they say that it's more for temporary and interior constructions, because the waterproofness still not that developed. So, yeah, it could be also for example facades, house facades or insulation material. Or, yeah, these kind of or temporary enforcement's for constructions or things like that.

Api

Pol

E5 05:41
I can understand that we then maybe if we have a temporary building in an exhibition or whatever we can use the product or yeah lend our project to this cause of testing it. All the buildings in the city are not made by us. And we cannot describe what builders should use, we can at least describe how sustainable it should be like which criteria, like there we have some influence. But I think we will never go as far as we prescribe a specific material because that's really up to the markets. And that's good because they're the innovation takes place faster than, like, if we describe all materials we we want to be used. Yeah, we are way too slow compared to the market.

I1 06:34
Okay.

Policies

E5 06:36
We all that sounds negative, but we always try to ask for the goal and not the means.

I1 06:46
Mm hmm. Okay. Because all the processes are too, like the Gemeente is too big to coordinate all those processes?

Dependei

E5 06:58
No we are not we're not a party building some buildings we are making because we have some municipal buildings of course but most buildings are not made by us. And it's up to the market to fill in the question like we want the building or are we allowed to build something somewhere so we can say some demands or get on, ask some specific qualities to meet our quality levels to meet but we will never say you should use this product specifically. Because that's not our role. Okay. We ask people to realize a goal and not not a specific element.

I1 07:44
Okay. And this would be a bit different for public furniture, for example, for benches, or is there like.

E5 07:55
Yeah because that's eh

I1 08:01
Sorry.

Api

Api

E5 08:04
Yes different because they're we are the ones building or hiring parties to build our public space. And the thing there is that it should be highly standardized so we can reuse elements in other parts of the city when you refurbish and also to have efficient processes. So the before it becomes a product that's used in Amsterdam, it should be really tested and proofed and also, like, be sure about weather conditions about your ability, or about how easy it is to replace. So I think

on the short term, it will not be part of that. Yeah, book of options, book of furniture. But yeah, you might find a location in Amsterdam, where we want to touch some new products. So that could be, but before it's really a large scale used product, I think. Yeah, it will take a while.

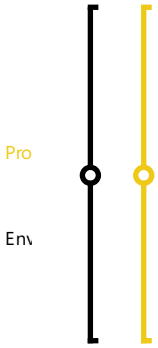
I1 09:11
Okay. Thank you. And now some political questions. Ehm, which political regulation do you perceive as the most preventing one for concepts such as Compro. So, yeah, is there any political regulation that is, again,

E5 09:38
I'm not entirely aware of it, but what I know from what is a political regulation

I1 09:52
and, sorry, I think,

E5 09:54
like regulations or political elements? I think those are not together.

I1 10:00
More regulations. So yeah, regulations from the Gemeente for example. Yeah.



E5 10:10
I think like in the food chain, you of course have the issue of waste getting into the food chain again, which is for logical reasons not easily possible. But with furniture, it's probably I cannot answer this like, completely but what I guess might be a problem is if you use it in public space, that's elements leak out and get into the surface below or into the ground or into the water system, which you want to be really really sure about is not harmful. Same goes for for like children playing around or people. Or yeah, touching or using the objects. That's one thing so safety and environmental safety. And I think the other one is that it's, like, has the certificates to be not environmentally safe, but You-safe so it doesn't break down, it doesn't fall down or, like most products that are used in public space are heavily tested on on their safety in use.

I1 11:31
Mm hmm. Okay,

E5 11:32
so certification sort of.

I1 11:35
Okay, so at the one side environmental regulations, and on the other side, more public health or safety regulations.

E5 11:45
Yeah, like physical safety. It's also what you have in buildings where you want to reuse elements is that they're not certified or there's no guaranty that they are saved. So, although they might be save, they are not used.

I1 12:06
Mm hmm.

E5 12:06
Because everything in new buildings has to be certified. Probably Yeah, sometimes you can't you cannot get a certification on secondary materials. Or like reuse materials.

68 **I1** 12:23
69 Okay, thanks. And is there or what measures.

70 **E5** 12:29
71 If you really want to know more about this is probably smart. Is it possible to call

72 **I1** 12:41
73 and the thing is that I then don't can't record it.

74 **E5** 12:47
75 So if you call me and put your phone on speaker or do we then get an echo? Mmm hmm.

76 **I1** 12:57
77 Or, or we can just maybe I I will always just ask the question and don't ask questions. Or only when you finish, I will ask another question. Maybe we can just handle it like this, because I'm not sure with the telephone. Because I'm also recording parallely with my telephone. And then I don't have this back up. And yeah, I don't know it when you call me. Um, yeah, I think then I can't really recorded. That's the problem. All right. Cool.

78 **E5** 13:37
79 Thanks. Let's try. Yeah, I think if you want to know more about the certification issues of public space, elements, you should start with the department that that buys and distributes those elements.

80 **I1** 13:53
81 Mm hmm. Okay, so there's a own department in the Gemeente for this.

82 **E5** 14:01
83 Yeah, it's Statswerken.

84 **I1** 14:03
85 Okay. And yeah, what measures the Gemeente or other political bodies like for example, Waternet could take to make innovative projects less risky and uncomplicated?

86 **E5** 14:27
87 Governmental bodies? Yeah, I think providing test and showcase locations. Yeah to Yeah. To have projects or locations where we are diverting from the standards and putting some more effort in and I think it would be really good if we consciously choose them because we have only a limited amount of people and money to spend so. Yeah to coordinate it well that you can test and stimulate innovation as much as possible. If you do it in every projects, then it's probably not feasible. And also then the lessons are maybe less well distributed.

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88 **I1** 15:23
89 Okay, so you can't provide that space for every innovation that is coming up. Just a limited capacity.

90 **E5** 15:39
91 Yeah, I'm not sure. Probably we cannot do it in one municipality for all innovations. But what I say is that you maybe should give some more time and money to some projects to Yeah, to make it possible that it's that it's done because in a normal process, Yeah, there's really limited time and money to have a lot of innovations at the same time.

Cos

Dev

92 **I1** 16:07
93 Yeah. Okay, um, so the financial performance, do you see any financial barriers in

implementing a project such as Compro into an urban development such as HavenStad?

E5 16:28

Well, I think it's a bit too early for that, because I'm not sure how, like the cost and the cost for maintenance are compared to existing products. Because it's mostly a sum of how much does it cost to buy it, but also, how much does it cost to, to maintain it and to replace it if it's, yeah, end of lifespan I have no insight in the cost of the Yeah, the furniture made from regular materials compared to the Compro materials. And what we see is that there's well what I hear from colleagues that work more on the on the maintenance of the city, which I think you could also ask like, and this also connects to Statswerken is that a lot of new products or circular, products that are Yeah, might be more difficult to maintain. So sometimes the maintenance phase is forgotten.

I1 17:40

Yeah. Okay. Yeah. So it's more about this innovation thought and that they are reusing materials but they don't consider too much what is needed to Yeah, maintain it and

E5 17:56

What are for example materials that are taking in more dirt or Algea, which is a pain in the ass to clean and we have very limited amount of people cleaning outdoor spaces. So if that's not thought through in beginning and it's not gonna happen, or it's gonna happen and then it's a bad experience and it will not survive.

I1 18:25

Mm hmm. Okay. Cool. Um, yeah, I think we continue with the urban integration. Some general questions How do you imagine the Urban integration of a project such as Compro?

E5 18:45

That's a really wide question. I think an urban integration, like from resource still used in buildings and public space. Or like the steps?

I1 19:00

Yeah, at this point I would say it's more concerning the product. So how do you think the product would be integrated into urban space? Yeah,

E5 19:17

I would go via the urban space is not only public space of course but yeah, I would go via test locations or showcase locations where you can show it to people both in public space but also maybe in semi public or private spaces like in a gardens where communities designed their own inner areas or I think you need some some test projects before you can integrate it in the standards refurbishment of public space elements.

I1 20:04

Okay. And in which way can Compro contribute to the aims of the city of Amsterdam or national Urban Development Goals?

E5 20:20

Yeah, I think it can be a very nice part of it if it'sYeah, far enough in development. I mean, it's fits really well with the circular goal of Amsterdam, like the circular strategy that we recently adopted in the municipality. So it would be nice part. I think it's a small part but a nice one. It's very visible, it's very touches, touches upon, yeah, many aspects of the circular city. It's really getting stuff out of your Like, worst part of the waste, basically. And yeah, bring it back into into the city.

112 **I1** 21:10
113 Mm hmm. Okay, thanks. And are there now more to the wastewater recovery concept? Are there other wastewater recovery strategies that are competing with a project or other wastewater treatment concepts planned for HavenStad?

