Sustainability Criteria and the bio-based materials sector in the Netherlands

Van den Broeck William

Thesis Research Project

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Contents

Glossary

ANEC European Association for the Coordination of Consumer Representation in Standardisation

BBE Bio-Based Economy

BBM Bio-Based Materials

BEUC Bureau Européen des Unions de Consommateurs

BIC Bio-based Industries Consortium

Bonsucro Bonsucro EU

C2C Cradle to Cradle

CDB Commissie Duurzaamheidsvraagstukken Biomassa or Corbey Committee

CEN European Committee for Standardization

CENELEC European Committee for Electrotechnical Standardization

CLM Centre of Agriculture and Environment

CSR Corporate Social Responsibility

DIN Deutsches Institut für Normung

EEB European Environmental Bureau

ETSI European Standardization Organization

FP7 7th Framework Programme for Research and Innovation

FSC Forest Stewardship Council

GD Green Deal

GhG Greenhouse Gas

GM Genetically Modified

GWP Global Warming Potential

IDI Inclusive Development International

ILUC Indirect Land Use Change

IRS Institute for Rational Sugar Production

ISCC International Sustainability & Carbon Certification agency

ISO International Standardization Organization

JTI BBI Joint Techology Initiative Biobased Industries

KBBPPS Knowledge Based Bio-based Products' Pre-Standardization

LCA Life Cycle Analysis

LICADHO Cambodian League for the Promotion and Defense of Human Right

LIF La Isla Foundation

MBDC McDonough Braungart Design Chemistry

NEN Nederlands Normalisatie-instituut

NGO Non Governmental Organization

nova nova-Institut für politische und ökologische Innovation GmbH

PEFC Programme for the Endorsement of Forest Certification

PLA Poly-Lactic Acid

RED Renewable Energy Directive (2009/28/CE)

RSB Roundtable Sustainable Biomaterials

RSPO Rountable on Sustainable Palm Oil

RTRS Round Table on Responsible Soy

SAI Sustainable Agriculture Initiative

VIBE Vlaams Instituut voor Bio-Ecologisch Bouwen en Wonen

WNF Wereld Natuur Fonds (Dutch Branch of World Wide Fund for Nature)

WWF World Wildlife Fund

Summary

Fossil fuels will run out in the foreseeable future. Out entire economic system is build upon fossil fuels and building up another base for this economic system is challenging. The only alternative for making materials that normally are derived from fossil fuels is the Bio-Based Economy. Materials in this way get made from biomass, such as sugar cane, sugar beet, and soy, and are called Bio-Based Materials. The switch between producing chemicals and products from fossil resources to producing them from biomass resources has to be done in a sustainable way. In order to achieve this, sustainability criteria for the production of these Bio-Based Materials (BBM) are developed at the moment. It is not known, however, how sustainability criteria influence the development of the BBM sector. The objective of this research is to understand how companies, at different stages of the supply chain of a BBM, are influenced by sustainability criteria.

Therefore, the main research question in this paper is 'How do sustainability criteria in the bio-based materials sector influence companies across the supply chain?'. Three main factors were deemed important to shed light on this question, namely sustainability criteria themselves, mechanisms through which these criteria diffuse through society to the companies, and the responses companies eventually have on these. The factors were formulated into four research questions.

The research questions were answered through describing the societal context in which these companies operate and asking the companies themselves how they deal with this context. Concerning the first factor, it was found that natural resource efficiency, greenhouse gas balance and GMO usage were sustainability criteria that could be institutionalized in the BBM sector. Natural resource efficiency dictates the efficient use of resources such as fossil fuels, primary energy, forests, and animals. Greenhouse gas balance is linked to climate change and dictates that greenhouse gas emissions should be reduced as much as possible. GMO usage might not be a sustainability criteria on itself, but seems to be treated this way by companies. Social sustainability criteria didn't seem to be common. Concerning the second and third factor, companies addressed mostly legislative sustainability criteria linked to biomass when they were a biomass producer inside Europe. Other companies addressed sustainability criteria that were either connected to the company culture or when they were asked by customers.

In the discussion, these elements, natural resource efficiency, greenhouse gas balance and LCA, usage of GMO, social sustainability criteria, and legislation and customer pressure were further explored. First, natural resource efficiency was discussed on general and specific level. Generally speaking it is of utmost

importance that the shift from abiotic resource depletion to biotic resource depletion or impacts is limited as much as possible. Furthermore, the efforts on European level to establish a market that considers natural resource efficiency are noteworthy. Specifically, it was found that a focus on biodegradability was present at the companies. This biodegradability or industrial compostability focus is not necessarily sustainable. Either recycling pathways need to be setup for these kind of plastics or the plastics should be used in specific situations where they are sustainable. The companies in this study addressed this nicely by either working on recollection, recycling pathways or on specific business cases where it makes sense to use the product.

Second, there was a focus on greenhouse gas balance and the usage of LCA in order to prove the greenhouse gas balance. Whether greenhouse gas balance makes as much sense to focus on for Bio-Based Materials (BBM) as for biofuels or bioenergy is debatable. The fact that LCAs are used in the sector is useful. Policies can be set to include targets for BBM. A reformation of the Renewable Energy Directive to include BBM is one of the advices from this report. The Netherlands have a similar mechanism (SDE+) in place which should also be extended to BBM.

Third, there was a focus on not using GMOs in production. Although this might be necessary from the companies standpoint, it helps the institutionalization of not using GMOs in the BBM sector. This might affect future development in a negative way. The Netherlands is preparing to enter this debate and companies are advised to do the same.

Fourth, Social sustainability criteria are only moderately taken into account by the sector. The Netherlands has a leading role in developing and stimulating certification systems for BBM with its own NTA 8080/81. The certification need for biomass can be circumvented, however, by using locally produced biomass.

Fifth, legislation in the Netherlands concerning environmental and social sustainability criteria is advanced. Companies take these into account. Through customer demand, other sustainability criteria are also taken into account by companies. The government should take this more into account than it has in the past and use it towards the benefit of sustainable development and market formation. Several suggestions were made at the end of this work.

The findings in this report point out that the Netherlands has a strong focus on sustainability in the BBM sector. The development of criteria and support of certification is noteworthy, but these do not equal actual sustainable development yet. This is especially the case when considering the end-of-life phase of BBM. Extra efforts are needed to stimulate the market and sustainability at the same time. This report ended with some recommendations and identified opportunities.

Chapter 1: Introduction

1.1 Bio-based economy

The **Bio-Based Economy (BBE)** "encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy" (European Commission, 2012). This is in contrast to an economy that uses fossil resources such as petroleum, coal and natural gas as inputs. These two are extremes on the same line. Currently, products are considered to be within the bio-based economy if a significant part of it is sourced from renewable biological feedstocks.

The main driver for the adoption of a BBE is to reduce our dependency on fossil resources (Pfau et al., 2014). Fossil resources are finite and becoming harder to acquire while biological resources are renewable. In the light of sustainable development, switching to renewable resources instead of finite resources is essential. "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland et al., 1987).

Additional drivers for adoption of the BBE are explained by Langeveld et al. (2010). They include reduction of greenhouse gas (GHG) emissions, contribution to regional economic development, and diversifying energy resources. The first driver is seen as a direct consequence of using plant biomass. Plants store carbon dioxide from the air into biomass and, thus, work as a carbon sink. Converting this biomass into fuels and burning it for energy could theoretically release the same amount of carbon dioxide as was initially stored. Using the biomass in non-fuel products, sequesters carbon that does not get released again, unless the product is incinerated at the end of its life. The second driver reflects a potential benefit of high employment provision by a BBE as happens in Brazil and the revitalization of rural communities. Finally, diversifying energy resources is necessary to be able to replace fossil fuels. Bioenergy is one of the components in a potential renewable energy mixture including solar and wind, that is not dependent on fossil fuels. Other drivers include secure supply of commodities, environmental concerns, economic benefits, and food security.

The previous references mainly talk about BBE as providing renewable bioenergy and biofuels (Langeveld et al., 2010; Pfau et al., 2014). However, the BBE, includes "the sectors of agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries" (European Commission, 2012). Most of these are well known and established sectors. Each of them with their specific sustainability issues.

Agriculture, forestry, fisheries, food, pulp and paper are sectors that have never used fossil resources as primary input, but always biological feedstocks. This is slightly different than the new emphasis of BBE which is on alternative products to fossil based products.

This thesis addresses non-fuel products or **BBM**. From here on, BBM refers to materials of all kinds, used in industry or sold in/as commercial products, that are derived in part or wholly from processed biological feedstocks (biomass). Examples of BBM are chemicals such as ethylene and isobutanol, polymers such as Poly-Lactic Acid (PLA), polyethylene (PE), and polyhydroxyalkanoate (PHA), enzymes such as casein, composite materials enforced with flax and hemp, wood materials from alternative sources such as straw, which are all produced from biological feedstocks.

One of the countries that invests in developing a BBE is the Netherlands. The bioeconomy in the Netherlands created an added value of 2.6 to 3 billion and around 31.000 jobs in 2011 (excluding food and feed sectors) (Smit et al., 2014). Sixty percent of forestry, forest services, textile, clothing and leather industry, fiber industry, wood, pulp and paper industry added value was bio-based (2.0 to 2.4 billion). A small part of the bio-based added value comes from the chemicals sector (0.5 billion). Biogas, solid and waste biomass take up a negliglible part of the energy sector (70 million). The chemicals and energy sectors are mostly based on fossil resources. It is expected that the Dutch chemicals and energy sectors will grow considerably in the years to come. On a larger scale, the entire bioeconomy, including the food, feed and beverage industries, in the EU generated around 2.1 trillion EUR (Piotrowski et al., 2016). Excluding forestry, agriculture, food, feed and beverage industries the EU BBE generated 600 billion euro. The Netherlands ranked 10th in size concerning turnover in EU member states, and 16th concerning its bio-based share in the chemicals sector (Piotrowski et al., 2016). These numbers show that the Netherlands still have some work to do to be a top contestant concerning bio-based chemicals and energy in Europe. However, continued efforts to establish a BBE in the Netherlands make it an interesting country for research.

1.2 Bio-based materials

A normal generic supply chain for BBM is following. There are biomass producers, biomass processors and end-product manufacturers or sellers. In between them are logistics companies. This supply chain is depicted in figure 1.1.

One example is the supply chain for PLA. The feedstocks or biomass (e.g. sugar cane, sugar beet, corn, tapioca, etc.) are converted into sugar. From sugar, lactic acid or lactides are produced. Eventually these lactides form the basis of PLA which is a polymer of lactides. PLA can be sold as such and/or used to produce other consumer end-products. PLA is an example of a bioplastic. Bioplastics, an important commercial bio-chemical right now, have a small but significant market share already in the global plastics market (Waltz, 2008). Each step in this pathway is being heavily researched and has to be improved in order for the BBM sector to become profitable and resource efficient.

The main driver for the use of BBM is the same as for other bio-based products, namely to reduce fossil resource dependency. However, there are also different drivers for adoption of BBM in comparison to the bioenergy and

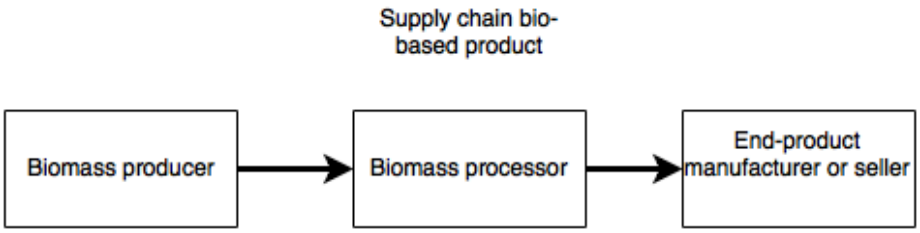

Figure 1.1: A generic supply chain for a BBM. Biomass producers produce the raw feedstocks. Biomass producers are sometimes also partly biomass processors, processing the raw biomass into more usable forms. Eventually, the end-product manufacturers and/or sellers are at the end of the chain having direct contact with consumers.

biofuels sectors. For example, it is said that BBM sequester more CO_2 per hectare, that they lead to higher employment, and that BBM have higher profit margins than biofuels (Philp, 2015). This is partly already reflected in the Netherlands by the added value of the bio-based chemicals industry, which is estimated at around 500 million euro, in comparison to that of the biofuels and bioenergy sector, which is around 70 million (Smit et al., 2014). The bio-based materials sector comprising of forestry, textile, clothing, leather, wood and paper industry even accounts to the majority of added value, around 2 billion euro. In the past three years, more than 1.5 billion has been invested by governments and private organizations, of which 1.1 billion were for bioenergy (Minister Kamp, 2015). This shows a rather disproportionate focus on bioenergy.

The transition towards a BBE is generally expected to increase sustainability in our economic system, but the BBE is not inherently sustainable. This becomes clear when looking at the many problems formulated around the BBE (Pfau et al., 2014). The major problems, based on the number of scientific papers describing them, were identified by Pfau et al. (2014).

- It is expected there will be an increase in competition for land and for resources.
- The proposed reductions of emissions associated with BBE are often unclear.
- And finally, the intensification of biomass production poses heavy environmental pressures.

These three examples are few of many problems and conditions formulated. An example that entails all three factors is ongoing in Western Europe. Currently, bioenergy, which is in the UK, Denmark, Netherlands and Belgium mostly burning wood pellets for electricity, is receiving a lot of criticism (Boulet, 2016). This practice tends to be more expensive, leads to higher usage of biomass out of forests in Canada and the USA, and leads to a carbon debt (forests get used up more quickly than they can store carbon). Especially the import of biomass for electricity actually offsets the major benefit of independence from fossil resources that the BBE offers. Recently it seems the Belgian government is not going to support these kind of subsidies for bioenergy anymore (Belga, 2016).

Pfau et al. (2014) pose that a positive impact of the BBE is not self evident, and that sustainability should be the central topic when researching the BBE. This has been extensively researched and discussed with bioenergy and biofuels. Therefore, the focus of this thesis is on sustainable development of (non-fuel) Bio-Based Materials. One concept that helps with sustainable development is the formulation of sustainability criteria.

1.3 Sustainability criteria and indicators

There are multiple ways to try to guarantee the sustainability of the BBE. One concept that is commonly used is the formulation of sustainability criteria. The definition of sustainability criteria by Fritsche et al. (2012) is adopted in this thesis. Criteria are

> "'second order' principles that add meaning and operationability to standards/principles without being a direct measure of performance."

Criteria are derived from standards and first order principles. These standards and principles are concepts from ethics, morality, tradition and knowledge in general. From criteria, indicators are derived. Indicators in turn are defined as:

> "Quantitative or qualitative factors or variables providing means to measure achievement, to reflect changes, or to help assess performance or compliance, and -when observed periodically- demonstrate trends."

Indicators as such are measures for criteria. For example, it is deemed that biodiversity is a good thing and loss of biodiversity is a problem. Therefore, there is a principle about biodiversity. The criterion here is conservation of biodiversity. Indicators of this criterion are, for example "conservation of land with significant biodiversity values" (measured by hectares) and "land management without negative effects on biodiversity" (reflected by use of certain cultivation practices). In order to make this more clear, a table is provided with a range of examples of criteria and indicators to determine the sustainability of bioenergy production from Fritsche et al. (2012).