114 **E5** 21:36
115 I think that's also a question for Waternet, basically, but what I would say is that currently we still plan for the regular way of wastewater management, which is transported all to a central facility which is outside of HavenStad, and, like further away in the city there is two pilot-locations where we have a decentralized sensation system as a pilot, one is already built in Buiksloterham and another one is now prepared for I think it was Strandeiland for a new build area. And before those pilots are finished, we will not do it in different areas of the city. And it also needs to certain scale like four to 5000 house holds at once or a bit within a Yeah, a small or a short period. And I think the main elements that are taken out of the wastewater flow are now like the biomass to make energy from the heat itself and the phosphate, but those are also recovered in the current central process. And it's still not clear which option is the most efficient. The only thing we know is that's getting the heat out locally. Yeah is, of course, closer to source, you have the most residual heat. Yeah, but for the phosphate or the getting to biomass outs for energy production indirectly. I think there's still no, no definite answer to that skill question. And what I understood also is that it's important to get out the medicine residuals, which might be easier to do locally, but I'm not an expert on that, but I could imagine that on certain locations like hospitals or elderly homes or like that it's more efficient to get the higher amounts out locally before it blends into this central system.

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116 **I1** 24:13
117 Okay, so you think that like these more decentralized projects, like you mentioned in Strandeiland and Buiksloterham they need more smaller scale projects and not so huge like HavenStad to be tried out.

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118 **E5** 24:36
119 Yeah, yeah, it's both smaller but also new builds because HavenStad is transformation area so it will transform slowly in small steps. And you will have a system which consists of existing and new builds blocks mix, so it's really hard to make a system change in that areas. So we could do that if it's really proven that's a good idea, but doing it as it as a test side, you rather have a small area or a area that's completely new build.

120 **I1** 25:10
121 Okay.

122 **E5** 25:11
123 And so far it's not proven enough to make a really huge effort for this.

124 **I1** 25:16
125 Yeah. Okay.

126 **E5** 25:19
127 And I think I'm not sure how it is with the Compro project, but I think you should Yeah, give more information about how much flow of residual water you need to have a serious production possibility because if you do decentral then if you then have to bring all the stuff that you get out to a other location to produce your furniture or your products, then I wonder whether that is smart?

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128 **I1** 25:52
129 Yeah. Yeah, no, I think the Compro project is more combinable with this bigger centralised treatment plans and I think the like centralized treatment plant that

would be connected to HavenStad or Havenstad would be connected to that treatment plan that could eventually be turned into a Nereda plant. That would be one possibility to Yeah, use this fact that you have as well this Niewue Sanitatie concept in Buiksloterham. And but then maybe parallely have a Nereda treatment plant more centralized. Would that be an option or do you think?

E5 26:47
Yeah, I think so. I think for sure, like in the first 15 years in HavenStad, I don't think we will switch to de-central treatments but maybe for the later areas like the latest areas if we have new insights, and maybe also the central wastewater treatment plants are to the maximum of their capacity is could be could be reconsidered so. So that's the advantage of HavenStad or the I'm not sure if it's an advantage, but it will be developed in 30 years, and it's so big. That's what we say what we know now for the first phases, does not necessarily mean that it's like that in whole HavenStad. So I think, yeah, for the first phases, it might be different than for the later phases.

Applicatic

I1 27:37
Yeah. Okay. Thanks. And can you imagine to strategically integrate the Compro concept into HavenStad somehow?

E5 27:55
I think on the wastewater side, not so much. I think that's really Waternet and I think it will the decision to go decentral or central and what you get out of the water will never be, I think decided upon only the Compro-project. It will always be a sum of how to get out the phosphates, the medicine, leftovers, the biomass particles, I think it will always be a sum. So that's not HavenStad I think but on the use of the product side I think HavenStad is big enough to to have their own sub-styles so to say in public space furniture, for example. So if the concept is ready enough for larger scale application, then it might be that you have like an Amsterdam-standard, and maybe some HavenStad-elements but I'm not sure yeah. If you aim for usage in a public space I would aim for Amsterdam standard as the whole. In the end.

Applicatic

I1 29:13
yeah so not limited to HavenStad

E5 29:18
yeah okay and of course providing like a test space or providing vital locations that would be that would really well fit with the ambition of HavenStad.

Applicatic

I1 29:38
so that like to provide these public spaces you mean for the

E5 29:42
yeah to say okay in this project within HavenStad like the first park or the first waterside redevelopment. We reserve some space or some budjet for these kind of pilots. Okay, that could be an option. Yeah.

Applicatic

I1 30:05
Yeah. And yeah, do you see any barriers in implementing an Nereda wastewater treatment plant into HavenStad?

E5 30:16
is a Nereda I'm not sure if I know the term. I guess it's the central.

I1 30:22
Yeah. Yes, it's this Nereda is the treatment technology that is invented by the TU-Delft, which is basically connected to the conventional treatment, but it's, more

effective because the, the fluid and the solid phase is separated faster, so that the solid phase can be used for products such as Compro. So this is the Yeah, that's the very fast explenation of Nereda but.

E5 31:02
yeah, I think if it's depends on how the plant looks like and how its the sound and the smell of the plants, I mean the current situation is that all that kind of functions are pushed out towards the harbor area. Because they are very large and the price you pay for, like four square metre in HavenStad will be much higher than outside of the city. That's one thing and then the second is that it has smell and noise or visually not very well integrated with the demands we have for dwelling areas or living areas. So that's why they are now not in the inner city. But if it gets like compact, smaller, multi layered, and there is no nuisance around like noise or smell, then these limits are maybe more financial limits. Only now it's a combination of financial and nuisances.

Applicatic

I1 32:17
Okay. And yeah, I think we continue with the product part. And where do you see an added value of the RE-PLEX for HavenStad?

E5 32:32
RE-PLEX is the product from Compro?

I1 32:35
Yes. This is like the material out of the wastewater.

E5 32:40
Yeah. Yeah. It could be, I think in public space elements basically, mostly, would also be in buildings, but that's not so much up to us.

Applicatic

I1 32:51
Yeah, okay. Thanks. And is there a minimum market scale the project would need to reach, yeah to be valuable for a project such as HavenStad? I think you already mentioned. Yeah, I think yeah, we have a question. Yeah. Okay. And for which urban applications do you consider RE-PLEX most useful? Maybe this is also already partly.

E5 33:22
Yeah. Because I'm not entirely aware of the specific material.

I1 33:31
Properties. Yeah. Properties. Yeah, I think well, it would be the next question the product performance. Yeah, which property of the biocomposites such as RE-PLEX do you consider most important for an urban application? For example, the durability, weight, viscosity and resistance to water, solar and chemicals and non flammability. So, maybe I can just mention these Yeah. characteristics and you just say if you find it more important or less important and yeah then we cover this questions maybe like this.

E5 34:30
Alright and then also considering time, I think we can only do a few more questions and then we have to..

I1 34:37
Okay maybe then I will skip this one, then I would go to customer satisfaction. That is maybe more important. And which criteria do you think RE-PLEX need to fulfill to be to primarily reach customer satisfaction?

E5 34:59

Pro

Circ

171 Yeah, I think safety, durability and of course it should look good yeah in some way I hope that in a few decades are at the point that's all new materials we are all new elements we use in public space are completely circular. So you don't see that they are circular but they are but maybe in the meantime in between you want to show that they are circular but I find it a bit hard that use sort of forcefully have to. Yeah. Yeah. On one hand, you want to show it on the other hand, you want to have them like naturally better than the older versions of products. I mean, the I always think about the building and woods for example, that It's of course really nice to to arrange your project as a circularly build project. But it's even better if it just proves itself by being just as stable just as safe like fire for fire regulations, but even more comfortable and more with a better indoor climate. So you would want it not only because it's circular, but it's just better.

172 **I1** 36:36
173 Yeah. Okay. And what are you doubts about a product originating from rest materials? Like for example, smell or safety or design? I think you said already designs kind of doubtful.

174 **E5** 36:55
Product pe
175 Yeah, well, yeah. It could be a good side and a bad side again, showing it's it's circular. And sometimes it's a bit forced but I think main concern is durability, I think because while we are used to products that are never breaking down or only breaking down if humans set up a fire or like, if you have riots or protest, that a people demolish it. But that's also a bad thing because you cannot recycle it and it will stay on the earth forever. You know, on one side is durability on the other sides it's maybe also a change of mind that things don't need to be everlasting, or Yeah, but it means also something for our day to day maintenance. It's for example, if benches are degrading within 10 years then it's probably not something we want. But if they are degrading after 30 years, that's maybe fine.