Criterion	**Indicator**
Sustainable resource use	Land use efficiency
Biodiversity	Conservation of land with significant biodiversity values
Climate protection	Life cycle GreenHouse Gas (GHG) emissions and direct land use changes
Soil quality	Avoid erosion
Water use	Water availability and use efficiency
Limited airborne emissions	Emissions of sulfur dioxide equivalents
Food security	Price and supply of national food basket
Social use of land	Allocation and tenure of land
Healthy livelihoods and labor conditions	Adherence to ILO principles for labor rights

Table 1.1: Results from Fritsche et al. (2012). Criteria and indicators to assess the sustainability of bioenergy production.

Sustainability criteria are used in almost every setting that is prone to sustainability discussions or conflicts. They can be used for example by regulative

authorities, standards, subsidies, or as part of sustainability assessment frameworks. Authorities use criteria and indicators to set conditions and requirements to industrial sectors or companies specifically to guarantee sustainability. Standards consist of criteria or norms that have to be met. Standards can be voluntary or linked to legislation. Subsidies require companies to comply to certain criteria in order to acquire the grant. Sustainability assessment frameworks, of which life cycle assessment (LCA) is most noteworthy, use criteria and derived indicators to assess certain products or processes concerning sustainability. Generally speaking, sustainability criteria can be used as a tool to safeguard sustainable production and sustainable products in a developing industrial sector (Pavlovskaia, 2015).

Sustainability for biofuels and bioenergy has been given a lot of attention. This is not so for the BBM sector. The development of sustainability criteria for the BBM sector has been lagging behind. This is logical as the biofuels sector is much bigger than the BBM sector and policy in Europe has been focusing heavily on bioenergy and not on BBM (Philp, 2015). The development of criteria is being done at this moment. Some criteria are already developed in the Netherlands. However, it is not known whether they are (or will be) effective. Although it is claimed sustainability criteria do safeguard sustainable production in the bioeconomy, if and how the sustainability criteria do this is not known. This is an interesting topic with the young developing sector of bio-based materials.

A brief overview of sustainability criteria identified by academic research is given in appendix C together with the 'umbrella' sustainability criteria that are used in this research. These umbrella criteria are necessary to link different terms used by different actors in this research to the same concepts. An actor which talks about recycling has a similar focus as an actor which talks about composting, i.e. natural resource efficiency. For a more elaborate explanation of this see appendix C.

1.4 Relevance of sustainability criteria

1.4.1 Scientific and societal relevance

Sustainability indicators are a point of interest to scholars because they are used in sustainability assessments. Here, indicators are measurable characteristics derived from criteria. Criteria, parameters and indicators are often used interchangeably. For policy and decision makers, criteria and indicators are considered to be central in order to develop sustainable bioenergy and biofuel markets (Hecht et al., 2009). Even more, Waas et al. (2014) stated that sustainability indicators and sustainability assessments are necessary in decision-support for sustainable development. In this way, decision making (e.g. managers and policy makers), sustainability assessment, and sustainability criteria are closely linked.

This was confirmed by Lehtonen et al. (2016), stating that criteria and derived indicators are 'boundary' objects which connect policies, science and society. "The ability of indicators to connect science, policy and society stems from their flexibility, ambiguity, and even vagueness, which allows them to have meaning in these distinct social worlds, but also be stable enough to travel back and

forth between them" (Lehtonen et al., 2016). Currently, sustainability criteria for BBM are developed and worked with by several societal actors. Companies and scholars already perform LCAs on BBM. Governments (EU and the Netherlands) are supporting the development of certification systems for biomass and might eventually take up these criteria in legislation (see chapter 5). Several non-profit and for-profit organizations are trying to provide information on sustainability and guide the sustainable development of the BBM sector. Therefore, sustainability criteria are definitely 'boundary' objects. Because the BBM sector is a developing field that has a strong focus on sustainability the progress of sustainability criteria as boundary objects has to be tracked and researched. The current research here adds perspective to this progress.

For bioenergy and biofuels, several researchers have proposed sustainability criteria or frameworks for selecting sustainability criteria and indicators (Fritsche et al., 2012; Fritsche and Iriarte, 2014; McBride et al., 2011). Most, if not all, of these criteria are covered by the umbrella criteria of this research (see appendix C). When researching the sustainability criteria, important or relevant criteria are usually identified through expert surveys or questionnaires. Buchholz et al. (2009), Van Dam and Junginger (2011), and Markevičius et al. (2010) are research examples in which questionnaires or surveys are used to rank criteria or indicators for bioenergy according to for example importance, relevance, or practicality. Greenhouse gas balance and energy balance are consistently ranked as important for bioenergy (Buchholz et al., 2009; Markevičius et al., 2010; Van Dam and Junginger, 2011). These types of research look at identifying as much criteria as possible for bioenergy and biofuels to cover all social, economic and environmental impacts. These broad criteria are eventually to be used in policies, certification systems, or sustainability impact assessments.

Efroymson et al. (2013) states that using a broad generic set of indicators (to assess sustainability for biofuels) can be a barrier to the usage of said indicators. This is because it takes time and high costs to use a lot of different indicators and these indicators might not be relevant to the case in question. Therefore Efroymson et al. (2013) propose to see sustainability impact assessments (and indicator selection) always in the context of which it is performed. "The context of a sustainability assessment includes the purpose, the particular biofuel production and distribution system, policy conditions, stakeholder values, location, temporal influences, spatial scale, baselines, and reference scenarios" (Efroymson et al., 2013). Especially when it comes to decision makers they need to understand the context of the indicators and the sustainability assessment. According to Dale et al. (2013b) the context and clear transparent communication about criteria selection and impact assessments is central to provide relevant and clear information to decision makers.

In conclusion, this section started of by pointing out that sustainability criteria are 'boundary' objects between science, policy, and society. Knowing how these objects function is interesting to scholars and decision makers. The progress and development of these boundary objects have to be tracked and researched both from a practical and theoretical standpoint. This research tries to add perspective to the practical side of the BBM sector development by performing an Industrial Ecology analysis using a sociological theory. Lehtonen et al. (2016) looked at the influence of sustainability indicators as boundary objects on governance processes by using a policy viewpoint. **The current research follows this line of thought, but takes an Industrial Ecology**

standpoint by looking at the influence on companies. This Industrial Ecology standpoint on sustainability criteria as boundary objects has not been formulated before. The insights on how companies deal with the criteria are useful to develop efficient criteria for policies and standards. It might also create a more efficient dialogue between companies and policy makers.

In the second part of this section, it was pointed out that enough sustainability criteria are already formulated for bioenergy and biofuels. These sustainability criteria are mostly overlapping with the ones for BBM. However, the context in which these sustainability criteria and assessments exist is necessary to understand results from them and support decision making. Researching the influence of sustainability criteria on companies directly addresses this context. The insights provided by this research should be used to develop sustainability criteria (and derive indicators) that stimulate the development of *sustainable* (!) bio-based materials.

1.4.2 Relevance to industrial ecology

This research is directly relevant to industrial ecology as sustainability criteria are used in sustainability assessment frameworks. A typical Industrial Ecology (IE) tool is the assessment framework known as Life Cycle Analysis (LCA). There are already many environmental criteria used in LCA. Variations include Social LCA (social aspects) and Life Cycle Costing (economic aspects). The development of LCAs for BBM specifically will be crucial in the future to guarantee that products are indeed more environmental friendly. Thus, specific indicators based on criteria for the BBM sector have to be created. This research addresses a first step in this path.

Further, the practical research problem addressed here, is a typical IE problem. This shall be explained by highlighting a few aspects of the problem. First, the BBM sector is an industrial field. It is addressed in this proposal as a socio-technical system, containing technologies embedded in social structures. To highlight this even further, the BBM sector shall be looked at as a collection of companies that produce a certain product and all actors that possibly influence these companies. The most convenient way of doing this is by looking at a supply chain of a certain representative product. That is why the BBM sector here shall be approached by such a representative supply chain. Second, the impacts of these industrial systems is the central research theme in IE. In this proposal, the impacts of the BBM sector are addressed by the sustainability criteria. Although a sustainability assessment might be enough to classify a research work as IE related, it is the target of this research to take a holistic perspective on the BBM sector to put sustainability criteria and sustainability assessments into perspective. Third, IE uses specific principles to analyze, design and eventually stimulate sustainable industrial processes. One example of a central principle in IE is that of waste cascading. Usage of wastes or by-products is also central in the BBE. When using biomass, different by-products are often created and can be used in other processes by other companies. This is the central concept with biorefineries. Biorefineries integrate processes that convert single biomass sources into a range of bio-based materials (chemicals, materials), biofuels and bioenergy (power, heat) analogous to petroleum refineries producing chemicals, fuels and energy (King et al., 2010). This is exactly done to allow chemicals, as higher value added products, to compensate for low efficiencies in biomass

conversion processes. To allow the design of these kind of industrial systems using waste cascading, criteria for the sector could be of use.

Finally, as stated in the previous section, the practical problem will be addressed from an IE standpoint. This entails that the problem shall be looked at from multiple disciplines. It will take into account aspects from social-science, economy, environment, and technology. The methodology and theory used in this research can be first step towards developing an IE perspective on sustainability criteria as boundary objects. These are relevant to IE because IE inherently looks at society, policy, science, and technology at the same time. A perspective on boundary objects can add oversight on certain processes like criteria development and usage.

Chapter 2: Research Strategy

2.1 Problem

The development of sustainability criteria for the bio-based materials sector is ongoing. Some sustainability criteria are already in place in the Netherlands. It is not known, however, if and how sustainability criteria safeguard sustainability across the supply chain of bio-based materials.

2.2 Objective

The sustainability criteria should be developed in relation to the companies and adopted to the specific needs of the sector, while guaranteeing sustainability. The objective of this research is to understand how companies, at different stages of the supply chain of a BBM, get influenced by sustainability criteria and act upon them. This is a first step in order to understand how sustainability criteria can help the sustainable development of the BBM sector. From this objective, the phenomenon at hand becomes clear. Figure 2.1 is a depiction of this phenomenon.

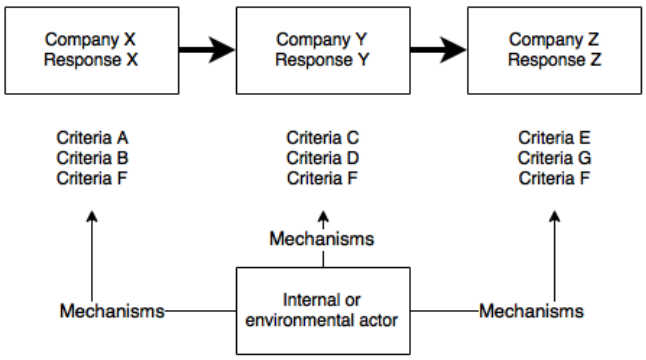

Figure 2.1: The phenomenon that is under scrutiny. Company names are represented by 'Company'-Letter combinations. Company X is a biomass producer. Company Y is a biomass processor and Company Z is an end-product seller. Company X and Company Y are also used outside of this figure, but hold no relevance to it. The different criteria are represented by 'Criteria'-Letter combinations. Actors from society develop sustainability criteria that influence companies. The sustainability criteria are perceived by the companies through a variety of mechanisms. The companies across the supply chain have different responses to sustainability criteria.

2.3 Research phenomenon and questions

The approach in this research is inductive, through research questions. The research questions are related to observations and these help to come to more general insights. The following main research question shall be used in order to reach the stated objective:

How do sustainability criteria in the bio-based materials sector influence companies across the supply chain?

From the phenomenon (see figure 2.1), it becomes clear that every criterion comes from an actor, every actor has its mechanism, every company has its response. These three factors shed light on how companies currently get influenced by sustainability criteria. In order to answer the main question there needs to be clarity about the separate stages depicted in the figure. These separate stages are investigated through subquestions. Solving these will help answer the main question. Following subquestions were derived:

1. Which are the sustainability criteria currently influencing companies in BBM supply chains?

2. Through what mechanisms do the companies perceive the sustainability criteria?

3. What are the different responses to the sustainability criteria that companies have?

4. Which sustainability criteria and mechanisms influence sustainable processes and production positively?

2.4 Approach & line of reasoning

In this research, the phenomenon at hand is how companies in a supply chain of the BBM sector perceive and act upon sustainability criteria. This is a decision-making phenomenon. Qualitative research is deemed appropriate to investigate the 'why' and 'how' of decision making. Furthermore, exploratory research is performed when there is not much known about the phenomenon. An exploratory research tries to gain insight with the research questions, but does not try to provide ultimate solutions to the problem. Therefore, the research here shall be qualitative and exploratory in nature. Furthermore, the preferred way to study the topic is the case study. Why this is the preferred method is explained in the case study methodology section (chapter 3). What is necessary to know in this section is that companies in a supply chain of a BBM will be contacted.

As stated above, the approach in this research is inductive. By proposing specific research questions in the beginning of the research and following them throughout, observations achieved by answering the questions will help gain insight into the phenomenon at hand. In the following sections, the research questions are shortly explained together with the logic which will help answer them through the use of the case study.

1. **Which are the sustainability criteria currently applicable to companies in BBM supply chains?** In order to identify the influence of sustainability criteria on the companies in the supply chain, the sustainability criteria that presently influence the companies are identified. This step is, thus, a compilation of sustainability criteria specifically for the companies in the case study. This compilation shall be performed by looking at secondary data and interviews to help us find the sustainability criteria that are currently used. It's not the intent of this research to make an absolute list of sustainability criteria that should be used to develop sustainability assessment frameworks, legislation, standards, etc.

2. **Through what mechanisms do the companies perceive the criteria?** In question 1, sustainability criteria that are perceived by the companies are identified. The core of question 2 is how these criteria are perceived. Different criteria will find its way to companies through certain mechanisms. Mechanisms have already been theorized or empirically found in academic research. These mechanisms shall be identified in academic literature, and then their presence in the BBM sector shall be either confirmed or denied by contacting the companies.

3. **What are the responses to the criteria that companies have?** The case study shall be supply chains of BBMs. That way, the difference in adoption of different criteria between the companies shall also be taken into account. Companies at the end of the supply chain might take up more criteria that are apparent to users, such as certificates with labels. Companies at the beginning of the supply chain shall, most likely, look at criteria from policies and subsidies. The responses versus the sustainability criteria shall be determined by contacting the companies.

4. **Which sustainability criteria and mechanisms influence sustainable processes and production positively?** In this final question, the currently used criteria (question 1) that have a positive response (question 3) shall point at what type of criteria and mechanisms could be most successful in influencing sustainable production. This part is actually the analysis phase in which the collected data shall be scrutinized.

Main question. How do sustainability criteria in the bio-based materials sector influence companies across the supply chain? Insight into what sustainability criteria are present, through what mechanism they arrived or were perceived and the different responses throughout the supply chain will shed light on how sustainability criteria currently influence the bio-based materials sector. If possible, recommendations on how sustainability criteria can help the sustainable development of the BBM sector shall be made.

The only part of the research in which theory has to be used is research question 2 and 3. The theorized (or empirically found) mechanisms through which sustainability criteria influence companies have to be found in academic literature. Potential responses as well. A brief literature review has identified a theoretical field that addresses these kind of mechanisms and responses. This field is addressed in the theory chapter (chapter 4). Before going into the literature research, the case study methodology that will be followed is outlined.

Chapter 3: Case Study Methodology

For the case study methodology, the book by Yin (2003) shall be followed. There are six phases in case study research, as outlined in figure 3.1. First phase is the planning of the research, then the design of the research, the preparation to collect data, the collection of data, the analysis of the data and the sixth stage is sharing the data. These steps are explained in the following section.

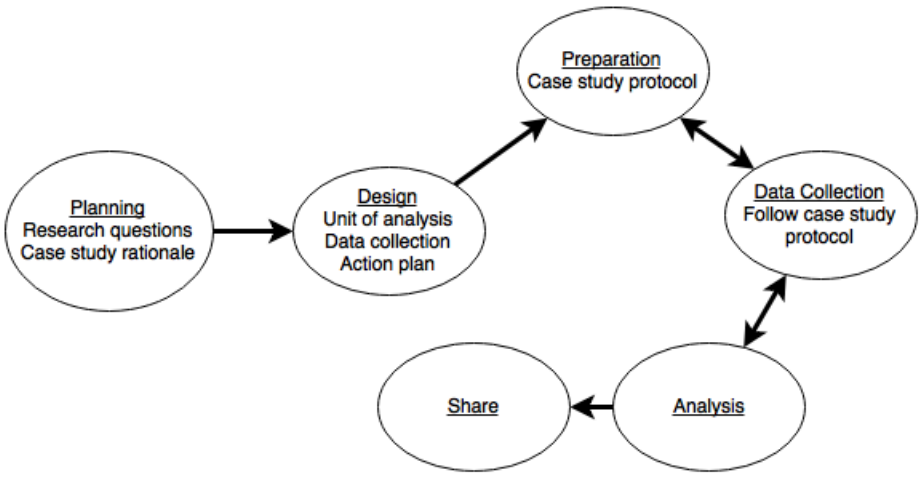

Figure 3.1: Case study methodology. The different steps are explained in detail in the text. This figure is adopted from Yin (2003). The outlined steps will be followed throughout the research.

3.1 Planning

The planning of the research involves mostly formulating research questions and explaining the rationale for choosing to do a case study. The research questions can be found in chapter 2. This section explains the rationale for doing the case study. There are multiple ways of doing social science research such as, experiments, surveys, archival analysis, history search and case studies. According to Yin (2003), there are three conditions on which to choose the research method:

- The type of research question

- The control the investigator has over events
- The focus on historical versus contemporary events.

Case study analysis is used when the research questions are of the type 'how' and 'why', when the analyzer has no control over events, and the focus is on contemporary events. For the current research, the research question is of the type 'how'. This is because this research tries to find out how sustainability criteria influence the BBM sector. Furthermore, the analyzer has no control over the events and the events described are ongoing. Thus, a case study would be fit to answer the research questions and provide insight into the phenomenon at hand.

3.2 Design

The design of the research is the blueprint on how the research should specifically be done. It indicates the unit of analysis, the type of design (single, multiple, holistic, embedded), and what data has to be collected. The latter is described in the action plan. The action plan also tries to explain what has to be done after the collection of the data in order to interpret the findings.

3.2.1 Embedded Case Study

From the main research question it is clear that **the units of analysis** *are companies in the supply chain of a bio-based material.* The material could be manufactured through various technologies and starting from various feedstocks. Based on the typical supply chain described in the introduction, one company producing the raw biomass, one processing the biomass and one selling the final product are preferably interviewed. Thus, the **design** *is a case study of the supply chains of BBM.* With different units of analyses, the companies, embedded in the cases, supply chains. The design is represented in figure 3.2.

The government of the Netherlands is very keen on establishing a BBE and one already established product in the Netherlands is PLA. The companies at all stages of the supply chain are present, although completely Dutch grown PLA does not exist yet. However, PLA is a bioplastic which can be made from sugar beet and there are Dutch companies that produce sugar beet, intermediaries and PLA. Therefore, the supply chain of PLA in the Netherlands seems to be a *representative* case study for the phenomenon at hand. The companies that would preferably be studied are, SuikerUnie (SU), Synbra, and an end-product seller (company Y). Suiker Unie is the biggest producer of sugar in the Netherlands. It produces sugar from sugar beet which it grows itself. Synbra purchases lactides to produce PLA. Synbra effectively produces 100 % bio-based PLA, although the feedstock for this is not sugar beet but sugar cane. The supply chain presented here is, thus, theoretical. This is, however, still representative of a supply chain of BBM that would be produced completely in the Netherlands. Some customers of Synbra or end-product manufacturers of PLA were contacted but were not interested in partaking in the case study. An end-product seller of PLA was interested and was interviewed. This was Company Y (CY). The usage of another supply chain as a case study of a non-bioplastic would be advantageous in this study. It could work as contrast to

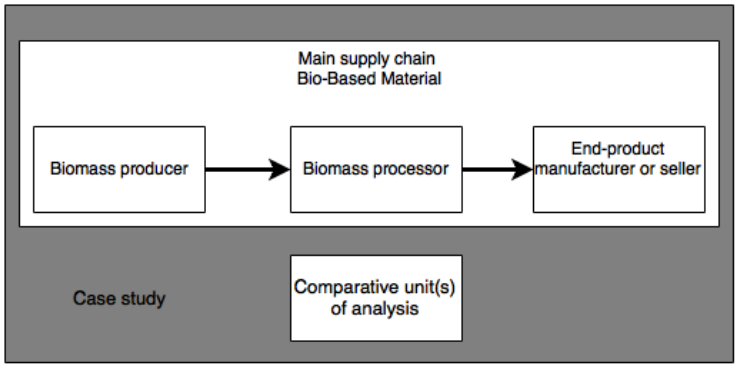

Figure 3.2: The embedded case study is the design of the current research. A case study is a supply chain of a bio-based material in the Netherlands. Within this case there are different units of analysis. The units are companies that take a position within the supply chain, biomass producers, biomass processors and end-product manufacturers or sellers. The main supply chain is actually that of PLA, a representative bioplastic. Comparative unit(s) of analysis that are also companies in the BBM sector in the Netherlands, but not in the main supply chain can be used as well.

the popular bioplastics research topic and give insights on other types of BBM. However, it was not feasible to have a complete alternative supply chain, as can be seen further in the research. However, additional companies that are part of supply chains of other BBM were interviewed. These companies are formulated as comparative units of analysis to the main supply chain and case study. One company is Ecoboards which produces strawpanels. As it is an alternative to current woodpanels and effectively produces panels that are almost carbon neutral, Ecoboards is seen as an interesting unit of analysis. Another company that wanted to be anonymous like Company Y is Company X. Because Company X is a large company producing bio-based products and materials it also provides relevant information.

3.2.2 Action plan

In this action plan, references are made to **the Prepared Lists or PLS** (see table 3.2). These PLS are lists that contain the sustainability criteria present at the companies and the actor from which they come. The actual PLS for every company are given in the results chapters 6 and 7. Furthermore, the actor list contains a list of all actors and the mechanism through which the actor is perceived by companies. The actual actor list can be consulted in appendix B. These lists are a representation of the phenomenon described in figure 2.1, in which every actor puts forward criteria, every actor works through a mechanism, and every company has a response.

1. **Identification of the relevant actors.** Any of the actors connected to the companies shall be listed in the actor list and given an Identification Number (ID). Preliminary contact with the companies is preferably made here to acquire a list of partners and connected organizations. The actors have to be ordered by mechanism type. The different groups of actors

that are responsible for the development and propagation of sustainability criteria identified by Pavlovskaia (2015) can be used as a starting point. These groups are international institutions, states and governments, independent bodies established by states, NGOs, producers, users and research institutions. A simplified representation of the actor list is given in table 3.1.

Result: list of relevant actors

ID	Actor	Mechanism
1	Actor A	Mechanism A
2	Actor B	Mechanism B
3	Actor C	Mechanism A
4	Actor D	Mechanism D

Table 3.1: A simplified representation of the actor list. Actor names are represented by 'Actor'-Letter combinations while the different mechanisms are represented by 'Mechanism'-Letter combinations.

2. **Literature research to identify mechanisms.** In parallel with step 1, a literature study is performed. As this is academic literature, papers and books shall be consulted on the matter at hand. It is expected that in order to find different mechanisms (research question 2) and potential responses (research question 3), academic literature of a specific discipline has to be consulted. The different mechanisms shall make up the categories in which the actors shall be grouped.

   Result: theoretical mechanisms to classify the actors in the actor list (table 3.1) and different potential responses are identified.

3. **Prepare the PLS.** This entails identification of sustainability criteria that presently influence companies in the supply chain. Sustainability criteria, and derived indicators, put forward by the identified actors in step 1, in public documents, policy documents, academic literature, forms (e.g. registration forms for certificates, standards, subsidies) etc. shall be identified and ordered in the PLS. The product of this step is the PLS. This list has to be refined and annotated so that it is comprehensible and usable to conduct interviews and create insights. A simplified representation of this list is given in table 3.2.

   Result: Prepared Lists (PLS), which is a list of criteria

4. **Develop case study protocol.** At this stage, dates for the interviews shall be fixed. The case study protocol has to be developed as a preparation towards the interviews. For more information on the case study protocol see section 3.3.

   Result: case study protocol, interview guideline and description of companies.

5. **Interviews with the companies.** This stage will get all necessary data by direct contact with the companies. The sustainability criteria perceived as important by the companies themselves in the case study shall

Criteria	Actor
Criteria 1	Actor A, B, D
Criteria 2	Actor B, D, E
Criteria 3	Actor A, E
Criteria 4	Actor D, F

Table 3.2: Simplified representation of a PLS. Actor names are represented by 'Actor'-Letter combinations. Multiple actors can push forward multiple criteria towards the company.

be identified. These shall be added to the PLS. Similarities (differences) will indicate that these criteria successfully (poorly) influence the companies. This indicates which criteria by which actors actually influence the companies and what response they have, thereby answering research question 1 and 3. The mechanisms with which the above criteria have been perceived have to be identified in order to answer research question 2. This can confirm or reject whether the mechanisms are in place and, furthermore, which criteria (with mechanism) influences companies variably across the supply chain.

Result: transcripts from interviews.

6. **Identify most successful type of criteria.** Based on similarities and differences between the PLS and the case study, conclusions shall be drawn about what type of criteria and mechanisms were most successful. The most successful criteria and their development methods and propagation mechanisms shall be highlighted.

   Result: written analysis on the results identifying insights into the phenomenon.

7. **Discuss specific insights found in the analysis.** To discuss the insights from the analysis other studies in academic and white literature shall be investigated to see whether these findings can be confirmed in other places. Further insights into how sustainability criteria in the BBM sector influence companies across the supply chain shall be formulated, answering the main research question. Finally, careful recommendations about how sustainability criteria can help the sustainable development of the BBM sector shall be made.

   Result: insights into the phenomenon depicted in figure 2.1, written discussion.

3.3 Preparation

In the preparation phase, the case study protocol has to be developed, candidate cases for the case study have to be screened, and the researcher has to prepare himself by either practicing or conducting pilot cases. The case study protocol

needs to guide the investigator to do the data collection from a single case. The case study protocol should have four parts included.

- Overview of the case study project

  This shall contain the background information on the companies.

- Field procedures

  These contain information on how to gain access to information through the company contacts, making sure there is a recorder during the interviews, a clear schedule in which to do the data collection and try to account for unanticipated events, such as when the representative doesn't have certain information immediately available.

- Case study questions

  This is the body of the protocol. **Questions** are formulated so that they are posed to the investigator themselves and not the interviewee. These are guidelines to help the investigator orient himself while performing the case study. The questions are reminders of the data that has to be collected. The questions then can in turn be accompanied by the **sources of 'evidence'** from where the data can be retrieved. Thus, when wanting to know which criteria are present, a question could be 'which indicators reflecting sustainability criteria are in place?' Sources of data can be public and internal documents and reports that stipulate or report on certain indicators. Thus, these have to be retrieved. There are six sources of evidence that are explained in the data collection part.

- Guide for the case study report

  This is in order to make sure that while writing the case study report, no unexpected outcomes occur. This was taken into account in the research by reiterating a table of contents while discussing the research work with supervisors of the project.

3.4 Data Collection

During data collection the case study protocol is followed. The goal here is to find the sources of evidence. As mentioned before, there are six sources:

1. Documentation
2. Archival records
3. Interviews
4. Direct observations
5. Participant observations
6. Physical artifacts

There are a few principles related to the data collection. Firstly, if possible, use multiple sources of evidence. Second, the information from the case studies also has to be presented in a data base. Finally, maintain the chain of evidence, from research questions, over the protocol, references to specific evidence sources, the case study database, to finally the case study report.

There are two main parts of data collection in this research. The first one is literature research in public and academic documents and archival records. These are secondary data sources, such as journal articles, books, magazines, Internet sources, public documents of the companies, policy documents, certification forms, documents about standards, academic literature, and such. This first part of data collection shall actually be in the preparation phase in order to line out the environment or context of the sustainability criteria and the companies. Second, the actual data collection shall be done by contacting companies and performing interviews with knowledgeable representatives. Preferably, documentation and archival records are also obtained from this contact. This is the actual data collection phase in which presumed effects are compared with what is actually going on. From this it is concluded that direct observations, participant observation and physical artifacts will not be of value in this research.

3.5 Analysis

In the analysis phase, the data is analyzed according to a general analytical theory and with specific techniques. According to Yin (2009), there are four general strategies, namely relying on theoretical propositions, developing a case description, using both qualitative and quantitative data and finally, examining rival explanations. As this is an exploratory study, there would be no propositions immediately. The phenomenon at hand is the influence of sustainability criteria, and while studying this phenomenon, several explanations for the way the criteria influence the companies could be formulated. Therefore, using **rival explanations** in order to gain insight will be prefered here.

The analytical techniques are a part of the general strategy. There are five techniques, namely pattern matching, explanation building, time-series analysis, logic models, and cross-case synthesis. Based on the design of this research, cross-case synthesis (only for multiple case study analysis), logic models (concerns a chain of events), and time-series analysis (single variable) don't seem applicable. **Pattern matching and explanation building** are both possible with using rival explanations. The logic behind pattern matching is that the predicted patterns are contrasted to the empirically found patterns. The wanted result is the alignment of these two. Explanation building is a more elaborate type of pattern building.

Although the analysis might change according to what is found in the preparation phase, it is concluded preliminarily that in this study, **rival explanations will be seen as patterns**. Different patterns of variables (e.g. indicators) are interpreted as explanations. These will be predicted in the preparation phase, and then the patterns will be searched for during data collection. In the analysis phase, these empirically found patterns or rival explanations can, thus, be compared.

3.6 Sharing

Finally, the case study has to be reported. This research will be reported textual in the form of a thesis paper (this document) and visual as a powerpoint presentation to the board of examiners. The chain of evidence will be kept clear throughout the paper in order to provide the reader the opportunity to judge every part of the chain.

Chapter 4: Theoretical Literature Research

The mechanisms that were previously introduced are mechanisms in which sustainability demands are perceived by companies, influence the companies and potentially elicit an organizational response. These demands are formalized as criteria and indicators to measure performance. In the search for theoretic fields handling these kind of mechanisms, it was found that **institutional theory** is useful when looking at organizational responses to external pressures, such as sustainability demands (Jennings and Zandbergen, 1995). What institutions are and the theory around it, is presented below. This research treats sustainability as an outside pressure which is looked upon through sustainability demands (criteria and indicators) set forward by stakeholders.