176 **I1** 38:06
177 Yeah. Okay, so after 15 years, you could say or 20 years, you could say, well, this bench is getting insecure and then you make some security tests and then you can

178 **E5** 38:19
Applicatic
179 I just replace it and reuse the part that you take out in a good way or if the lifecycle on the whole process is still good, than might be an option, but I think you have to keep in mind sort of the refurbishment circles of public space.

180 **I1** 38:39
181 Okay, um, would it be a difference for you if the wastewater for the composite material derives from municipality streams or from wastewater streams of one company? For example, a diary company or..

182 **E5** 39:00
183 Not necessarily. It's only a problem if that's reuse is withholding a company to improve their primary process if it's an excuse to not make their primary process more sustainable it's a bit the same with waste. Burning waste for heat. If residual heat is the reason you exist and you need ways from other countries for example, it's a bit of a weird situation. Yeah, although reusing heat is in the basis is a good idea.

184 **I1** 39:52
185 Okay, and yeah, last but not least, do you have like 10 minutes or five to 10.

186 **E5** 40:01
187 Five I would say, Yeah, I need to finish something before 5:30.

188 **I1** 40:06
189 Yeah. Okay. And so the RE-PLEX has a lot of environmental advantages, but do you also see disadvantages?

190 **E5** 40:22
191 No, not yet. I think the main disadvantage for me now is that, yeah, I have not enough feeling for what it really is and how far it really is in development. So the disadvantages mainly did is too early in the development to really know that. Okay, yeah, sounds really good, but it's super-early.

192 **I1** 40:47
193 Yeah. So you think there's too many uncertainties yet? Still?

194 **E5** 40:53
195 Yeah, yeah. Okay, it's just me doesn't mean that you shouldn't do it. I mean, Yeah, really good initiative.

196 **I1** 41:02
197 Yeah. Okay. Um, and last question, is there anything that has not been considered so far that you would like to mention?

198 **E5** 41:22
199 What I like about the way we now think about wastewater streams in the city is that there's not only one purpose or not one, really one use of it, but that there's many there is more and more claims to the wastewater, like you get different components out of it. So I think you should also consider it. Yeah. Consider those streams and how it's [...Dutch] I don't know- my English gets worse in the end of the day, and how it's. Yeah, all these different uses and all these different possibilities to gain something from this flow has to be considered, like looked at in an integral way.

200 **I1** 42:22
201 Yeah.

202 **E5** 42:25
203 And that's why I think it's really good to it's more something to to bring further with Waternet, for example, because they have a very good view on that.

204 **I1** 42:38
205 . Yeah. But for them that like the urban dimension is still sometimes a big question, I would say.

206 **E5** 42:48
207 Yeah. And was it urban dimension? You mean the market for selling products? out of it?

208 **I1** 42:56
209 Or maybe Yeah, yeah. Also, the The acceptance by the public and by the Gemeente. And yes, I think

210 **E5** 43:08
211 yeah, I think you need many, like a company that's like a industrial design company that's that's deals with all that questions. For example, that is not something Waternet is not like a organization that's built to sell stuff, except for litres of water.

212 **I1** 43:26
213 Yeah.

Interview E6 via mail only

For how long are you in your position in the company?

I am two years employed by BMN from which one year in this position.

2. Questions regarding the concept and the network

2.1. General

What do you consider as social advantages of the Compro-project?

The reuse of wastewater is an interesting and attractive story which fits perfectly in the sustainable body of thought. When you can replace fossil raw materials with waste products and reduce energy usage at the same time it can have a big impact and contribution for sustainability in the building environment.

By carrying out this story I expect a lot of enthusiasm and engagement which will benefit sales.

What do you consider as economic advantages of the Compro-project?

Sooner or later the demand of circular/sustainable materials in the building material market will grow rapidly. Whether or not instigated by the government.

Also you don't need to buy new raw materials, but you subtract them out of waste. So eventually (after investments etc) this will have a benefit on production costs.

What are the social/economic risks of the Compro project?

An economic risk will be the competition of other circular materials. There are many circular initiatives (in particular insulations) which you will encounter. What I think can be a competitive advantage is when it can be developed to be suitable in the cavity wall (moisture wise). Not many other circular insulations can be applied there.

There can be also the threat of the current established suppliers of building materials which are afraid to loose their share in the market.

2.2. Organizational aspects

Does a project like Compro that is connected to a network of different stakeholders
(wastewater-plant, manufacturers, end-users) involve operational (e.g. communication/infrastructure) risks for you?

I don't think so. On the contrary, it could be an addition to our range of circular building materials that we are selecting for our circular assortment.

What organizational difficulties could arise when depending on the by-product streams of a wastewater-treatment-plant?

Availability maybe. I don't have insights about the quantity of materials for producing the product. For us, availability of the end product is from upmost importance. So there has to be a structural flow of products, otherwise we can't promise the customer we can deliver.

2.3. Political and legal guidelines

Which political or legal guidelines do you think could be a preventing regulation for

Legal regu

Cos

Policies

Uncertain

Costs

Circularity

Circularity

the Compro-concept (e.g. waste-label)?
It is very important that you can provide the adequate certifications and documents. Not only legally (Bouwbesluit), but also that customers can trust the product in comparison with existing products.
What measures have to be taken by political bodies (e.g. Gemeente Amsterdam or
Rijkswaterstaat) to make innovative projects such as Compro less risky and uncomplicated (e.g. subsidies)?
Yes subsidies are often necessary to cover the costs for testing etc. (expensive) in order to obtain the appropriate certifications for your product.

2.4. Financial performance

Are there financial risks you have to accept when depending on waste-based materials (e.g. supply shortfall)?
It may be difficult to guaranty the same quality for every product developed out of waste-based materials. However it is very important that quality is constant, so there can be a risk of failure.
Will the production/installation-costs raise with the use of innovative technologies
considered for the use of biopolymers?
I'm not familiar with the use and costs of such technologies. However, it probably will raise costs at first, but I can imagine it may also reduce production costs considering an upgrade in efficiency etc.

3. Urban integration

How do you imagine the integration of the Compro-concept (collaboration of enterprises; wastewater-treatment at the centre of the product) into an urban development such as HavenStad?
?
Could you imagine that RE-PLEX is applied in a bigger urban scale in a symbiotic network of companies?
?

4. Questions regarding the product

4.1. General

Where do you see an added value of RE-PLEX?
I think the 'product out of waste materials' is a very strong story. This is a powerful USP. Sustainability-wise this is very appealing.
Is there a motivation to consider RE-PLEX in your company?
Considering our circular assortment we attach great value to the story behind the product. This story is strong and attractive and therefore interesting to consider in our company.

4.2. Market Scale

Can you say which amounts of RE-PLEX would need to be generated to make it economically valuable for your company? (Current market-size is around 125.000 ton/year)
No, that is not possible to indicate with current information. At first, you have to create widespread support.

4.3. Technological feasibility

Do you see technological barriers that could prevent the implementation of RE-

PLEX
in your company?
Really depends on the application.
What applications the product can have in your company? Are there other applications that you would consider RE-PLEX more useful for? (E.g. ceiling plates,
isolation, façade elements, traffic signs)
As mentioned earlier, in the cavity wall as an insulation. There are many other 'new' circular insulations, but none of them are suited to be applicable in the cavity wall where you have to deal with moisture.
But there are multiple options, ceiling plates and elements may also be interesting. Alternatives for current 'fossil' materials are always interesting.

4.4. Infrastructural and logistic feasibility

Are there parts of the infrastructure in your company that would still need to be created to integrate the RE-PLEX-composite into the standardized productionprocess
of other products?
We don't produce products, we are a retailer.

4.5. Procurement Costs

Which procurement-costs are connected to an introduction of the RE-PLEX?
I don't know.

4.6. Product performance

Which quality criteria the product needs to fulfil to be competitive with conventional
products? (E.g. glass-fibre; polyester composites)
Please prioritize them in the following table:
Durability: Very important
Weight: Neutral
Viscosity Neutral
Resistance to
water/UV/chemicals: Important
Non-flammability: Very important
Biodegradability: Very important
Do you perceive the biodegradability of RE-PLEX as an advantage or a drawback?
Advantage in closing the loop in the story of sustainability.

4.7. Customer satisfaction

What are your doubts about a product (e.g. walls of a house) originating from residual
waste (smell, safety, design etc.)?
Safety maybe. Therefore testing and certifications will be very important.
In which product-application these properties would be most accepted?
Only non-constructive.
Would it be a difference for you if the wastewater for the composite-material derives
from municipalities or from the wastewater-stream of one company?
No.