There is one more reasoning to use institutional theory. Criteria and derived indicators for sustainability assessments often do not include "institutional and policy aspects that are important and relevant for sustainability" (Dale et al., 2013a). And indicators and criteria (and sustainability assessments) have to be seen within the decision making context which "includes the social, political, and institutional framework in which decisions are made."(Efroymson et al., 2013). By looking at the institutional frameworks in which sustainability criteria are present and are used, some insight will be gathered on whether institutional aspects can indeed provide additional information or a contextual overview to sustainability assessments.

4.1 Institutional Theory

Institutional theory handles the concept of **institutions** in social science. In this, "institutions consist of cognitive, normative, and regulative structures and activities that provide stability and meaning to social behavior" (Scott, 1995). It is, however, easier to think of institutions in terms of rules, norms and conventions. Thus, a similar definition is that institutions are "systems of established and prevalent social rules that structure social interactions" (Hodgson, 2011). In our daily life, it is these institutions that enable us to make certain choices and restrict unwanted behavior. In research, social phenomena and events can be described, in part, by using formal and informal institutions. Formal institutions take on explicit forms, such as legislation and the justice system. Informal institutions take on a tacit form. A good example of this is the typical shaming and shunning to indicate unwanted behavior in an implicit way.

Institutions are propagated and developed through social interactions, effec-

Coercive	Normative	Mimetic
governments	*research NGOs*	*internal actors company*
(fiscal, subsidies, legislation)	*committees*	*similar companies*
customers & suppliers	*certifying and standardization agents*	
partners	*trade unions*	
investment organizations	*professional associations*	
environmental organizations	*consultancy companies*	
	educational institutions	

Table 4.1: Three types of institutional actors. Detailed explanation can be found in the text.

tively creating **the institutional environment or context**. This is a context that entails "symbolic and behavioral systems containing representational, constitutive, and normative rules together with regulatory mechanisms that define a common meaning system and give rise to distinctive actors and action routines" (Scott and Meyer, 1994). These actors, that draw their own 'roles' and behavior from the systems that the institutional context creates, also establish the institutional context themselves. Every actor in the context contributes to the creation of it and is at the same time influenced by it and draws meaning from it. They shall be referred to as **institutional actors** from now on. In table 4.1 there is a list of identified actors subdivided by the type of pressure exerted.

Institutional actors are any type of actor inside a pillar, exerting its specific pressure. There are thus, three types of actors, namely the coercive, normative and mimetic pressure actors. Coercive actors are typically governments (subsidies, fiscal benefits, legislation), suppliers, customers, partners, and environmental organizations. The governments have two main ways of exerting pressure, through subsidies (or fiscal benefits) and through legislation. It is expected that legislation does not play a big role yet for the BBM sector. Through subsidies and fiscal benefits, the government can demand the companies to meet certain requirements. In a similar way, investment organizations, associations, or funds invest in certain projects that are aligned with their themes. Suppliers and customers can also have specific demands. For example, if a customer wants to buy only products that meet certain sustainability requirements or meet monetary goals. Environmental or social organizations (NGOs) often highlight problems in society and at companies. By threatening with negative publicity, they can force companies to discontinue certain practices. Normative actors are mainly research NGOs, committees, certifying and standardization agents, trade unions, professional associations, consultancy companies and educational institutions. Actors of the last pillar, cognitive pillar, are those that work on a cognitive level. Therefore, these are more connected to the culture. Examples are internal actors of the firm, or other similar companies.

Companies, and organizations in general, also operate in an institutional context. The institutional context for organizations is **the organizational field**. The organizational field can be seen as a set of "organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar service or products" (DiMaggio and Powell, 1983). Similar to the institutional context, the institutional actors within an organizational field draw meaning from it. The organizational field dictates what appropriate

	Regulative	**Normative**	**Cognitive**
Basis of compliance	*Expedience*	*Social obligation*	*Taken for granted*
Mechanisms	*Coercive*	*Normative*	*Mimetic*
Logic	*Instrumentality*	*Appropriateness*	*Orthodoxy*
Indicators	*Rules, laws, sanctions*	*Certification, accreditation*	*Prevalence, isomorphism*
Basis of legitimacy	*Legally sanctioned*	*Morally governed*	*Culturally supported, conceptually correct*

Table 4.2: Three pillars of institutions as based on Scott (1995). Detailed explanation can be found in the text.

behavior is. Institutional forces on and between organizations in an organizational field leads to structuration (DiMaggio and Powell, 1983). Structuration of organizations and institutions by both organizations and individual actors is a central concept in institutional theory (Tolbert and Zucker, 1999).

4.2 Three pillars of institutions

There are three pillars of institutions. They are shown in table 4.2 with several of their distinctive features. This table and the explanation thereafter frames the three pillars as explained by Scott (1995). Different scholars emphasize different pillars, but all three are present. This is clear from the definitions of institutions given above. Social rules, constraints, conventions, etc. give rise to three distinctive pillars or structures. From these pillars, the systems of rules are created which are institutions.

The regulative pillar is to point at the aspect of institutions that contrains behavior. Regulative processes are the main focus in this pillar. They "involve the capacity to establish rules, inspect or review others' conformity to them, and as necessary, manipulate sanctions-rewards or punishments-in an attempt to influence future behavior"(Scott, 1995). Actors comply on basis of expedience. This means that going against the regulations would be disadvantageous, and thus not wanted. The mechanism of control is clearly **coercive**. Organizations are forced to comply. The enforcement is often done by the government. Organizations don't have to be intrinsically motivated or follow morals in order to comply with the rules. Legitimacy of the rules comes from the legal sanctions or enforcement. Finally, the instrumental logic behind this perspective is that organizations are rational and operate on the basis of cost-benefit analysis. From this analysis, choice is structured around what is *advantageous* or 'in my best interest'. The main actors involved in this pillar are governments, customers, suppliers, and environmental organizations. Governments, for example, have laws in place that limit dumping of toxic substances in the environment.

Most, if not all, companies in the Netherlands comply with this, as not complying is disadvantageous due to fines the government issues in case of non-compliance. For environmental organizations, a good example is that of the Greenpeace-LEGO-Shell case. Greenpeace campagned against arctic drilling by Shell. In one video it used LEGO toys to inform the public. After this was released, LEGO (customer of Shell) discontinued a 50 year partnership with Shell (Vaughan, 2014). Although Shell did not immediately stop with its arctic drilling/testing, it is put in a disadvantage and has to do a cost-benefit analysis (explicit or implicit) on whether or not to continue its operations.

The normative pillar can be misinterpreted as regulative, as the normative rules constrain behavior. But the real nature of this pillar is prescriptive,

empowering social actions. It is different from the regulative pillar because compliance is not based on expedience or incentivised by rationality and instrumentality. It is not in their own advantage that they comply, but it is because of social obligation. Actors comply with the normative systems because of values and norms they share with each other. Values are principles or goals that are regarded as desirable. Norms are rules of conducts. So, not only does the normative pillar indicate what desirable goals are, it also dictates how the goals should be achieved. The mechanism that is appropriate here is that of **normative** processes. Some groups of actors (or even individual ones) have very specific values and norms. This way *roles* are created. Roles "confer right as well as responsibilities, privileges as well as duties, and licences as well as mandates" (Scott, 1995). Based on its role, the actor structures its own choices according to what is *expected* from it.

Normative actors are standardization bodies, certification organizations, consultancy agencies, and international (inter- or non-governmental) organizations. These all have normative influences on companies. They suggest certain standards, principles, criteria or indicators that a company could follow. In the normative pillar there is one additional aspect that is important for this research, namely LCA. LCA is a tool that has a strong normative influence when it comes to environmental impacts. It is an environmental impact assessment tool that is used by academics and companies. Because of its wide use, it is considered a normative influence through professionalization in this research. The impact categories in which the eventual results of an LCA turn out depict the major environmental impacts. The main impact categories are translated in the appendix C to sustainability criteria that can be used for this research. LCA is given a separate status in this research and is taken up in the actor list.

The cultural-cognitive pillar contrasts the two previous pillars heavily in terms of objectivity. Subjective reasoning, based in a social reality, is the basis for social 'action' in this pillar. Compliance here is not willingly or active, but happens because the rules are taken for granted. In contrast to the roles actors can have as part of a normative system, actors have *social identities* in a cultural-cognitive system. Actors devise meaning and make sense from this identity. This seems to reflect mostly on individuals but there are also wider belief systems and cultural frameworks above these individuals and for organizations. The mechanism at hand here is a **mimetic process**. "Individuals and organizations deal with uncertainty by imitating the ways of others whom we use as models"(Scott, 1995). Although this imitation happens implicit.

Legitimacy plays a central role in institutional theory. It is "a condition reflecting cultural alignment, normative support, or consonance with relevant rules and laws" (Scott, 1995). In table 4.2, the indicators for every pillar, indicate the most important elements of legitimacy. For regulative legitimacy, a company has to comply to rules and laws, and undergo sanctions. For normative legitimacy, certification and accreditation by state and professional associations is necessary. The cultural-cognitive legitimacy is measured by the prevalence of "similar individuals or organizations exhibiting a given form or practice" (Scott, 1995). The concept that legitimacy is not only sought after by companies but that it is also relevant for companies' survival is gaining proof. Organizations that resist institutional rules can be seen by the contextual actors as doing things that are unnecessary and may be harmful. Bansal and Roth (2000) have shown that legitimacy is a key driver for organizational ecological responsiveness. Colwell and

Joshi (2013) have shown that this organizational responsiveness mediates the effect of institutional pressures on organizational performance. Furthermore, Berrone et al. (2007) showed that these institutional pressures and reactivity to them can actually be a 'source' for competitive advantages. This supports the idea that legitimacy or the strive for it increases organization's prospects of survival.

4.3 Diffusion and mechanisms

According to three pillars explained above, there are three types of institutional mechanisms, namely coercive, normative, and mimetic.

- The coercive mechanism consists of pressures that try to limit companies' behavior as much as possible through rules, laws and sanctions. These come mainly from legislation and through pressure from suppliers and customers. Typical examples are pollution control targets in industries, and fines and penalties for non-compliance to certain environmental targets. Coercion implies that compliance by companies is motivated by force. The government (state) is a strong regulative agent. But the influence customers of companies have, is also very big as customers' wishes are part of the cost-benefit analysis that companies perform explicit or implicit.

- The mimetic mechanism is the phenomenon that companies or individuals copy other (successful) companies' (individuals') behavior in times of uncertainty. Imitation of more successful and legitimate peers is completely voluntary. Prevalence of certain types of companies in the specific field or industry indicates legitimacy and succes.

- Finally, normative mechanisms occur mainly through professionalization. This happens through interactions with industry peers, pan-industry associations, individual memberships in professional associations, accreditation, influence of standards and certifications. Compliance is not forced with these institutional pressures, but it is deemed appropriate by the professions and companies.

As said before, institutional pressures from institutional actors leads to structuration in the organizational field and within the companies. Structuration through institutional pressures or mechanisms can homogenize the organizations (DiMaggio and Powell, 1983). This was coined **institutional isomorphism**. Isomorphism is apparent in organizational fields and it is the strive for legitimacy by organizations that lets them conduct behavior that is deemed appropriate. Thus, organizations strive for institutional legitimacy and in an aging organizational field this seems to homogenize the field creating isomorphism. Institutional isomorphism is a field level effect. Companies within a field tend to look a like. They tend to incorporate the same practices and behaviors. This is logical as all companies in the field can be subject to the same institutional pressures. However, companies do not always respond in the same manner because they can differ in some field level aspects and organizational aspects. The next two paragraphs discuss some field level and organizational level

aspects. These could have an influence in adoption or rejection of institutional pressures. Individual responses by companies to the institutional pressures are outlined in section 4.4.

There are multiple institutional aspects empirically analyzed (Scott, 1995). The institutional context has a large influence on the organizational structure from the start up phase. The institutional context changes over the years. A company founded in 1960 will have a different organizational structure because it takes different institutions for granted than a company founded in 2010. This aspect can be defined as **temporal embededness**. Another aspect is **the prevalence** of practices, cultures, etc. If a lot of companies within the field adopt one practice, the practice will be seen as legitimate. If a company perceives its reality as uncertain, it will mimic (mimetic process, cognitive pillar) other companies and take over the practice.

Finally, the institutional context is not necessarily painting a coherent picture. Organizations can get conflicting demands from their context. These conflicting demands makes the environment for companies complex and uncertain in terms of what is legitimate behavior. This complexity is termed **institutional complexity**. This complexity and subsequent influence can explain differences among organizations in the same field. This is a concept frequently used in the field of institutional logics. For more information on institutional complexity, consult the review by Greenwood et al. (2011). There are several important aspects to institutional complexity, mainly fragmentation, consistent support by certain actors, formal structuration, visibility (often correlated with company size), vulnerability and location (central vs periphery) (Scott, 1995; Greenwood et al., 2011).

4.4 Results of institutional pressures

Depending on the mechanisms through which institutional pressures are exerted and depending on the field level and organizational aspects, companies will react in certain ways to specific demands or pressures. There are five general strategies of companies in response to institutional pressure, namely acquiescing, compromising, avoiding, defying, and manipulating (Oliver, 1991).

- **Acquiescense** is the most straight forward response. The institutional demands get internalized. In terms of sustainability demands, criteria and indicators reflect the institutional pressures.

- **Compromising** is a response in which there is negiotiation between the company and institutional actors exerting the pressure. This is likely where there is high institutional complexity.

- Next, **avoidance** is a response in which the company shall try to divert the impact of the institutional pressure away from the company. This can be done by *decoupling company structures from activities*. With decoupling is meant a phenomenon in which companies "decouple their formal structure from their production activities when institutional and task environments are in conflict, or when there are conflicting institutional pressures" (Boxenbaum and Jonsson, 2008). This kind of decoupling allows the company to keep doing what they do while at the same time being perceived as

more legitimate. Thus, it is a form of superficial conformity. Decoupling is a major theoretical construct in institutional theory. Sometimes, only conformity and decoupling are researched. To keep our broad perspective, decoupling is seen as an avoidance strategy in this research. Decoupling occurs when the efficiency of adoption of the institutional demand is questioned (Boxenbaum and Jonsson, 2008).

- The second to last strategy is **defiance.** The company defies the pressure. By doing so it stands out and perhaps this is their main focus. In defying institutional pressures the company tries to define what is legitimate themselves. This can be very strategic. Large companies, with enough power and influence, can become 'trendsetters' in this way.
- Finally, **manipulating** institutional pressures is also a straight forward response. Here, the companies try to exert power and influence in the other direction in order to change its institutional environment or the organizational field.

4.5 Institutional theory and industrial ecology

This research does not contribute to the field of institutional theory. Rather it focuses on using institutional theory to look at influences between society and companies. Institutional theory is adapt at doing this. However, clear metrics are difficult to find, leaving a lot of researchers up to their own devices. The research presented here can be seen as an exploratory research in which the usage of institutional theory in a practical research setting is part of that exploration as well. This could contribute to the field of Industrial Ecology to provide insight into how to use institutional theory in a practical and fast way to study complex systems without losing the holistic perspective.

IE heavily relies on material or physical impact assessments. But to institute change in our current physical systems, the social systems need to be analyzed and understood as well. This was formulated by Hoffman (2003):

> "Tools such as life cycle, material flow, input/output, and industrial metabolism analyses can aid in the whole-scale systemic analysis of the material aspects of industrial systems. But to implement the solutions they uncover, they must be augmented with tools and disciplines that consider the dynamics of social systems. Systemic environmental solutions require a tie between technical and social systems. They require linkages to the social science disciplines previously outlined."(Hoffman, 2003)

Hoffman (2003) further proposed institutional theory to add perspective to IE as a discipline covering sociology and organizational studies. So far, institutional analysis in IE (mostly related to the concept of industrial symbiosis) has focused mostly on government involvement (Walls and Paquin, 2015). As stated in the introduction, the effect of sustainability criteria as boundary objects on governmental processes has been investigated before. Effects go both ways though.

4.6 Summary

To recap, institutions are rule systems. Institutions structure social behavior, give meaning and purpose, and distribute roles. They have three distinctive structures or pillars on which they are based, namely the regulative, normative and cultural-cognitive pillars. Every social actor works in an institutional context. For organizations, it's possible to rephrase this context as the organizational field. In this organizational field, suppliers, similar companies, governing agencies, stakeholders and such all have demands. These demands are institutional pressures. Depending on the character of the institutional actor and the specifics of the demands, specific demands can be bundled under one of the pillars. The pillars have specific mechanisms through which the diffusion of the institutions happens, namely coercion, normative and cognitive mechanisms. The institutional pressures, thus, influence the companies through these mechanisms. Depending on certain aspects in the organizational field and on aspects of the company itself, the company shall have some kind of response. Above were outlined five strategic responses, namely acquiescing, compromising, avoiding, defying, and manipulating. In the next chapter, the organizational field shall be outlined, keeping in mind some of the important aspects that were explained in this chapter. Afterwards, the results from the interviews in the case studies are organized, followed by answering the research questions and a discussion.

Chapter 5: Organizational field

The BBM sector is the organizational field under scrutiny. The companies within are being influenced by sustainability criteria set up by actors. It is the previously mentioned mechanisms (see section 4.3) that institute diffusion of criteria. When facing pressure to adopt criteria, companies can choose several strategies to cope with the pressure. The institutional actors, that belong to a type of institutional pillar, exert pressures according to that pillar, thus, effectively supporting that pillar. The three pillars, or rather their diffusion mechanisms are described using the actual institutional actors that are found in the data collection. The actors are listed in appendix B. The next chapter summarizes the information found in the case studies.

5.1 Coercive mechanism

Actors representing the regulatory pillar, and thus exerting coercive pressure, are governments, customers (consumers), and environmental/social organizations. Governments can influence through legislation, subsidies and fiscal measures. Consumers are represented by consumer organizations which are interest groups that represent and inform consumers. Consumer demand is also a factor but is difficult to find numbers about and it is also difficult to use it here as a single actor. Environmental/social organizations stress sustainability issues and heavily influence companies to 'do the right thing'.

5.1.1 European

Legislation

In Europe, there is a policy that includes bio-based energy and fuels. This can be found in the Renewable Energy Directive (2009/28/CE) (RED). The RED states that member states of the EU have to get at least 20% of total energy needs and 10% of transport fuels out of renewables by 2020. Another related directive is to reduce indirect land use change for biofuels and bioliquids ((EU)2015/1513)). For bio-materials there is no legislation. However, on the 7th of March 2011 a mandate was issued for European Committee for Standardization (CEN), European Committee for Electrotechnical Standardization (CENELEC) and European Standardization Organization (ETSI) to establish a committee on bio-based products and a single standard for bio-based products (European Commission, 2011). The mandate states that sustainability criteria for BBM should be developed in 2016 by CEN. More on this can be found in section 5.2.2.

The main sustainability criteria for biofuels out of the RED are that the biofuels have to have greenhouse gas savings in comparison to fossil fuels (35% in 2009, 50% in 2017 and 60% in 2018) and that the biomass cannot be grown on high carbon stock land (wetlands, forests) or land with high biodiversity (primary forest or highly biodiverse graslands) (European Parliament, 2009a). There are no social sustainability criteria, other than the European Commission has to report on the situation of social aspects in to the European Parliament and the Council (European Parliament, 2009a). Although this is for biofuels it seems that these criteria are easily applicable as well for bio-materials, and eventually for all biomass. There are numerous voluntary certification schemes that are recognized officially by the European Commission in the RED, such as the International Sustainability & Carbon Certification agency (ISCC) certificate, Bonsucro EU (Bonsucro) certificate, Round Table on Responsible Soy (RTRS) certificate, Roundtable Sustainable Biomaterials (RSB) certificate, and the NTA8080 standard (Netherlands, NEN). These voluntary schemes can be used to show that a company complies with sustainability criteria necessary to receive public support and count towards mandatory national renewable energy targets. In this way, the normative certification systems also exert coercive pressure when linked to legislation.

Subsidies and fiscal measures

Laws and legislation are not the only form of coercion. Government subsidies or tax reductions are also ways for the government to put pressure on the industry. In Europe there is quite a lot of money available for the BBE. For example, in between 2014 and 2020, 3.8 billion was given to the Joint Techology Initiative Biobased Industries (JTI BBI), of which 1 billion came from Horizon 2020 (Europa Nu, 2016). Horizon 2020 is an European Union Research and Innovation programme which has about 80 billion in available subsidies (European Commission, 2014). JTI BBI is a Joint Technology Initiative which is a European partnership between public and private organizations to perform a research agenda. The private organizations are gathered in the Bio-based Industries Consortium (BIC). JTI BBI will demonstrate value chain projects, stimulate R&D projects, and support projects that help the value chains become a reality. Value chains that are focused upon also include BBM. Apart from resource efficiency and mentioning the presumed benefits for sustainable development, all action points and publications by the JTI BBI or BIC concern the setting up of the market. The focus here is with increasing the competitiveness of Europe, resource efficiency, Research & Development, innovation, technology and building supply chains. Sustainability does get mentioned once in a while, and it is expected the developments of the bio-based products and value chains will induce carbon emission reductions. Sustainability criteria are not addressed directly by JTI BBI, but within the Horizon 2020 programme there is some attention for sustainability schemes for the bio-based economy. The predecessor of Horizon 2020, 7th Framework Programme for Research and Innovation (FP7), included standardization for bio-based products (see section 5.2.2).

Consumer pressure

On European level, two big consumer organizations are Bureau Européen des Unions de Consommateurs (BEUC) and European Association for the Coordination of Consumer Representation in Standardisation (ANEC) (European Commission, 2016). These are umbrella organizations representing national consumer organizations. BEUC is the umbrella organization for 40 European consumer organizations from 31 countries. No position papers or articles at BEUC address BBM. ANEC works on standardization on European level so has mostly contact with CEN, CENELEC, and ETSI (see section 5.2.2). ANEC has no immediate task forces on BBE, but did respond to the Green Paper on Plastic Waste (ANEC, 2013). An interesting stand point found here is that they do not find consumer information powerful in regards to sustainable development. "Experience shows that consumer information is generally a weak lever to promote sustainability. It is inadequate to shift political responsibility on the shoulder of consumers. It is unlikely that consumers will make a significant contribution to resource efficiency."(ANEC, 2013). Furthermore, they advise to make a legally enforced distinction (e.g. standards) between naturally compostable and technically biodegradable plastics. They point out that consumers don't know the difference and that there needs to be a separate collection system for technically biodegradable plastics, which doesn't exist at the moment. In terms of sustainability they stress that BBM still compete with food production and may promote deforestation, meaning that BBM may not be sustainable. These consumer organizations' influence works more on legislation level than on consumer level, and thus, it is presumed here that they have minimal direct influence on companies. However, it must be noted that end-of-life concerns of plastic (natural resource efficiency) is one recurring criteria.

Environmental and Social Organizations

Environmental and social organizations can bring to light certain aspects of production that are unsustainable. In this way, they contribute to the dialogue and highlight sustainability criteria that need to be met. The topics these organizations address can be very specific or more general. La Isla Foundation (LIF) is a Non Governmental Organization (NGO) that works on a very specific topic, namely chronic kidney disease of non traditional causes with sugarcane workers in Latin America (La Isla Foundation, 2016). It is supported as well by the Solidaridad network (see section 5.1.2). There is growing scientific evidence that this disease is occupationally caused (Raines et al., 2014). This means that sugarcane workers might have a higher risk of getting chronic kidney disease because of working conditions at sugarcane farms. This is a social aspect that needs to be addressed in the supply chain.

European Environmental Bureau (EEB) focuses on the EU to represent 150 member organizations of 30 countries in environmental issues. EEB responded to the same communication as ANEC, namely the Green Paper on Plastic Waste (European Commission, 2013; EEB, 2013). Here they also supported a legal enforced distinction between technically biodegradable and compostable products. Furthermore, they also stressed in the same way that it has to be proven first that the bio-based plastic is sustainable.

5.1.2 Netherlands

What needs to be mentioned from the start is that the document, declaring the medium-long term vision of the government on the supply chain of sustainable biomass for the BBE was declared controversial in 2012 (BBE, 2012). A new one doesn't seem to have been constructed yet. On a national level, the Dutch government does intend to establish a bioeconomy. Together with companies and some NGOs the government signed the 'Manifest (of) Biobased Economy', in which was declared to research and collaborate together to install the BBE in the Netherlands. This happened in 2011, but it does not include any demands, state any objectives, nor does it give any concrete goals.

Legislation

In the Netherlands there are already legal regulations for biofuels and biomass for bioenergy. These are based on the European RED. Sustainability criteria for solid biomass for energy are expected to be taken up in legislation by 2017 (Voorzitter van de tweede kamer, 2016). Until then, companies have to report on the used biomass and how it is certified or verified. Biomass for coal powered stations and industrial steam has to comply with sustainability criteria to be eligible for subsidies (which they need) (Voorzitter van de tweede kamer, 2016).

For bio-based materials, there are only specific sustainability criteria when it concerns specific industries such as agriculture, or the pulp and paper industry. For the bio-based materials in the chemical industry, there are only voluntary systems in place (Minister Kamp, 2013). It is the ultimate goal of the current government to have an international system with agreements on sustainability criteria that cover the entire supply chain of bio-based products (Voorzitter, 2014). The government wants to expand sustainability criteria for all biomass producing or biomass processing industries and has developed and aided several national and international initiatives in order to do so. The main initiatives and organizations are the NTA 8080/8081 norms, Nederlands Normalisatie-instituut (NEN), CEN, Commissie Duurzaamheidsvraagstukken Biomassa or Corbey Committee (CDB), OESO, FAO, UNEP and ISO. These initiatives are mostly normative. Therefore, these shall be discussed in the appropriate pillar. To recap, the government supports the development of one real national standard and certification system, namely the NTA 8080/8081. To extend the sustainability criteria for BBM, the current government has explicitly stated that it will wait for international agreements (Voorzitter, 2014). This is in contrast to what the CDB advises (section 5.2.3).

Apart from the abscence of regulations on the production of BBM in the Netherlands, there are some initiatives to help companies nonetheless. One example is the Green Deals (GDs) initiative. GDs are agreements between the government and companies, societal organizations or other governments. These agreements are in place in order to tackle specific barriers for sustainable development. This goes from financing and tax reductions to changing laws and regulations. There are a number of GDs that work specifically on BBM. Some of the GDs that are currently in effect and linked to BBM are listed below. There have also been multiple other GDs in the past that worked on BBM. At first sight, it does not seem that these GDs are useful for or heavily influence individual companies.

- GD002 is an agreement between the government, the Dutch Biorefinery Cluster (DBC) and the Vereniging van de Nederlandse Chemische Industrie (VNCI). It tries to develop business cases that can actually be implemented immediately to valorise biomass flows (Green Deals, 2011a).

- GD041 tries to establish a community of companies in Westland that valorise the organic waste streams for the horticulture sector (Green Deals, 2011b).

- GD113 tries to intensify the R&D investment in Zuid-Holland, Zeeland and Flanders (Green Deals, 2012a).

- GD181 is a cooperation in which HarvestaGG cascades biomass to produce a range of products and eventually biogas (Green Deals, 2015).

- GD119 is a test in which is researched how toxic chemicals can be substituted by bio-based alternatives (Green Deals, 2012b).

- GD153 and GD154 has as goal to stimulate innovation towards bio-based building materials while at the same time leveling the playing field between bio-based and conventional building materials. This last part is key in establishing a good market strategy for bio-based building materials (Green Deals, 2013).

Subsidies and fiscal measures

In the Netherlands there are several financial initiatives that are specific to BBM, namely the MIT subsidy (Mkb-innovatiestimulering Regio en Topsectoren), BBEG (Biobased Economy en Groen Gas Innovatie BBEG), and MIA and VAMIL tax reductions. The MIT subsidy is defined by top sectors. The BBM is considered part of the Energy and Chemistry sector. The subsidy supports innovation, but a company can only apply if the proposed innovation lies within one of the predefined themes. Themes within the MIT subsidy to stimulate BBM, are focused on chemical and biotechnological conversion technologies and bio-based materials manufacturing. It is not known to the public if and which sustainability criteria get used to judge applications to the subsidy.

The BBEG subsidy supports R&D projects for chemical and biotechnological conversion technologies of biomass into end products. The projects have to meet certain criteria, namely cascading of biomass, significant (not specified) GHG savings, significant energy savings (energy oriented subsidy) and societal relevance (generic). The technologies should mainly lead to energy savings or energy production as an end goal.

The MIA and VAMIL tax reductions are specifically for investments of companies into environmental technologies. There are about 9 technologies related to the BBE that could get a tax reduction. For example, tax reductions are possible for production equipment for bio-based products and bioplastics. The description and goals of these equipments are specifically generic and underspecified so that a wider range of technologies are potentially eligible. The government probably doesn't have very specific requirements for these because details about these potential future technologies is not known. That the MIA and VAMIL technologies are connected to the GDs is very interesting. It might

be that by connecting oneself with a GD heightens chances for tax reductions by MIA and VAMIL.

Consumer pressure

Consumer organizations protect the interests of the consumers. In the Netherlands there are multiple consumer organizations, such as Consumentenbond (biggest, 580.000 members) and Goede Waar en Co. However, the traditional consumer organizations are focused on entire product categories, such as food, energy, cars, electronics and clothing, not on resources used (Goede Waar, 2016; Consumentenbond, 2016b). Thus, these type of organizations mainly have an impact on end-product manufacturers. The consumer organization Kritische Massa does have some limited articles on resource usage and on BBM. For example, they referenced to the PlantBottle from Coca-Cola as not being a verified sustainable product and to bioplastics (such as PLA) and the way they should be treated when sorting the garbage (Kritische Massa, 2016). Some organizations do give information on the sustainability of certain types of biomass (e.g. soy, palmoil), but in general they do not talk about BBE or BBM in terms of sustainability.

There are also non-traditional consumer organizations that inform consumers. Milieucentraal is a more general consumer organization that gives more information on sustainability, labels and certificates for a variety of end-products and a variety of materials. The labels are compared and listed, detailed information is also given (Milieucentraal, 2016). Bonsucro and RSB are not mentioned by milieucentraal, but Cradle-2-Cradle certification by McDonough Braungart Design Chemistry (MBDC) and Dubokeur are (certificates see section 5.2.1). They also wrote an app which was only downloaded 5000 times, pointing at mimimal exposure. There is only one article specific on bio-based resources, i.e. bioplastics (Consumentenbond, 2016a). Sustainability criteria mentioned in the article are energy balance, greenhouse gas balance, natural resource efficiency, and land use. The general takeaway of Milieucentraal for bioplastics is that it is not known whether bioplastics are more sustainable, but that it is beneficial that it is renewably sourced. They say to give attention to OK compost logo and European Bioplastics Association's Seedling logo (see section 7.2).