Environme

84 4.8. Environment

85 The RE-PLEX-product has a lot of environmental advantages such as the
86 degradability, energy savings and independency of fossil fuels. Do you also see
87 environmental risks connected to RE-PLEX?

88 Maybe emission of some harmful gasses or something?

89 4.9. Conclusive

90 Is there anything that has not been considered so far, that you would like to mention?

/

91 Is there something you want to know from me?

I think it an interesting project and therefore I would like to receive updates about the development and outcome of this project when possible.

Interview E7

SPEAKERS
I1, E7

I1
And now that it's recording

E7
Oh, yes, I see.

I1
Um, yeah. So let's start or are there any more questions before?

E7
No. I don't think so. One yes, how did you come to us?

I1
I Yeah, of course. And I I'm in this consortium as well, and this COMPRO project consortium with Mark Lepelaar. And he's from NPSP. He's, that's the manufacturer as well, they are in the product development. They do a lot of research as well. And he said that you are very innovative office or company and that you work a lot of with these materials and then he gave me the contact of Jelle Feringa. Yeah. And yeah, he referred me to you. So it was Yeah, but Mark was I think you don't know him probably right.

E7
No, I don't think so.

I1
No, yeah. Yeah. That was the way and okay, let's start.

E7
Yes.

I1
What is your main work and responsibility at Aectual?

E7
I'm responsible for the product development of the products we sell. We create 3d printed custom made products for the building industry. We have a flooring product and wall cladding products and some furniture pieces and we are working now on facade panels, mainly. Yeah, so that's what I'm doing. So I'm working on. My main goal at the moment is to make the materials we bring to it, or at least one material being ready for the process. Mm hmm.

I1
I quickly close the window.

E7
Yes. And then the biggest issue is the fire certification. So yeah, that's what I'm working and the main material we print with is a bioplastic from Henkel, we developed it together with them for the last eight years. And also with them we are now working on how to get it more fireproof. And yeah.

I1

How to get is more, what?

E7
Fireproof. Okay.

I1
Yeah. And and how long are you working on your position?

E7
Ehm, yeah, I'm the co-founder. So and the office is now we now work since three years, I think the Aectual and we had an architectural office since 2001.

I1
Ah, okay. So your an architectural office as well as manufacturer of the products. Yeah. Okay. Yeah, because I was a bit through the website. I was a bit confused sometimes. But it's the I thought that product manufacturing is the main focus right?

E7
Yes.

I1
yeah. Okay. And yeah, does an integrated project such as COMPRO involve any difficulties for you, when it comes to the stakeholder coordination like that there are so many stakeholders involved and yeah, they have to be organized.

E7
What kind of stakeholders or are involved?

I1
The for example, the wastewater treatment plan then yeah, Chaincraft, like the manufacturer of the Kaumera, then the manufacturer of the, of the product of the RE-PLEX, like for example, NPSP, and then the end user like construction companies as well as for example architects. Yeah. These kind of...

Dependei 

Sounds to me like a normal product development process, there's not too much more or less. So, that should be doable I don't see any problem there.

I1
okay. And and what organizational difficulties could arise when the product is coming from a wastewater treatment plant?

E7
Uncertain 
Well of course, the problem is constancy. So, you are having it from a waste stream you never know hundred percent sure what the ingredients will be for your product. So, that will be the most the biggest issue I think, Hmm.

I1
okay. Um, yeah, and you also deal a lot with these waste products right?

E7
We make mainly plastic waste.

I1
And is it comparable like these plastic streams are they also more inconstant?

E7
Policies 
It's the same. So it's very difficult to put specifications for products on it. So for

Policies

example, if you would like to make a facade, you really have to have your certifications in place for all kinds of specs.

60 And then it's very difficult if your basic ingredient is changing a lot. Yeah, so from there is Yeah, for example, be very difficult, I think to create a facade with it. Yeah. Because Yeah, because that's that's a difficult point.

61 **I1**

62 And can you can you say how you deal with this inconsistency or that you don't know what the plastic? Yeah which which ingredients are in the plastic so yeah how you deal with it when you have to specify the product?

63 **E7**

Policies

64 Yeah. So most of the time then you use only a small portion of the waste stream in the virgin material. So you so you can so you can give it a bandwidth, let's say. So that's one solution. The other solution would be just to create products with it that need lower specs. So they're they're there. There's not too much of risk hanging on it. Yeah, so lower risk products. Okay, floor for example. It's a lower risk and facade.

65 **I1**

66 Floor? Like, basement-floor, yeah or okay.

67 **E7**

Policies

68 Or indoors most of time has less yeah, a lower demand than outdoor and Hmm. Okay.

69 **I1**

70 That's the kind of for me its a contradiction, but because we always breath the indoor elements or we can, though, yeah. Can you explain a bit why indoor is less risky?

71 **E7**

Apl

Pol

72 How do you call it? yeah, it's less riskfull. The outdoor elements are way, like below with temperature influence, rain but also fire regulations are way, way more heavy and normally when somebody buys it is really the ownership of it. So he will probably take good care of it. But whereas if something is standing outside, it's from the municipality, it's Yeah, you can, you can just well, no one takes care of it. So it's, it's way, way higher. Well, it should be more after prove it should have just been more more proof. Okay.

73 **I1**

74 Okay. I see as well for houses like outdoor housing parts as well as urban furniture, for example. Yeah, okay. Okay, thanks. And which political or legal guidelines do you perceive as very preventing regulations for? Which political regulations do you see as preventing, regulations?

75 **E7**

76 You mean from the municipality?

77 **I1**

78 Yeah, for example.

79 **E7**

Pro

Apl

80 Yeah. Well, for example, in Amsterdam, I know they only use one particular brand of street furniture. Okay, so and it's very hard to Yeah, to, you know, because they have their way of dealing with it and their way of taking care of it, their maintenance system is completely organized around this one brand okay and how they do it. So I think that will be very difficult to get or to sell furniture from this particular material.

81 **I1**
82 Yeah. Okay.

83 **E7**
84 Unless you sell it to the brands and then they certify it as good enough for their brand.

85 **I1**
86 Yeah, I think they have very standardized processes.

87 **E7**
88 Yeah. It's very standardized. Yeah. I don't know if it's political but it's just the way they do it because they have a lot of experience with how things go in the city. And yes, they have to take care of our money. So yeah. That's how it goes.

89 **I1**
90 Yeah. Yeah. And, and which measures could be taken by the municipality for example, to make these innovative projects less risky and uncomplicated.

Applicatic

91 **E7**
92 Make it an art project.

93 **I1**
94 Sorry, make it an art project. Ah, okay. Okay. I urban art, like urban art thing or.

95 **E7**
96 What also would be possible I think you have these kind of democratic ehm...How to say the municipality of Amsterdam they have per part of the city, they have a kind of money pot where people that live there, can do a proposal and that, that's all then people have to vote on it. And then there are certain proposals that will be realized. And I think you can get this guy's such a project in these kind of processes. That's interesting because then you already have people that live in the neighborhood that will take care of the project and really want to get it in their street or their square or, you know, so it's, it will make it more easy to to really realize it in into the city.

Applicatic

97 **I1**
98 Yeah. Okay. Thanks. And yeah, do you think there are financial risks in applying or using the waste streams from a wastewater treatment plant?

99 **E7**
100 Depends. I don't know. What the expenses will be from to make it a polymer? Like a polymer if you know if the economical if its there's a really nice I read a really nice article yesterday from Eastman about sustainability and their claim to endless sees circular plastics. And they also say, you know, they're there yet. Three very nice. Well, the most the easiest the easiest way Well, if you think about how it could be a success, then there are these three things I think you should have in your mind. Oh, it's, it's it's really banal and easy, but I will get one moment.

101 **I1**
102 okay.

103 **E7**
104 How it could be a success. It's a Mark... What's his name again. Mark Costa is the CEO of Eastman. Do you know Eastman?

105 **I1**

106 Eastman nee No.

107 **E7**
108 It's a polymer company from the United states its really big. It's huge. And they were all they were also from Kodak.

109 **I1**
110 Kodak.

111 **E7**
112 Yeah. Kodak, you know, probably from your photographs.

113 **I1**
114 Yes. Yes. Yes. Very famous in germany as well.

115 **E7**
116 Kodak is a small part of Eastman. But Kodak is faint, as you know, but yeah, people know Kodak. They don't know Eastman. But you do know Henkel do you?

117 **I1**
118 Yes, I know. Yeah. Yeah. I already ehm... One of the members of the consortium of COMPRO is also in contact with Henkel. The TU Delft people are yeah, oh, yeah.

119 **E7**
120 So Eastman is the american Henkel. Let's say.

121 **I1**
122 Ah, okay. Yeah, they don't do washing powders. Ah.

123 **E7**
124 I see. Well, he says, first, the waste has to go back into products. You need to find a way a good product for it that people want to have. It's easiest, then second, the carbon footprint of recycled material must be better than its fossil fuel equivalent.

125 **I1**
126 Mm hmm.

Product pe

127 **E7**
128 Okay, like I said, it's very banal, but it's, yeah, it's logic. No?

129 **I1**
130 Yeah.

131 **E7**
132 And then he says, third, customers shouldn't give up a lot of their quality of life. Mm hmm.

133 **I1**
134 Yeah. That's interesting. Maybe this article is online or? Sure. The link? Okay, cool. Yeah, that would be great. I think maybe I can take it this like three main points this product should fulfil.

135 **E7**
136 Like I said, it's very banal. It's like every school here child would, you know think yes, of course these three but then still. Yeah.

137 **I1**

138 You have you have to bring it down to yeah.

139 **E7**
140 So I think that's the financial also the financial risk.

141 **I1**
142 Yeah.

143 **E7**
144 Okay. Then what I mean? Yeah, if you don't have these three in order. No one is going to buy your product.

145 **I1**
146 Yeah. Yeah, of course. It's very connected.

147 **E7**
148 Yeah, if it's too expensive, nobody will be up by it.

149 **I1**
150 Yeah. Okay. Um, yeah. But do you think that for example, Aectual could integrate a project like Re-PLEX into the production processes.

151 **E7**
152 That would be interesting. Is it a thermoplast?

153 **I1**
154 Um, well, it's a biopolymer. Um, I am not exactly sure about the properties of thermoplasts.

155 **E7**
156 Probably it is a thermoplast. Okay. Would be interesting to see if we can print with it.

157 **I1**
158 Yeah, yeah, sure. Yeah, I am not 100% sure. I'm not so much into this technical...

159 **E7**
Circularity
160 But we we also do a lot of combinations of 3d printed elements with other kinds of materials. So could also be that the plate or as long as its going into sustainability and circular approach, we are interested in it.

161 **I1**
162 Okay. Okay. Um, yeah, now a bit about urban integration. How do you imagine the integration of RE-PLEX into an urban development such as HavenStad? like yeah

163 **E7**
164 I think we are in HavenStad. Yeah.

165 **I1**
166 yeah, you're on the map. So you're one of the companies that is actually yeah would be interesting for symbiosis or something? I think so.

167 **E7**
Product pe
168 Yeah. Urban integration yet. Yeah, it's hard to say because I don't know the material. Yeah, it all it all goes well or bad by having a good design which fits the material. So you have the right design. To create the right product with it. That will be the most difficult point, I think.

169 **I1**
170 Yeah.

171 **E7**
Product pe
172 Even if it's brittle. I mean, also, glass is also brittle. If you can make the right design for it and the right purpose find the right purpose for it, then probably that will go right. But since this is not there yet, it's hard to say.

173 **I1**
174 Yeah. Okay. I understand. And but could you imagine that it's applied, like the product is applied in between different companies like in a symbiotic network. Eh like in HavenStad for example, that there's for example, the wastewater treatment
Applicatic plant and then it gets to Chaincraft and Kaumera is created and then it would get to your company the manufacturer and yeah.

175 **E7**
176 yeah, sure. I can imagine.

177 **I1**
178 Okay. And, and which material properties do you consider very important for public space application?
Product pe

179 **E7**
180 Yeah, it's the strength. It's the strength and the and also fireproof. So it's both those two are most important ones. And then it's easy to clean. So, if you can bring it all down to maintenance, more or less.

181 **I1**
182 yeah, yeah, I already had an interview with one person from the Gemeente and she said, of course. Its the maintenance, you need a lot of people and you, yeah.

183 **E7**
Product pe
184 It should be durable, durable, durable, durable and should be able to smash it and put grafity on it.

185 **I1**
186 Yeah.

187 **E7**
Product pe
188 It should all be possible to get it off or clean it or whatever.

189 **I1**
190 Okay. And for more interior applications, what do you think? Yeah. Okay. Okay, but are there any specific properties that it would need to fulfill for interior applications

191 **E7**
192 for furniture? No.

193 **I1**
194 Okay.

195 **E7**
196 No, furniture is the easiest.

197 **I1**
198 And for facades for example what?

199 **E7**

200 what?

201 **I1**
202 For facade elements or isolation or?

203 **E7**
204 Yeah then the fire is most problematic I think with the polymer.

205 **I1**
206 Mm hmm.

207 **E7**
208 Although I don't know the specifications of this polymer but most probably fire will be the biggest.

209 **I1**
210 Yeah its quite fire-resistant actually okay. Yeah, that is one of the properties that is already quite proven.

211 **E7**
212 But then the difficulty with the polymers is that they the way they qualify the fire resistancy of a polymer is very different from the way they qualify the fire-resistancy from a building product. These two are hard to...

213 **I1**
214 combine? Yeah. Or to relate. [Dutch word]

215 **E7**
216 Yeah, I don't know the English word. But then at least I think you always need the highest fire provements of the Polymer. So the V zero. If this is to any any of your knowledge, I don't know.

217 **I1**
218 Okay. So there are these specifications for the polymer and for the facades and it's difficult to combine them that's...

219 **E7**
220 Yeah, combine, it's more how to relate how they relate to each other. So a building a product you need a certification which is way higher than the highest point of certification for the polymer.

221 **I1**
222 Okay.

223 **E7**
224 So you really need the highest region let's say and with that you might be able to create a facade element.

225 **I1**
226 okay. And and where now for the product directly, where do you see an added value of the RE-PLEX?

227 **E7**
228 Well, I think the waste streams and circularity and ehm are very trending at the moment it must be possible to create a product which is interesting. Yeah, it can be anywhere. Almost. But if you can say its a plate, it could also make wardrobes for IKEA for example. Why not?

I1
Yeah.

E7
That would be very cool, no?

I1
Yes. would be a good retailer, I would say. Yeah. retailer, I think. Yeah. Yeah. And, and do you also? Yeah, I think it's the same motivation for your company as well, right? If you take the product and think about, okay, why Could it be interesting for us? It's probably the same story. With the circularity and yeah. Okay, and is there a market scale that need to be reached to make it interesting for your company? Like minimum amount of material?

E7
No, most of the time, it's the the amounts are too big for us.

Scale

I1
Okay.

E7
Yeah. So we are more interested. Yeah. For us. It's easier to to. Yeah. For us. It's interesting to have these small experiments to work.

I1
Yeah.

Scale

E7
I think especially when you start it's interesting to have these small batches, to sell to different companies to see what they can make from it. Like for example, if Henkel makes a batch for us, it's always about 10 thousand K. Yeah, it's, it's so much. It's like goes into Yeah. It's hard to experiment and develop with such amounts.

I1
Okay. Yeah. So yeah, it's more experimental. And that's why, yeah, so big amounts are too much.

Scale

E7
Yeah, at the moment. I mean, I would say if you start, it's easier to sell small batches. So you can start and do experiments with it. And then of course, if it works, find a way into the market, with a certain product, it's important to get to upscale. But at the start, I mean, product development probably will still take place one or two years. So with time it might also be possible to upscale the facility.

I1
Yep. Okay.

E7
We start with finding manufacturers or designers. Yeah. To find your way into a certain market in that spot.

I1
Okay. Ehm and do you think there are any technological barriers that would prevent an implementation of COMPRO?

E7

I don't know.

I1
Okay.

E7
Innovations is always difficult to know. Yeah, yeah.

I1
Okay, this can only be seen with time probably.

E7
Yeah. Yeah.

I1
And is there any application that you could imagine in your company to apply the RE-PLEX, the product?

E7
In a plate variant or as pellets?

I1
sorry?

E7
In a plate or sheet variant or as pellets?

I1
Eh more in a plate variant.

E7
Yeah. No, not yet.

I1
Okay. And do I know, do you consider it more useful for temporary or permanent constructions? The RE-PLEX?

E7
It's hard to say because I don't know the properties. Okay. Yeah. So yeah, that's I don't know.

I1
Okay. Yeah, it's very biodegradable for example, and yeah, probably but this is then logic that you would say temporary because...

Applicatic

E7
Ah ok, but some biodegradable products are very high resistant. So yeah, I wouldn't say biodegradable is definitely only for temporary solutions. I wouldn't say that. But because most of the time biodegradable means that you have to shred it and put it in a bio-degradable system. It really gets back into yeah, before it degrades. So yeah, I don't know.

I1
Okay.

Product pe

E7
For me biodegradable doesn't mean right away temporary.

I1
Okay. Yeah. And and these materials that are biodegradable, do they have a coating or something that they are more longer.