Keuringsdienst van waarde is a journalistic program that tries to give insight to consumers by addressing specific consumer related topics (such as biodegradability, sustainability of flowers, cotton T-shirts, labels, fuel and food) (kro ncrv, 2016). All these organizations that try to inform the consumers, mostly address specific topics. Here as well, the only topics related to BBM that come back are, biological degradability, and recycling. A similar organization is Duurzaam Nieuws, which is a journalistic organization that brings news exclusively about sustainability (Duurzaam Nieuws, 2016). In terms of BBE, it reports on general events (e.g. conferences, study groups), research programs (mostly by Wageningen UR), plastics and packaging. To summarize, most Dutch consumer organizations focus on bioplastics. Natural resource efficiency (i.e. degradability, packaging, renewable biomass resources) is the recurring sustainability criterion.

Environmental Organizations

Environmental organizations bring specific pressure to companies by highlighting certain situations or focus points that need to be addressed in society. There are a multitude of environmental organizations in the Netherlands. The biggest organizations also operate on international level, but when possible the local branch of that organization shall be taken as actor. The major environmental organizations in the Netherlands are Wereld Natuur Fonds (Dutch Branch of World Wide Fund for Nature) (WNF), Greenpeace, Stichting Natuur & Milieu, and Milieudefensie (Dutch branch of Friends of the Earth). Greenpeace (Netherlands), WNF and Stichting Natuur & Milieu do not have any specific opinions or topics concerning BBM. Only bioenergy is mentioned often and then in relation to the excessive use of wood biomass for incineration and accompanying price rises of that biomass and potential deforestation.

Milieudefensie included BBM into the discussion, mentioning Indirect Land Use Change (ILUC) (26 million hectares of the Netherlands which only covers 4 million hectares) and food conflict (Ritsema, 2011). Although this was only briefly mentioned back in 2011. Earlier, in 2010, Milieudefensie published an article in their own magazine about the quietness of environmental organizations and the green movement towards BBE (Vriend and Schenkelaars, 2010). Thereby, the authors refer to Greenpeace, Friends of the Earth and the EEB as not being represented in technology platforms at all. WNF would only focus on first generation biofuels, while white biotechnology (use of micro-organisms either genetically modified or not) and new biofuels (or BBM for that matter) are not really addressed apparently. This is different for the CDB where Solidaridad, Oxfam and Stichting Natuur en Milieu are representatives. Remarkably, Greenpeace and Milieudefensie did earlier, in 2006, condemn the sustainability criteria that were setup by CDB for solid biomass (Greenpeace, 2006). Although they rightfully pointed out that biomass of which the origin is unknown is likely sourced unsustainable and that all biomass for bioenergy should be proven to be sustainably sourced, this dialogue does point out their reactive approach. The authors continue to say that focus remains with environmental impacts of first generation biofuels.

In this current research it was seen that the NGOs might have an official standpoint so they were contacted. After contacting Milieudefensie they stated that they want strict sustainability criteria for biomass for bioenergy, with a strong focus on land use rights of local farmers, food security and nature. Concerning BBM they stated that high value added use of resources makes more sense than energy applications. They stressed, furthermore, that end of life of BBM is very important, with reuse, recycling and composting as respectively the best options.

The only organization that did bring out a more elaborate opinion was WNF Denmark. Bang et al. (2009) was a very extensive report on the BBE which highlighted a lot of potentials and pitfalls that industrial biotechnology represent, including the production of BBM. After contacting WNF they confirmed that WNF doesn't have a specific standpoint when it comes to BBM and BBE but that they do endorse the RSB certification scheme (Stevens, 2016). However, WNF has supported a PLA packaging for Danone and is not negative towards PLA. At first sight WNF does not have any sustainability criteria for BBM. Still today, it seems that the major environmental organizations are aware

of BBM and associated impacts and advantages, but that they decide to take a reactive approach to BBE, apart from bioenergy, biofuels and linked deforestation. Genetic modification is always a focus point, but almost exclusively in relation to the food and agriculture sectors.

Finally, Solidaridad is a Dutch based international NGO that focuses on creating sustainable supply chains for biomass. It focuses, for example, on better working conditions, higher production, less use of water and pesticides. It seems that Solidaridad has a lot of influence and connections on sites of production, and influence as well in the Netherlands on companies. This results, in the improvement of sustainability standards on site as Solidaridad proves in their reports. Solidaridad is a member for example of the Bonsucro network, supporting the Bonsucro standard in several ways. However, attention goes to food, biofuel (ethanol) production etc. In the case of sugar in the EU, food products still consume most sugar (either from sugar cane or beet), followed by biofuels and BBM. This might be one explanation for why focus on industrial biotechnology for BBM is not a focus point at the moment.

5.1.3 Summary Coercive Mechanism

Across the EU there is now a heavy focus on biofuels and bioenergy because of the RED. European subsidies mainly talk about technological innovation, biofuels, bioenergy and bio-refining. This is why member states mostly focus on these sectors. The example of the Netherlands investing 1.1 billion in bioenergy and biofuels in comparison to 0.5 billion in other BBE sectors has already been given in the introduction. However, with growing protest against bioenergy (not necessarily biofuels) it is not certain how member states are going to react. International consumer, environmental and social organizations mainly focus on biodegradability of plastics when it comes to BBM. Some organizations such as LIF also focus on more specific impacts, and thus, sustainability criteria. The main international sustainability criteria is thus natural resource efficiency because of the strong focus on end of life of products and the renewable characteristic of BBM.

The Dutch government is trying to stimulate the sustainable use of biomass through the setup of legislation on biomass for biofuels and bioenergy on the one hand and the support of voluntary standards for BBM on the other. Subsidies and fiscal measures focus on developing technologies for BBE. Efforts to clear barriers in legislation have also been noted (e.g. GDs). On national level, natural resource efficiency is the sustainability criterion focused on by consumer organizations. Environmental organizations in the Netherlands do not present a strong focus on BBM yet. After contacting them they stressed that BBM should be resource efficient and, furthermore, that end-of-life is important. Noteworthy are the efforts of Solidaridad on sustainable biomass. **In conclusion, the coercive pressure on international level and on Dutch level, focus mostly on natural resource efficiency (e.g. end-of-life plastics) when it comes to BBM.** The 'new' BBM sectors (non-established sectors, so not forestry, food and feed) do not receive a lot of attention yet. Both Bonsucro as RSB are certification systems that were mentioned.

5.2 Normative Mechanism

5.2.1 International

Internationally there are various actors present that could put forward normative criteria. Only the most relevant are discussed. There are several certification organizations adhering to RED, namely RSB, ISCC, Bonsucro, Rountable on Sustainable Palm Oil (RSPO) and RTRS. All of these are extended to non-biofuel materials as well. RSB and ISCC can certify all crops or biomass sources while the others focus on specific crops.

The first standardization organization is the RSB. The RSB was a standardization and certification organization for liquid transport biofuels originally. Since 2011, it expanded its vision to include multiple bio-based products. There are 24 companies globally that have the RSB certification, of these, 14 companies are biofuel producers, 6 are feedstock or biomass producers, 1 produces biofuels and biochemicals, 1 produces biochemicals, and 3 are traders and distributors. There are various requirements in the RSB standard. **The major criteria for biomass processors and end-product manufactureres of BBM is that it has to have a significant amount of bio-based carbon in it.** The indicator for this, is the bio-based carbon content. For bio-based chemicals and materials it has to be above 25 % (RSB-STD-02-001). Remarkable is that the Greenhouse Gas (GhG) requirements are optional. The criteria is that GhG emissions should be lower for the bio-based material than for the fossil based counterpart. The indicator identified here is the emissions reduction which should be above 10 % (RSB-STD-02-001). This last criteria is necessary for biofuels that want to comply with the RED from the European Union. The major sustainability criterion for BBM is thus resource efficiency (bio-based carbon content).

An additional criteria is that there needs to be a chain of custody system in place. The above requirements have to be met by everyone that wants RSB certification. However, there are additional *specific sustainability requirements* for biomass producers, processors and bio-chemical producers (RSB-STD-01-001). These entail virtually all sustainability criteria on social and environmental side. Bio-material manufacturers do not have to meet these requirements. RSB seems like a very extensive certification. It is backed by major representatives of the field; farmers, biofuel and biomaterial producers, banks, retailers, rights-based NGO's, local organizations, environmental organizations, climate change and policy organizations, and intergovernmental organizations (IGOs). Although there is a vast quantity of members that endorse the standard and helped develop it, the lack of certified companies, indicates this standard has relatively low influence in the field. This is much different for the ISCC certification which has issued over 4000 certificates and is deemed crucial for the European biofuels market (Potts et al., 2014).

ISCC also takes into account multiple feedstocks. ISCC can be used to demonstrate compliance with RED and ISCC PLUS can be used for food, bioenergy and BBM. The main sustainability criteria is greenhouse gas balance for biomass producers. There are other sustainability criteria that are necessary for biomass producers, such as biodiversity (and carbon stock), energy balance, human rights, labour rights, land use, ecotoxicity. Add-ons are voluntary for organizations downstream of the biomass producer and include criteria such as

biodiversity, use of chemicals, greenhouse gas balance downstream from farm and natural resource efficiency (consumables of a production process) (ISCC, 2016a). Thus, **ISCC is mostly focused on biomass production itself in relation to greenhouse gas balance.** Interesting is that there is also a special provision for bioplastics. This gives the additional requirement that of quantity bookkeeping and how to voluntary get the add-on for greenhouse gas balance.

There are multiple international certificates that focus on specific feedstocks (crops), such as the RSPO, the RTRS and Bonsucro (Potts et al., 2014). Bonsucro is a certification organization (non-profit) that has a lot of members (over 400 in very varying countries), from farmers to end-users. World Wildlife Fund (WWF) helped establish Bonsucro. Amongst the members (this doesn't mean certified for their products) are Suiker Unie, Synbra and Company X as representatives in the case study. As of yet, most certifications are on sugar cane mills and work for the B2B sector. Only 4 companies have the Bonsucro label on their end-product. Bonsucro focuses on the sustainability of the sugarcane sector. Bonsucro has a long term vision on what the sugarcane sector should look like. It developed the 'Bonsucro Production Standard' in which sustainable production of sugarcane and sugarcane derived products are addressed. The Bonsucro production standard applies to sugarcane mills and the supplying sugarcane farms. In the end, only the mill operators are certified. Other members can get certification through the chain of custody standard. This is the 'Bonsucro Mass Balance Chain of Custody Standard', to which the sugarcane mills already have to be certified for. It also has Bonsucro EU certificate which involves extra criteria necessary to be compliant with the EU RED directive. This is a good example of how voluntary certificates and standards are connected to legislation. The extra criteria for the EU RED are focused on global warming and percentage of land with high biodiversity value, high carbon stock or peatlands planted to sugar cane. Audits are conducted at the mill and on a sample of individual farms supplying the mill. The production standard of Bonsucro entails multiple sustainability criteria such as energy balance, natural resource efficiency, land use rights, biodiversity, human and labour rights, water and waste management, soil quality and compliance with laws.

However, it is not clear whether the Bonsucro standard has strict enough standards and whether their criteria are well enough followed up in the field. In 2016, Bonsucro got another complaint in against the winner of 2015 Bonsucro sustainability prize Mitr Phol Group for not complying with human rights. The accusations were considerable (Inclusive Development International, 2016). The complaint was filed by Inclusive Development International (IDI), Cambodian League for the Promotion and Defense of Human Right (LICADHO), and Equitable Cambodia. However, Bonsucro has a system to deal with these complaints, pointing out that is expects them and is willing to deal with them.

Another certification system that is commonplace is the Forest Stewardship Council (FSC) system. FSC is an international certification organization focused on sustainable foresting. It is widely supported by environmental and development organizations and FSC products are commonplace in supermarkets. It is a certification system that has a strong chain of custody focus. The system is centralized around 10 principles, compliance with laws, property rights and rights of use, respect for formal and traditional rights of local population, social and economic welbeing of workers and local communities, longterm vision in forest management, biodiversity and ecosystem services, creation of a manage-

ment plan, monitoring of forest and chain of custody, extra care for forests with high value nature and culture and eventually management of forest plantations according to the other nine principles. These reflect several sustainability criteria. The RSB standards are basically the same as the FSC standards and RSB also declared that it will recognize FSC certified forests as compliant with RSB principles and criteria. This gives FSC certified wood and biomass an immediate entry point to biofuel and bio-materials market. The Programme for the Endorsement of Forest Certification (PEFC) presents also a certification system for forests and woody biomass. Requirements are here biodiversity, ecosystem services, use of chemicals, working conditions of workers, local employment, respecting minorities and compliance with laws. FSC and PEFC are usually not immediately linked with the new kind of BBM. However, wood in any kind of form is already part of the BBE and represents a big part of it. Furthermore, the use of wood pellets for bioenergy under subsidy is something immediately linked to these kind of certificates. Finally, these certification systems are well established, with members ranging over the ten thousand each. This means that they can serve as a study case for other biomass certifications.

The Cradle to Cradle (C2C) certificate from MBDC is not directly to BBE but from the case studies it is evident it is a prominent certification system. The idea behind cradle to cradle is to design products that can be reused a 100%. MBDC has designed the certificate in such a way that other sustainability criteria also get included, such as energy balance, water management, waste management, and respect for human rights (mbdc, 2016a). This is on top of the main sustainability criteria, natural resource efficiency, that the cradle to cradle idea is based on. This concept is part of a new trend in which the circular economy is deemed a sustainable alternative to the new one. In this way, there are a lot of intersections with BBE. Both describe a new economic system where natural resource efficiency is the penultimate sustainability criterion. Several other intersections occur, for example where bio-based products often are made to be recycled (counting composting as recycling as well) and so are circular in design already. In later chapters you will see bio-based product manufacturers that use this C2C certificate to show the resource efficiency of their products. As concluding remark on C2C certificate, it has to be pointed out that the certificate only looks at the product and the manufacturing of the product, but not at the upstream supply chain.

International Standardization Organization (ISO) is the international standardization organization. It has a 161 national standards bodies, and works together with other international standardization organizations such as CEN and CENELEC (ISO, 2016). There are two family of standards that come back in the case studies, namely for environmental management (ISO 14000) and social responsibility (ISO 26000). ISO 14000 outlines practical tools for companies to *manage* environmental responsibilities. These standards outline how to setup an environmental management system. It is in this family that ISO 14040 resides, which is the standard for performing LCAs. Surely, this standard has helped the industry and society a lot in identifying environmental impacts. Furthermore, the environmental management systems and accompanying standards give companies a framework to organize themselves and identify environmental impacts of their organization. The main sustainability criteria coming back here is the greenhouse gas balance. Other sustainability criteria are covered through the emphasis on LCA. ISO 26000 describes how to incorporate social responsi-

ble behavior into the company. It covers the major social sustainability criteria. A company can be certified for ISO 14001 as an environmental management system can be in place, but this is not possible with ISO 26000 which rather provides guidance. Keep in mind that an environmental management system doesn't automatically make a company more sustainable. Aside from these more general families of standards, there are some norms specific for BBM. For example, ISO 16620 describes how to determine the bio-based content of plastic products and ISO 14855 describes how to determine aerobic biodegradability of plastics.