E7
No.

I1
Okay. The product performance - which quality criteria this product needs to fulfill to be competitive with other construction materials like with conventional materials.

Product pe

E7
Like wood, for example. Yeah, yeah. Well, it should. I think likeability is very important.

I1
Okay.

Product pe

E7
Yeah. It's as easy as that. But that might also be the way it's processed. But it's very important that it looks good and that it feels good. Mm hmm. It doesn't should not smell. Probably Yeah. I mean, no, I think it's very important that it's that it has a good. Yeah, that it feels good.

I1
Yeah.

Product pe

E7
It doesn't have to be smooth or you know, depends on the material. I mean, if you it can also be a rough material, which is very beautiful. As long as it's, you know, it has an appealing if it is appealing to humans.

I1
Mm hmm.

E7
Yeah. I think that is most important.

I1
So it shouldn't smell. It should be safety.

E7
As long as it smells very good. I mean, that is also possible...So that would be no smell, I think. Yeah. Yeah. With the smell it is very difficult to sell. Mm hmm. Yeah. especially indoor. Yeah,

I1
yeah, of course. Nobody wants to move into a smelly house. So no. Yeah.

E7
It depends on what kind of smell but when there's some kind of smell, it's difficult.

I1
Yeah of course. And yeah, and are there circular construction materials competing with the RE-PLEX?

E7

I don't know. Is it is it fully recyclable the RE-PLEX?

I1
Eh, its fully biodegradable. 100%.

E7
Fully biodegradable.

I1
Yeah, it's not eh... recycable... Yeah.

Competiti

E7
Yeah, it depends I think it has to do with this, this co2 footprint or lifecycle analysis. How you would put it in a sustainable map, let's say how much does it cost to create a product? How durable is it? So how long? What's the lifetime expectancy? And then how much does it cost to recreate and get rid of the old one? Yeah, that's mostly Yeah. You're then you know how sustainable or circular the product or the material product combination is. Yeah, that's hard to say.

I1
Okay.

E7
Do you know?

I1
Ehm, what exactly?

E7
What this lifecycle analysis is? And what are the co2 footprint would be of the product? Compared to other products in the sense.

I1
It's said that it's 67% less energy consumption.

E7
Yeah.

I1
Compared to conventional products, which also entails like it's very lightweight like the transportation is not so energy consuming as well as that that the source is basically waste. So, yeah, there is a comparison to glass fiber polymers. Yeah. And there were there. They were made, comparing calculations of glass fiber, and polymers and this one and then it came out to that it's kind of 67 % less energy consumption for this.

E7
It's very interesting.

I1
Yeah. Yeah. So it's very sustainable I think. But Yeah. It's still in development. We have to see. Hmm. And yeah, which criteria need to be fulfilled to primarily reach customer satisfaction? I think you already said probably. Yeah, that shouldn't smell it should be durable. And these things so. Probably it would be a repetition you now, say again. And yeah. And yeah, I think is already answered as well. Yeah. Do you think that there are any environmental risks also connected to the RE-PLEX?

E7

348 In what? In what way?

I1

349 For example, that it has emissions or like at the beginning, we talked about the
350 wastewater and that there are heavy metals or any toxins that could be in the wastewater that aren't like every wastewater is different. So that would be for example, yeah. Yeah.

Environme

E7

351 Ah yeah, in that way and before and most probably when you use it indoors that it
352 could still give fractions to the air lets say. Yeah, something like that, or that when it stands outside and rain goes over it that some elements that are inside get into the water. Like that kind of thing. That's possible.

I1

353 Yeah. Yeah. And do you have similar problems with plastic? Or is it?
354

E7

355 Yeah, we use a bioplastic which doesn't contain any difficult ingredients, let's say
356 that are now considered difficult, let's say you never know how it will change in the future. So at the moment No. But yeah, that could change.

I1

357 Okay.
358

Cor

Environment

E7

359 But I think you're every every material you use will have these kinds of issues.
360 Yeah, wood has it as well or stone.

I1

361 Okay. Eh yeah, I think we are already at the end of the interview. Okay. And is
362 there anything that hasn't been considered so far that you think is good to mention?

E7

363 No, no. Very curious. About how this project will go. Or where it will go.
364

I1

365 Okay, yeah, yeah, I can maybe send you my research. Yeah. If you're curious.
366 Yeah. Or Yeah, if the main, the administrator of the project is Peter Mooij. So, yeah, you can also or also through Mark Laplace through NPSP. You can always reach out and ask.

E7

367 NPSP - I know. Okay, finally it hits my head.
368

I1

369 Ah, okay, so you did not understand it. No.
370

E7

371 I do. Okay. Yeah, of course.
372

I1

373 Yeah. Yeah. This is the main connection.
374

E7

375 I get it. I get it. Okay.
376

I1
Um, yeah. And is there something that you would like to know from me?

E7
No. Okay. Yeah. Oh, I think we discussed it all. Yeah, yeah.

I1
It was very, formative I think I will stop the recording now. Yeah.

Interview E8

Fri, 8/7 2:14AM • 34:05

SPEAKERS

I1, E8

I1 00:09

Now you see probably also that it's recording.

E8 00:13

Yes.

I1 00:16

Okay, perfect than I would just start and yeah what is your task or position in relation to the COMPRO project?

E8 00:27

I work on building biocomposite from Kaumera, by adding Kaumera to some fibers and possibly some additives. And we try to optimize the impregnation of fibers with Kaumera this is the next coming task, but we also do try to optimize the mechanical properties of the final composit.

I1 00:59

Okay, thank you. And what or where do you see the economic advantages of the project?

01:09

Circularity

I think if the properties of the final bio composite is comparable to the conventional composites like oil based composites, we can have a really nice material regarding energy consumption because we as you know, we the energy consumed to produce the product with Kamera is much less than the other than the conventional oil based materials. And also Yeah, I think that the interesting thing is also of course, the circularity and you have the waste stream of one area like around Amsterdam or any any area you can imagine, you get the waste stream and you produce directly some new materials its also a win. Kind of being meaning economically and the material yeah, that goes back to material costs. So it has two aspects. I think material and energy costs are less, but only if we can compete the, you know, the conventional building materials or whatever composites.

I1 02:19

Yeah. Okay. Um, yeah. And the social advantages are kind of similar, right?

02:28

Circularity

Yeah. Yeah, because I thought okay, I think circularity is the most important aspect of Kaumera. Otherwise, you know, you can use that the I think that's the advantage of this project. That's one of the main advantages of this project that it's circular.

I1 02:46

Yeah. Yeah. And, but also, did you already experienced some barriers in the project? Yeah, some technical or any barriers that are a bit more obvious, like...

03:09

Scale

yeah, now is getting in the beginning, I started working since a couple of months ago. And in the beginning, I think they were not there to produce much Kamera like that you need to do test experiments, but now I think they are upscaling, they

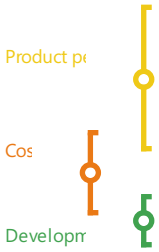
can produce much more amounts, and I think so far. No, not really. No Barriers. Technically, yes. Like, we have to do a lot with the materials still but not in collaborations or organizational problems. No.

I1 03:42
Okay. Cool. And yeah, that's the next question. Like, do you think that there were like, or that this, or yeah, like this project, which is connected to a lot of different stakeholders involve operational difficult like communication or any yeah infrastructural obstacles.

04:08
Not No, I think, other way around. I think it's quite helpful to have different organizations involved, especially like the small companies like Chaincraft, and I think they're all enough you have enough motivated people in these organizations. So not from that aspects. No, it's not like we are dealing with big companies and you have bureaucracy. It's quite easy to contact people and they are approachable. So I didn't have any bad experience. Yeah.

I1 04:42
Thanks. And are there or which political or regulations do you perceive as preventing for the project? Are there any political obstacles?

04:58
I think it's more eh. This question maybe it's a it's related to maybe to the municipality of Amsterdam could be that that's like, I think the most important thing is that the social acceptance of this material, if anything comes out of Kaumera, of course, it's from wastewater and you have to, you know, I think they have to work on people's acceptance. Because should not very something if you ask people around, you know, I'm not sure if everyone wants to use that material in the buildings in their buildings. I also asked my colleagues who are not really involved in compro, but they said no, not for my house. So I think that's the what they have to work on social acceptance. And, of course, money is a very important issue because this is a project which is in the initial phases and it costs more than what it gives back economically. So We still have a long way to go. Not even I don't think it's realistic to think about three years from now. I think even longer.



I1 06:09
Okay. Like for the first prototype, you mean, or...

06:15
We can have the first prototype maybe in three years, but like, really something that you can use in the building? I think we have a longer way to go.

I1 06:24
Okay. Yeah.

E8 06:28
I mean of course, it must be in the beginning subsidized, you know, you can imagine that, just in order to continue the research, you have to, because I don't see the market, you know, accept that project. So that product so easily, so we need more, more support from probably from government to continue.

I1 06:52
Yeah. And how could this support look like what in how far could they support the project?

07:01
I think financially like the subsidies that we have now and also working on social acceptance is just maybe by education or, you know, important it's like all like all

Pro

Cor

sustainable projects all like, we have a lot of work on bio based composites and some are more acceptable than the others like you are more willing to use a natural product which is from grass than from sewage, you know, this is very, I like every I think every for every person is more acceptable. Yeah. So, the cost of the material like I still know there are some estimations about final cost, but it might be that it goes higher in the beginning the final cost of a real product, like bio bio composites. And if someone wants to go really sustainable or buy those kind of products if they are more expensive or they are the same price as conventional composites, if conventional materials are cheaper and people think they are cleaner, and they are not from sewage probably they go for for that one.

I1 08:14
Yeah, yeah. Okay. And do you think that you still need to invest into a lot of technological installations to produce the Kaumera? Like are there Yeah. Do you need still a lot of machines or like processing installations or...

Scale

E8 08:36
At this stage eh no, but maybe later for now we have the machines we need in the in the small scale, but for the larger scale, yes. Probably not a lot, but we need more than what we have now.

I1 08:52
Okay.

E8 08:53
But this is already for the after the first prototype.

I1 08:57
Yeah. Okay. And could you imagine COMPRO to be applied in a bigger urban scale? Like, maybe if it's already in an advanced product? And yeah, some more companies are involved. And could you imagine that it's kind of like the wastewater treatment plant is the center and then companies that work with the product are clustered around?

Applicatic

E8 09:26
Like, yes, it all depends on the material of course. If the material is acceptable, and it has good properties, why not? I think even other parts of Netherlands or other parts of like any city, you know, it's you have everywhere you have sewage everywhere, you have wastewater, so the waste stream and if you find something interesting, I think it can be spread to other other areas as well.

I1 09:54
Yeah. And do you think it would be a logistical advantage? If the companies would be located around the wastewater treatment plants for example when...

Applicatic

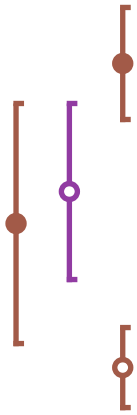
E8 10:08
Yeah in the case of I think yeah for of course for now we already we have everything here is around but in the future if for other parts like in the south or east in other parts of the country ehm I'm not sure if it makes sense to make all the installations on the spot this I'm not very sure about the cost and you know the added value so maybe.

I1 10:34
Okay.

E8 10:36
This is not very clear for me. But yeah, I think for this region it I mean in basically it is advantages but I don't know if other cities want to use the same system for their sewage they have to have their own installation or this is not very clear for

me.

I1 10:57
Yeah, okay. Okay, now I think we come to the more product related questions. And I don't know if it's maybe a bit too detailed question, but can you give an estimation about how much of the RE-PLEX would be approximately needed for one squaremeter of facades?



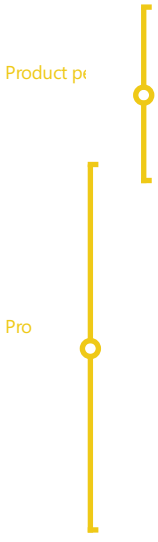
E8 11:20
This is very hard to answer this question because you need different things are. You know what is important is, for example, we don't know anything about the thickness required yet. So if we need a very, you know, or if we use the material in a sandwich panel, for example, like we have it's light core, and we have the two layers of the material, the compro material on top and both sides. It's all very different values depends on because we still don't know much about what kind of material is like we know that we want to use it for construction and for building but we still don't know which thickness. We still don't know if we use it as layer on top of something else or as in a sandwich panel, you know, just on both sides of some, some lighter material. So it's, I think at this stage its very difficult to answer this question. I don't know if there's a estimations to who work in building and construction because we still don't know even the which fibers we're using.

I1 12:31
Yeah.

E8 12:31
And it depends on the fiber, it depends on the thickness, it depends on the, as I said, if you use it alone, or if you mix it with other layers, it all depends on so it's not really you can I can't say any I can't have any estimation.

I1 12:47
Yeah. Okay. That is fine. And, yeah, now the technological questions. Can you say something about the technological difficulties in the production process of the RE-PLEX?

E8 13:11
We tried with you know that there were two different forms of RE-PLEX one was in the powder form. The other one is more as sludge. I think for some application, like if you want to use a fiber mat with long fibers, and maybe easier to use powder form, but for example, recently the test we did yeah, tow days ago when Tim was here, we used a sludge because he brought us some sludge. I think he took it from Peter. Robert, I'm not sure. And we saw that this is like maybe it works. We can also use that as a use that form of RE-PLEX. So it's still not easy to impregnate the fibers with RE-PLEX, not all the fibers as because impregnation is very important, if you want to get a good composite, and this is one of the problems we have to solve yet because with some fibers we don't have good impregnation with some sometimes with powder we have better impregnation some sometimes with this the sludge form. So, this is not the research we do is not yet very consistent, we have to shift from powder to sludge and you know this is one of the problems we have to solve. Yeah, and of course, the type of fiber we use because the idea of wastewater material was recycled toilet paper, which is basically short fibers that you can mix a bit with RE-PLEX. But we see that we get better properties with other types of fibers like not really necessarily from wastewater, just the fibers you buy, and they might be more expensive. They get you much better mechanical properties. But still with recycled toilet paper it's not easy to make a good material. It's quite weak and still, we don't we have this the problem and yeah, it makes a film, you know, if you mix, recell, recycled toilet paper with RE_PLEX and add those additives. You can make film but this film is very weak.



77 **I1** 15:40
78 Yeah. And recell is the toilet paper.

79 **E8** 15:45
80 So yeah, is it just recycled toilet paper, it's something you can get from wastewater basically. So I think that's the initial idea of COMPRO. To get all materials from, but with that material, I think it's very difficult, recell, because it's quite weak. Mm hmm. Yeah.

81 **I1** 16:04
82 Yeah. Okay. And are there already some properties that are certain for the RE-PLEX?

Product pe

83 **E8** 16:13
84 Well, it's light that's and then of course biodegradable. And well make I think it's also heat resistant or fire resistant. And that's the based on the test I saw video I think Robbert or not I think Peter shared with us so and I heard about but mechanical properties are still weak. We have to improve them. That's definitely one of the important factors for building materials or if you want to use it for example, in automotive industry. You should have a strong material when you when that you hit, you know, a strong against impact. And if they hit somewhere you don't have the problem of destruction of the whole material. So that's the main problem. I think until we don't solve this problem we can't really use it in construction.

Product pe

85 **I1** 17:13
86 Okay. Yeah, yeah, I think also durability was the most mentioned property that is kind of important as well. But also lightweightness and fire resistance is also super important. So yeah. Okay, and which functions yeah, RE-PLEX does not fulfill so far. I think we had it already. It's like, yeah. Yes. Yeah.

Product pe

87 **E8** 17:44
88 Stiffness and strength is still we have to, we don't have it with the material, you know?

89 **I1** 17:49
90 Yeah. Okay. And which material would be comparable to COMPRO? Like wood or yeah,...

Competiti

91 **E8** 17:59
92 Good question, yeah it's difficult because it is really yeah, it's really not a real you can't really compare it to any conventional composite yet, like material it's more, like a film like or you know, even with longer fiber mats, it's not really comparable to any industrial resins or conventional resins that I know, conventional composites that I know so it's hard to I think it's really that's the thing that always comes up in the COMPRO project is that also had we also had it with the team from Deutsche Welle because he had with the things advertisement which is made around compro he was expecting to see something way better and he just came here I could understand him and totally understood him. In the beginning he was a bit disappointed because you touch it, I showed him some samples. And I said, I told him, you know, I have to be honest with you. And this is what we get. And I don't that it doesn't go anywhere. Because it's all the beginning of research is always you get really the worst results and you know, you have to work on that. But that's what that's really not comparable to any material you expect. Like really strong material. So yeah, again, we are back to if we're realistic, and he was also like you said, I can't lie this is we will make a program about that but he won't be lying about like, this is a waow material, like really strong and I think that's the right approach. So.

De

Pro

93 **I1** 19:47
94 yeah, yeah of course.

95 **E8** 19:50
96 Honestly, it's not really comparable to conventional building materials.

97 **I1** 19:58
98 Yeah, yeah. I mean with time.