5.2.2 Europe

CEN is the European Committee for Standardization. It provides European standards and technical documents for a wide range of sectors. European standards, are automatically national standards in all 33 member countries of the CEN. Member countries are all countries of the European Union and others such as Turkey and Switzerland. National members are the National Standardization Bodies, such as the NEN in the Netherlands (section 5.2.3). The standards are prepared by Technical Committees (TCs), and in these TCs it are Working Groups (WGs) of experts that draft specific standards and documents. The experts in WGs are appointed by the National Standardization Bodies. So it is that expert consultants of the NEN also work on European Standards. The development for horizontal standards for bio-based products is at the moment of writing this research being done by CEN/TC 411. There are several working groups. Working group 1 focuses on terminology, group 2 on bio-solvents, group 3 on bio-based content, group 4 on sustaianbility criteria, life cycle analasys, and group 5 on certification and declaration tools. This was ordered by mandate 492 by the European Commission in order to help the establishment of the bio-based products market.

Working Group 4 of CEN/TC 411 has developed the EN 16751 standard very recently (April 2016), which entails sustainability criteria for bio-based products. The sustainability criteria described in this standard are numerous, covering major sustainability aspects on the environmental and social side. A presentation by the Swedish Standards Institute summarized the sustainability criteria. They cover greenhouse gas balance, water management, soil protection, biodiversity (species and ecosystem protection), natural resource efficiency, energy balance, waste management, human rights, working conditions of workers, human rights, standard of living, land use rights (land availability for other human activities than food production, food security, and property rights and rights of use), water use rights and local development. However, the standard does not contain any demands but merely points at sustainability aspects that companies can take into account. There are also more specific norms that are useful or necessary for BBM. EN 13432 is an example of such a norm. It describes the requirements in Europe to call a plastic product compostable (NEN, 2000).

There are two important projects commissioned by the EU under the FP7 around CEN/TC411 that have to be mentioned here. The Knowledge Based Bio-based Products' Pre-Standardization (KBBPPS) project focused on pre-standardization research for bio-based products and Open-Bio on co-normative research. Several research institutes and organizations, such as NEN, nova-

Institut für politische und ökologische Innovation GmbH (nova), and Wageningen University, are part of the consortium executing the projects. FP7 actually only ran from 2007 to 2013, being replaced in 2013 by Horizon 2020 programme, but Open-Bio is still running. Open-Bio will run until October 2016, while KBBPPS is already finished. The Open-Bio project is created on European level to look how public procurement, standardization and labelling help the market development.

5.2.3 Netherlands

The Dutch government supports and collaborates with national and international organizations. These were listed in section 5.1.2. In the Netherlands, there are two main normative influences that are interconnected, namely the NEN and the CDB.

NEN founded a committee for bio-based products in 2010. This committee expanded in 2015 the NTA 8080 norm and NTA 8081 certification system from 2009 for biomass for biofuels to include biomass for bio-products as well (Minister Kamp, 2013). The norm was derived from the Cramer-criteria (see next paragraph). The criteria in NTA 8080 cover almost all aspects (e.g. greenhouse gas balance, natural resource efficiency, law abiding, biodiversity, food security, land use change, soil quality, water management). Aside from this extensive scope and promising view, the only quota lies with greenhouse gas balance. Greenhouse gas quota are given for bioenergy and biofuel, but not for bio-based products. Better Biomass is a certification system based on the NTA 8080 (Better Biomass, 2016). It is owned by NEN. Currently, there are a few dozen companies, exclusively in the Netherlands, certified according to the NTA 8080. There are 24 companies that produce green gas, biogas or landfill gas. Others are involved with wood chips (7), colza, bio-methanol, pyrolysis oil, electricity, animal fat, or heat. The government wants to use the NTA 8080 together with the subsidy program for bioenergy, namely 'Stimulering Duurzame Energieproductie' (SDE). By doing this coercive and normative pressure get mixed (Boosten et al., 2009). This is also possible for BBM of course.

The CDB, is a committee ordered by the ministry of economic affairs. From its beginning it has given advice to the government on bioeconomy related questions. Since the government extended its tenure, it seems the government is satisfied with the advice. This committee might have a considerable influence on the development of the governments' vision on the bioeconomy in the recent past and as well in the upcoming years. The aspects and criteria considered by the committee are very extensive. Advices from the CDB to guarantee sustainability in the BBE, entail supporting the development of certification systems, set a minimum CO_2 reduction that is necessary to call something a bio-based product, support labels, and assure transparency in the supply chains. The

sustainability criteria devised by CDB are called the Cramer-criteria and the NTA 8080 is derived from these. The Dutch government eventually wants the Cramer-criteria in European (CEN) and international (ISO) normalisation organizations.

5.2.4 Summary Normative Mechanism

There are numerous international certifications systems that are growing in supporters. These all have different tactics and focus points concerning BBM. The biggest ones are probably FSC and PEFC that focus mostly on sustainable management of forests with a slight emphasis on human rights. Bonsucro is also specific for one type of feedstock and addresses this quite elegantly. Its focus is also on the production side (farm and mill level). ISCC is more inclusive and its focus on greenhouse gas balance for biomass production is noteworthy. The system however is quite fragmented and it is not clear what BBM should, according to their opinion, have as requirements. Finally, RSB clearly states sustainability criteria for BBM and has as requirement that product (end of supply chain) have a minimal of certified bio-based content (25%). RSB also recognizes Bonsucro and FSC which helps streamline the certification systems. **The sustainability criteria pushed forward, specifically for BBM is natural resource efficiency (bio-based carbon content RSB).** Other sustainability criteria are focused on the upper supply chain, namely human rights, labour rights, biodiversity, greenhouse gas balance (farm level), land rights, water management, waste management, and soil quality. RSB, Bonsucro and NTA 8080/81 focus more specifically on newer BBM (excluding wood, food and feed) but only have a maximum of 4 BBM producers certified together. This points at minimum coverage.

Standardization organizations focus on several points, namely bio-based content (EN 16785, ISO 16620), general sustainability criteria (EN 16751 and NTA 8080), and compostability and biodegradability (EN 13432, ISO 14855). These are thus mostly focused on natural resource efficiency. The general certification systems that come back (but don't have quota or are enforced) cover the majority of sustainability criteria. A strong focus on natural resource efficiency and greenhouse gas balance is noted with the NTA 8080/81. These standards merely point at what might be important sustainability criteria. **Because of separate standards for compostability, biodegradability and bio-based content, and because of the more specific certification systems for BBM focusing on resource efficiency and greenhouse gas balance, it is decided that natural resource efficiency is the most important sustainability criteria in the normative pillar, followed by greenhouse gas emissions.**

5.3 Mimetic Mechanism

In this section, cognitive pressures are investigated. The mechanism in this pillar is such that under times of uncertainty, companies can copy other companies behavior. Therefore, the companies in the field are described as institutional actors. In chapter 6 and 7 , the companies of the case studies are described as being influenced by the institutional context. Important standards, certificates and labels that are mentioned in this section are explained in the normative

pillar section. Smaller ones, or those that do not relate to BBM, are not. These are used to explain the portrait of the company culture. It is emphasized here that not only companies constitute the cognitive pillar. Cultural values of companies and individuals also play a key role in this pillar. Major companies that are very visible in general or specifically in the field of BBM are looked at.

5.3.1 Biomass producers

The largest agribusiness cooperative in Europe is Friesland Campina (Beckum, 2012). This is coincidentally Dutch. Südzucker is a sugar producing company and is the 7th largest agribusiness in Europe. These two are chosen as representatives of biomass producers. Friesland Campina has a turnover around 9 billion and is focused on dairy. It is the dairy farmers (around 19000) that own the company. The company is also active in Belgium and Germany. Remarkably, Friesland Campina pays farmers more when they have sustainable farming practices. These practices entail outdoor grazing of cows and energy consumption. Their CSR programme covers a number of sustainability criteria such as food security, greenhouse gas balance, water management, energy balance, waste management, and natural resource efficiency (biogas, refining). There is no focus on certification. Friesland Campina is a very big company and therefore can dictate itself what is important in the field.

Südzucker has 29 sugar plants all over Europe. The sugar comes from sugar beets. It has several branches that produce other products on the side as well, such as Beneo that produces components for non-food and pharmaceuticals as well. They also have a CropEnergies group that produces bio-ethanol for transport in several countries. They produce over 1 million m^3 of bioethanol. In terms of sustainability Südzucker states that "in the long run, sustainability is the only promising way of operating economically". They bring forward criteria such as soil quality (erosion), ecotoxicity (fertiliser and pesticide use), energy balance (efficient use), natural resource efficiency (by-product utilisation), and water management. There are no certificates mentioned. No references are made to the BBE or BBM. When looking further at the CropEnergies group there is a strong focus on the RED which is applicable to bio-ethanol (see section 5.1.1). The main criteria at RED is the greenhouse gas balance. In order to be compliant with the RED they have to be certified. This certification goes up the supply chain to the farmers as well and stipulates, among others, use of fertiliser and protection of green spaces. The certification schemes used by different plants are REDcert and EU ISCC (ISCC schemes for RED).

5.3.2 Biomass processors

NatureWorks (NW) is a USA based bioplastic producer (Ingeo). Their industrial facility in the USA has a production capacity of 140.000 tons of polymer. The polymer itself gets sold all over the world, including the Netherlands. NW says the polymer consists mostly of PLA. The biomass feedstock for this is corn starch, but they want to diversify to sugar cane and eventually lignocellulosics. The sourcing from sugar cane will probably happen when they finish building their second facility in Thailand. NW admits to using agricultural feedstocks that might have an impact on food security, but says this is an intermediate step. Some sustainability criteria addressed by NW are greenhouse gas balance

(eco-profile and LCA), food security, land use (LCA), GMO (non-GMO), energy balance (eco-profile and LCA) and natural resource efficiency (bio-based content, recycling, composting). They have multiple certificates such as Vinçotte and DIN CERTCO (EN 13432 compostability and bio-based content), GeneScan (non-GMO), ISCC PLUS (greenhouse gas balance, biodiversity, ecotoxicity, water management, soil quality, human rights, labour rights, land use rights), and feedstock sourcing certification (non-GMO). Important here is that unless a customer asks for it, no ISCC PLUS or feedstock sourcing certification is acquired. Furthermore, NW uses a lot of LCAs on their product and on end-products made with their polymer to prove that it is more sustainable. A lot of criteria are used, mainly greenhouse gas and energy balance, but also ecotoxicity, water management, air emissions, and land use. At a glance it seems that NatureWorks actively seeks sustainability criteria and tries to prove that their supply chain and product are sustainable. It doesn't shy away from discussion as it addresses food security and land use connected to bioplastics. It arguments that food security and land use are not issues when it comes to bioplastics.

Novamont is an Italian based bio-plastic (Mater-Bi) and biolubricant and greases (Matrol-Bi) producer. They have several offices, research branches, laboratories and factory (Terni) in Italy as well as subsidiary companies. They also have several seats across the world. When it comes to sustainability management they have a system in place with the ISO 14001. All their sustainability criteria are focused on the product, not on the supply chain or feedstock. The major sustainability criteria are natural resource efficiency (biodegradable, compostable, recycling), and greenhouse gas balance (LCA). They show this through a wealthy variety of certifications; Vinçotte (OK compost, OK compost home and OK bio-degradable in soil), European Seedling logo. DIN CERTCO. CIC compostabile, BPI compostable (USA counterpart to Vinçotte and DIN CERTCO according to norm ASTM D6400), eLabel!, European "Environmental Technology Verification" (marine degradation).

Metabolix is a USA based company that develops biopolymers. These polymers are mostly, if not entirely, PolyHydroxyAlkanoate (PHA) based. Examples of products are performance additives and plastic resins for injection molding. Sugar and non-food plant oils are the feedstocks. The company doesn't produce the polymers itself but develops the technology. It goes into partnerships with other companies that setup the production and sell the product back to Metabolix that subsequently sells it. Metabolix identifies itself as a BBM company. Metabolix solely focuses on the products themselves. The only sustainability criteria that can be derived from their website and presentations is natural resource efficiency (biodegradable, marine biodegradable, compostable). This clear because of certificates by Vinçotte (OK compost home, OK biodegradable water, OK compost, OK biodegradable soil) in Europe and BPI compostable in the USA.

Rodenburg biopolymers produces several bioplastics products. An example is its Solanyl® product can be used for injection moulding, sheet extrusion etc. The products are made mainly from starched based crops, such as potato, and starch based waste streams. They contain PLA and polybutyrate. They stress that Solanyl® mainly is based on reclaimed side stream starch from the potato processing industry. Solanyl® is also certified by Vinçotte (OK compost-EN13432-ASTM D6400, OK bio-based). They have performed an LCA on their products and report that greenhouse gas balance and water use are taken into

account. Sustainability criteria at Rodenburg biopolymers are mostly focused on the product itself: food security (land competition for food production), natural resource efficiency (cradle to cradle, bio-based, waste streams and crops), greenhouse gas balance, water management, GMO (non-GMO), energy balance (65% less energy than conventional plastics), and ecotoxicity. Furthermore, the company states that agricultural land use for bioplastics is minimal and, thus, doesn't interfere with food security. However, they do want to work on sustainable sourcing.

5.3.3 End-product manufacturer or seller

PLA filament is very common in the 3D printing world. Remarkably, the sustainability of the material is not important here. It is almost exclusively used for its properties. This was checked at several online webshops such as Filamentshop, 123-3D, and lay3rs.

Huhtamaki is an international company founded in Finland. The company produces mainly packaging for the food sector but also some disposables such as cutlery, cups, and bowls. Materials used to make the products are for example Ingeo PLA from NatureWorks. They have a disposables line of products called Bioware which is conform norm EN 13432. Furthermore, they use environmental management systems such as ISO 14001 in all manufacturing units. All their foodservice sector sites in Europe, Asia and Oceania have the PEFC chain of custody systems in place. And finally, they use LCAs to assess themselves and say that energy balance, waste and air emissions are their greatest environmental impacts. They give in comparison to other companies a lot of numbers and data about these impacts. Sustainability criteria addressed by Huhtamaki are natural resource efficiency (recycling), labour rights (ILO, safe work environment, lost day rate, certification for occupational health and safety systems), air emissions, waste management, water management, energy balance, human rights.

NPSP produces its own composites and develops specific products for customers. This is mostly business to business. They have a whole range of natural fibres as carbon and glass fibers. They have a Nabasco® label that signifies that the product is ecological. The eventual composites are not biodegradable though and their proposed end-use by NPSP is incineration with energy recovery. Therefore, NPSPS only focuses on two sustainability criteria, namely natural resource efficiency (recycling) and energy balance. NPSP doesn't have any certifications or norms concerning sustainability or sustainable sourcing.

5.3.4 Summary Mimetic Mechanism

Biomass producers focus on food security, greenhouse gas balance, water management, energy balance, waste management, natural resource efficiency, soil quality, and ecotoxicity. The only certificate that is mentioned is ISCC and this is linked to the RED. These are European companies, and thus, might have less of a need of these types of certifications as certain sustainability criteria are already taken up by legislation.

All biomass processors focus on industrial compostability (EN 13432 and ASTM D6400) and depending on their product, they also focus on further product specifics such as biodegradability and compostability at home. Thus, the major focus is on natural resource efficiency. Another common line is that

GMOs are considered a liability. Only Metabolix doesn't focus on this. This is because it might use GMOs to produce its PHA. Remarkably enough, Metabolix can produce a product that is biodegradable in every circumstance, and thus might be the most environmental friendly. Two of the four companies state that an LCA has been done and give positive numbers. The companies don't have a strong focus on certifying their supply chains. Only Rodenburg stresses that it takes it into account and with NatureWorks it is possible to get (partly) sustainable sourced plastic.