Developm

99 **E8** 20:02
100 Yeah with time, we need time definitely yeah.

101 **I1** 20:06
102 And yeah and like which for example, epoxy-resins or something are competing right now on the market? Do you know which material is right now very like the material in the circularity industry, like next to Nebasco?

Cor

Pro

103 **E8** 20:28
104 Yeah, we have bio based partially bio based resins like epoxy and polyester. And they are partially bio based meaning that they're monomers they and I want to use a word which is not very technical. Like they're what they are build up their building blocks are bio based or partially bio based instead of being completely chemical and building in a chemical plant they are bio based like they're taken from sugar or you know different material. So, we have epoxy and we have polyester which are synthesized so they are not completely bio based but we have up to 50% bio based material we also use them like the polyester we use in our Nabasco is partially bio-based. Yeah, that's why we always say that it's like 70 to 80% bio-based our Nebasco. It's not completely bio-based, but it's partially bio based. So actually are basically all the resins we use here are partially bio-based, some are hundred percent bio based like, like RE-PLEX and other resins there but they're still in the experimental stage. So we are doing some experiments with hundred percent bio based resins. One of them COMPRO or one of them RE-PLEX. But we are, you can mention epoxy and polyester as partially bio based resins not fully, yeah.

Competiti

105 **I1** 22:07
106 Okay. And eh for which application would you consider RE-PLEX maybe in the future more useful like yeah more interior or outdoor or where do you see it in your vision?

Applicatic

107 **E8** 22:29
108 Yeah, I think it's if we get again good results with the properties I think it's more an outdoor material and about yeah you have the next you had the next question I was reading like you can use it in buildings outdoor or you know, as a layer maybe between two other layers in the building outside the building because it's, it's biodegradable and it's quite I think it's also if we didn't do the tests with humidity, and in environmental terms but it might be if you, if you expose it directly to weathering it might not be very strong. So probably I can imagine if you use it in panel or you have a coating on top of it, maybe it can be used outside.

109 **I1** 23:21
110 Yeah. Okay. So yeah one expert were mentioning that it would be maybe possible to use it in the cavity wall, like between the walls yeah. Between the walls, but therefore like, Yeah, but therefore it would be need to be moisture resistant, right? So yeah. And there you don't really know yet if this would be it would maybe work or? Yeah. I'm sorry.

Product pe

111 **E8** 23:58

Product pe

112 Sorry. Sorry. I didn't to interrupt you, but yeah, no. Yeah, exactly. So we don't know if it's, we didn't do weathering test. But from what we see and from the material, it's from that much we know about RE-PLEX I think it might not be that moisture resistant.

113 **I1** 24:19
114 Okay. Okay. Um, okay. And do you consider it more useful for temporary or for permanent applications?

Applicatic

115 **E8** 24:35
116 I think more temporary, but maybe it is possible to have a longer life cycle. So like temporary, not maybe two, three months, maybe a bit longer, but I think it will, because it's biodegradable it's more suitable for temporary application. Okay.

Uncertain

117 **I1** 24:58
118 And Yeah. Okay. I have to look to the questions. And can you say something about the pace of the biodegradability? Like how long? Maybe it would stay as a product? And then...

119 **E8** 25:21
120 Ehm this I really don't know because I am not also aware of maybe, maybe Robbert have done some tests on it. I am not so sure because I didn't see any in the reports I've been reading I didn't see any information on I didn't like it's not the kind of test we do here at NPSP we work with work with composite tests, and I have really no idea. Okay.

121 **I1** 25:46
122 Yeah. And in the end, like, if there's a prototype anytime do you think that the maintenance would be higher than for conventional products? Yeah.

123 **E8** 26:08
124 Yes. Yeah, this I also don't really know. I don't have any any anything in mind like the I thought about it yesterday but yeah, again depends if you put it in like in again between two layers or in cavities. Maybe you don't need that much maintenance. I think it also depends on the application. But yeah, it's also not something I can answer yet. Yeah.

125 **I1** 26:39
126 Yeah. Okay. So and because it's biodegradable, probably you cant really use it right? After it's use-phase right? Yeah.

127 **E8** 26:48
128 Yeah.

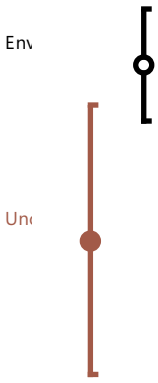
129 **I1** 26:51
130 Okay. Probably.

131 **E8** 26:53
132 But the good thing is oh, sorry, sorry.

133 **I1** 26:56
134 What would you imagine would you incinerated then or make energy out of it.

135 **E8** 27:06
136 I think that would be the way. Yeah. Because it is the source of energy. Yeah. Okay.

137 **I1** 27:15



Okay. And yeah, that was the technical block and the customer satisfaction, what do you personally expect from the product which consists of restaurants in real life? Do you have some expectations for smell or safety?

E8 27:42

Yeah, um, we still have we do have there, we have to think of a solution for the smell yet. Because in the form that we have, we still have some smell. If you use it in, maybe inside between two layers or again, cavities are in sandwich maybe this smell is less or disappeared. But you know, I don't think there is an regarding safety. This I think tests should be done. I am not sure if they did those tests. But this is something that must be done probably also, regulations will force the COMPRO partner to do those tests. Mm hmm. But the smell is much less than the beginning and that's what I heard because from people who work in the past with with the RE-PLEX, I hear that the smell was awful. Like no one wanted to work with that. So the smell is better but still is not completely gone. And of course you don't want to have it in the building if you have this material, but if you use it, maybe with some I think there, there are many solutions to for smell. So I'm not that much worried about smell, but for safety, probably some tests have to be done.

I1 29:10

Okay. And yeah, we were I was mentioning before this contents or pathogenes or any, yeah, heavy metals that could be inside the wastewater that then also could be, of course, inside the RE-PLEX. Do you have any estimations about what could be inside? Or how you could make sure that certain elements are not inside that are somehow riskful for the human? Or for the environment?

E8 29:47

Yeah, this is about the table you. Yeah. You mentioned there was a table I think I also asked Mark, but Mark said that he doesn't have it. So we don't have the values here, but I think Robbert has that. Yeah, maybe he has he can give you a better answer yeah I am, but what I what I remember from our discussions within technical meetings that depending on the source of wastewater is it industrial or is it municipal you have more or less we have different concentration of pollutants? So, I suppose they have enough information about that or they did you know the thing is that is also changing every time it is you see that in for example, even in by in fibres we use natural fibers, depending on the season, depending on the harvest, depending on the region, you have different results. So, it's always with bio based materials. I think the idea is that every time you get you start producing, RE-PLEX or not, we've not the composite but you get the waste stream you have to do all these tests there is no maybe you have this value now but next year you have other values because of industry you know there are different industry different pollution. So I think logically you have to do this test every time. Yeah, and like that makes more sense to me but I don't know about the Kaumera. I can imagine the first you know, the [...] even from two batches of RE-PLEX powder that I get from Chaincraft they are slightly different, the color is different, even the smell is slightly different.

I1 31:35

Mm hmm. Okay. Yeah. Yeah, probably with industrial wastewater, it would be more. Yeah, the same with municipality water, you have more changes and stuff. And then with industrial water, you can at least say okay, it's always the same or nearly probably they also use sometimes other things but yeah.

E8 32:02

But the value I don't know that if you have the if you find the table you can also send forward me. I think Robert has that table because. Yeah, sometimes they bring it up during technical discussions but it was not something I was very easy with but it's interesting to take a look. Yeah.

I1 32:20
Yeah. But I don't know why probably Mark once showed me but maybe he showed me any other table. Maybe he just showed me an example or something.

E8 32:31
It could be another Mark. Is it about Mark in NPSP or there's a Mark at TU Delft.

I1 32:38
No Mark at NPSP. Okay.

E8 32:41
He said he doesn't have I don't know. It could be that he showed something else but I asked him. He said but I think the source to get those information is Robert is more. Yeah, he has because they are working on the on the material itself and they send it to us and we make composite so its just better. And if you find it, I will be happy to have that too.

I1 33:03
Okay. Yeah, I can ask him. Yeah.

E8 33:09
Do you have is he available? Oh, because he didn't reply. Do you know if he's on vacation? Robert or you don't know.

I1 33:18
And I just wrote him an email and he responded me two days ago. So I think he should be available somehow. I was very glad that he was responding because sometimes he also took some time, like one week or something, but this time, it was kind of important. So I was...

E8 33:43
Okay. I tried to have getting because I need some some sludge from him. So he didn't respond. So I thought, okay, yeah, maybe he's on vacation.

I1 33:53
Yeah, no, I think he said you should try Yeah, yeah, I think I will stop the recording.