End-product manufacturers and sellers also seem focused on natural resource efficiency with their products. The biodegradability and compostability are the only sustainability criteria that are heavily focused upon. Supply chain certification is not a major focus point.

In conclusion, biomass producers in Europe mostly focus on legislation and define their own sustainability criteria further on. These are varying. Biomass processors mostly focus on product specific criteria and thus, on natural resource efficiency. The majority of them do use LCAs to prove greenhouse gas emission reductions. Certification of their supply chains is not a major focus point, while usage of GMO definitely is. End-product manufacturers focus also on product specific criteria such as compostability (EN 13432). Only limited focus goes to certification of the supply chain.

Chapter 6: Main Supply Chain - Poly-Lactic Acid

In the main supply chain, Poly-Lactic Acid (or PLA) is the material of focus. As stated before in the introduction, PLA is formed from lactides that are in turn formed from sugars. A lot of biomass has sugar as component, such as sugar cane, sugarbeet, corn, and tapioca. There are three units of analysis (companies) in the main supply chain. Suiker Unie (SU) is the first one. As the biggest sugar producer in the Netherlands it is representative for a biomass (sugar beet) producer in this supply chain. In practice it is in part biomass processor as well (sugar from sugar beet). Further, Synbra is definitely a biomass processor as it uses lactides to produce PLA. It sells several speciality products as well as bulk PLA resins. It produces and sells its products within the Netherlands making Synbra a representative biomass processor of this supply chain. Companies down the supply chain of Synbra which are end-product manufacturers, such as Isobouw, were contacted but these were not interested in partaking in this research. Eventually, an interested end-product seller was found, namely Company Y (CY). CY has a large variety of products which it sells wholesale and retail. It doesn't only focus on PLA, but also on other bio-based products, which it makes it an interesting representative for an end-product seller in the Netherlands. It must be noted that these companies are not necessarily connected in reality. The case study uses representative companies of a theoretical supply chain. Also, the sustainability criteria mentioned are 'present' at the company. This means the company takes them into account or is aware of them in some way. The amount of sustainability criteria or their mere 'presence' is in no way an indication of the sustainability performance of the company. Some companies acknowledge a wide variety of sustainability criteria without actually addressing these. The companies in the supply chains are not linked to each other in practice. The supply chain is theoretical. The individual companies are introduced as part of the supply chain. These chapters are chiefly based on the information gathered through interviews with said companies. To access the actual information (answers to questions, quotes) collected from interviews please consult the appendices.

6.1 Biomass producer - Suiker Unie

Suiker Unie is a Dutch cooperation and is a part of the Royal Cosun concern. Royal Cosun is a concern specialized in the agro-industry (Royal Cosun, 2015). Besides Suiker Unie, Royal Cosun also has Aviko, Sensus, SVZ, Cosun Biobased

Products and Duynie. In 2012, Royal Cosun was the 7th (out of 11) biggest agribusiness cooperative in the Netherlands and the 39th (out of the 100) biggest agribusiness cooperative in Europe (Beckum, 2012). Suiker Unie (Royal Cosun) is a cooperation of about 9000 sugar beet growers and already exists for over 100 years. They have multiple sugar factories in the Netherlands and one in Germany. Van Gilse is their consumer brand and Suiker Unie itself is the brand for industrial products in most of Europe. They produce a range of products such as sugar, molasses and syrup. In their factories they also have biomass digesters to produce green gas from residual organic matter. This makes them already one of the bigger biofuels producers in the Netherlands (20 million m^3 of gas). Suiker Unie itself is thus a producer of biomass and a biomass processor. Although mostly focused on the food sector, they are also part of BBE supply chains such as bio-gas and citric acid. Therefore, their visibility is high, but their visibility as a bio-based economy company less so because their majority of sugar goes into the food sector. As a biomass processor they heavily focus on biomass yield increases. As agri-food company they also focus on the 'naturalness' and health of sugar. The person of contact at the company was the manager of environmental affairs (milieuzaken) who also worked at the company as engineer for environment and sustainability. The transcript of the conversation with the manager can be found in appendix E.

In their sustainability report (2014) they gave some numbers concerning production and sustainability. They produce about 1 million tonnes of sugar per year, using 240.000 cubic meters of water. They use 904 kWh of energy and emit 400kg of CO_2 per tonne of sugar produced. This results in a turnover of 819 million euro (Jurriëns, 2015). It looks like Suiker Unie invests in increasing yield per hectare with keeping in mind their emissions and resource use. Remarkably, they mention the regulatory pillar twice as rather restrictive. First, the restriction seems to hold back yield increases. "Legislation on the use of fertilisers and crop protection agents is making it more difficult to increase the yield. Furthermore, society is making every stricter demands on food production methods" (Jurriëns, 2015). Then, the restriction seems to hold back sustainability goals. "The introduction of new trucks is the latest step towards the 30% target. [30% reduction in CO_2 from sugar transport] Changes in the law, however, mean Suiker Unie has been unable to invest in as many new trucks as it had planned" (Jurriëns, 2015). This also came back during the interviews in which the waste legislation in the Netherlands was deemed restrictive sometimes when they wanted to seek new revenue flows.

The main criteria coming forth from the sustainability report are energy savings and the carbon footprint, while biomass yield and the naturalness of sugar are also focus points. The report is extensive. The efforts mentioned are substantive. However, with biomass production, also criteria such as pollution, land use, and biodiversity are important. Furthermore, the report is written by a public relations company, which points at a gap between Suiker Unie company culture (cognitive pillar) and sustainability (Jurriëns, 2008). This is a possible indication of decoupling (i.e. avoidance strategy see 4.4).

Suiker Unie is connected to several actors, initiatives and programs to incorporate or improve sustainability. These are itemized below (Suiker Unie, 2016).

- The Plant and Planet program is the sustainability program of Suiker

Unie itself. It covers chain responsibility, climate & energy, natural & healthy, and social engagement. The program covers a range of sustainability criteria they are working on. These are mostly the same as in the sustainability report, namely energy savings and carbon emissions. The criteria are included in the PL.

- Suiker Unie participates in the Lean and Green programme. It is an external stimulation program performed by Connekt (LeanGreen, 2016). The program tries to stimulate companies to cut down on CO_2 emissions by cargo, personal, or shipping transport. Eventually, a Lean&Green award can be given and a special Lean&Green Tool label for the products. Suiker Unie has a Lean&Green award meaning they have cut down carbon emissions for their transport by 20%. The only sustainability criteria here is carbon dioxide emissions.

- Stichting Veldleeuwerik (Skylark Foundation for sustainable arable farming) is a partnership between farmers and biomass processors to stimulate sustainable farming and production. They stimulate through cooperation sustainable farming. It is also possible for farmers to get the Skylark certification. There are ten Skylark indicators that they use to focus the farmers, namely product value, water use, erosion, soil fertility, use of fertilisers, crop protection agents, local economy, biodiversity, energy and human capital. Most of these can be translated into sustainability indicators. Only a small part of the sugar beet farmers are farming according to these principles. Suiker Unie does not demand every farmer to do this, and does not give any extra premium prices for sugar beet produced as such. This is because it takes a lot more work from the farmer according to Suiker Unie and giving premiums is not wanted as it could be the standard operating procedure in some years.

- Sustainable Agriculture Initiative (SAI) has awarded Suiker Unie the gold level for its programs. SAI is a non-profit founded by the major international food organizations, such as Nestlé, Unilever and Danone, and works on promoting sustainable agriculture (SAI, 2016). It has an extensive set of principles with which it works. The most highlighted are, improving social and human capital, impact on local community, soil fertility, erosion, water use, fertiliser and crop protection agents use, biodiversity, energy use and waste flows management.

- SU sometimes buys sugar from sugar cane from outside of the European Union and then demands this sugar to be Bonsucro certified. Bonsucro entails many more social criteria than what is present in the day to day operations of SU. This is because SU operates mainly in the Netherlands where these kind of social criteria are not relevant.

- ISO 26000 is a norm from ISO to incorporate Corporate Social Responsibility (CSR) into the organization. This norm reflects some social sustainability criteria such as compliance with laws, working conditions of workers and respect for human rights.

- The government in the Netherlands covers several sustainability criteria for biomass producers already in legislation. Just a few examples, biodiver-

sity is focused upon through the 'flora- en faunawet' (protection of endangered animals) and 'natuurbeschermingswet' (protection of ecosystems), exotoxicity with 'meststoffenwet' (fertiliser use) and 'wet gewasbeschermingsmiddelen en biociden' (crop protection agents), and water management as well (besluit gebruik meststoffen, Activiteitenbesluit paragraaf 3.5.3) (Overheid, 2016d, 2015, 2016b,c,e,a). Biodiversity is also supported through the MIA/VAMIL tax reductions. Also on EU level work is being done on directives. For example, there is a directive regarding the sustainable use of pesticides, namely 2009/128/EG (European Parliament, 2009b).

There are also actors specific for SU's industry. Institute for Rational Sugar Production (IRS) is a Dutch research and knowledge institute that tries to improve the yields in Dutch sugar industry (IRS, 2016). This seems to be an influential institute for sugar beet producers in the Netherlands. IRS states explicitly on their website that they do not focus on bio-ethanol (and thus, by proxy BBE) as they are sugar producers. Furthermore, they focus on improving the yields. Focus points related to sustainability are the efficient use of fertilisers and crop protection agents, with a strong focus on regulations and norms. Centre of Agriculture and Environment (CLM) is an independent consultancy firm focused on sustainable food, farming and development. Projects from CLM are focused on soil quality (e.g. erosion, nutrients), biodiversity, climate change, land use, pesticide, water and fertiliser efficiency (CLM, 2016).

Suiker Unie has cut down carbon emissions in their transport and abides by regulations for fertilisers and pesticides. It also has a social responsibility program and tracks numbers on resource use and emissions. It turns out SU has to keep track from their industrial installations according to legislation. All environmental data of industrial facilities in Europe has to be reported and is collected in the European Pollutant Release and Transfer Register (E-PRTR) database (European Environment Agency, 2016).

6.1.1 Sustainability criteria

From the description above it becomes clear very soon what the main sustainability criteria are at SU. These are represented in table 6.1. They are mostly **process related**. There is a strong focus on fertiliser and crop protection agents together with carbon, water and energy footprint. These reflect ecotoxicity, greenhouse gas balance, water management and energy balance sustainability criteria. Other criteria that are touched upon in the environment of SU are biodiversity, soil quality (erosion), and some social criteria. It is important that fertilisers and crop protection agents use are limited, and that the carbon and water footprints are lowered when looking at biomass production. These are major environmental considerations linked with biomass production. Fertiliser and crop protection agents use are limited by law in the Netherlands and in the EU. The Netherlands has a lot of regulations for water use, but the commitment to reduce water use seems voluntary. This is also valid for carbon dioxide. Concerning carbon dioxide, SU has voluntarily committed to reduce emissions, but clear numbers, outside of transport, can't be found on this. Other criteria such as erosion and biodiversity are partly voluntary sustainability criteria (through the Skylark initiative) that some farmers in the cooperative invest in, but this

is not a major focus point.

Criteria	Indication of criteria	Institutional actor	Process/product/supply chain
water management	water used	5, 18, 37, 38, 40	process
energy balance	energy used, saved	5, 18, 37, 38	process
ecotoxicity	fertiliser use, pesticide use	5, 37, 38, 39, 40	process
soil quality	erosion	5, 37, 38, 40	process
biodiversity	biodiversity	5, 37, 38, 40	process
human and labour rights	ISO 26000	5, 13, 18	process
waste management	waste flows management	5, 38	process
land use change	land use change	40	process
GMO	non-GMO	18	product
natural resource efficiency	yield increases	18, 37, 39	process
greenhouse gas balance	carbon dioxide emissions	18, 19, 38, 40	process

Table 6.1: The PLS of Suiker Unie. The sustainability criteria present at Suiker Unie. The institutional actors are the government (5), ISO (13), Suiker Unie itself (18), Lean & Green (19), Veldleeuwerik (37), SAI (38) and CLM (40). These are five normative actors, one internal cultural factor, and one coercive actor. More explanation on these actors can be found in the text.

6.1.2 Mechanisms

The coercive mechanism is the strongest felt by Suiker Unie. Both legislation and pressure by clients seem to be the major forces directing Suiker Unie towards adoption of sustainability criteria. It is active in legislation on national and on European level, through lobbying and the Green Deal (GD). The focus when talking about legislation seems to be around production methods (agricultural and industrial) and what the company is allowed to do. For Suiker Unie it is advantageous to increase yields. Some regulations, for example of fertilisers and pesticides, therefore, seem restrictive to them but attain sustainable development. Some regulations like the waste and manure directives seem to be holding back sustainable and economic development of the company.

SU also feels pressure from clients that demand certain specifications of products, either technical or sustainable. The pressure from clients is the reason for focusing on more specific sustainability criteria. For example, specific norms for products have been asked and also the carbon footprint is a criteria that returns often. The customers that are big companies with high visibility demand certain norms and certificates for the products.

Thus, some criteria (fertiliser, pesticide, water, waste) come from the legislative side, while others (carbon emissions, biodiversity, social standards) also come from customers. Customers demand certificates, standards or sometimes simple numbers (e.g. water or energy used). It is with the certificates and standards (the normative pillar) that SU encounters more specific sustainability criteria. It is interesting to see that this goes through the supply chain as well, customers asking the products to be of certain standard and then SU themselves asks their suppliers to conform to certain standards. Here the Bonsucro certificate comes back. Also Synbra and CX (biomass processors, see section 6.2) are linked to the Bonsucro certificate, but do not yet demand Bonsucro certified biomass from their suppliers.

6.1.3 Response of company

SU acknowledges that fossil fuels are going to run out and that the BBE can grow. Thus, they see monetary gains in BBE. This is visible as they have a bio-based manager and inside the bigger concern of Cosun there is also an entirely new bio-based company. For SU itself there is no immediate value to be gained in the BBE though. Most of the sugar from SU goes into the food sector, thus, prices remain competitive. Farmers do not get higher value for products for producing more sustainable or for producing products for the bio-based industry. The adoption of sustainability standards is to keep up, and even be proactive, towards legislation. This makes sense as SU is a long-established company (**temporal embededness**) that has experience with regulations that changed and affected their industry.

> "In the long term, this [sustainable standards] is more about delivery insurance... It is just a license to produce." (de Crom, 2016)

The major sustainability criteria present at this company are bound by law. Acquiescense of criteria is thus a logical response. It is also culturally appropriate (cognitive pillar) as looking at fertilisers and crop protection agents is very prevalent and logical in the agricultural sector. Furthermore, as the industrial processing of the sugar beet consumes a lot of natural gas, reductions in carbon emissions are also a logical practice.

It is deemed the strategy of SU to deal with the institutional pressures by institutional actors is **acquiescense of sustainability criteria** that are **prevalent and obligated by law**. Through lobbying practices, SU also tries to compromise on some norms and manipulate institutional pressure. This is a logical step for example with the valorization of side streams (waste legislation).

6.2 Biomass processor - Synbra Technologies

Synbra Technology is a company that started producing Expandable Polystyrene (EPS) in the 70ies. As of 2011 it also does PLA polymerization and produces BioFoam® Expandable Polylactic acid (PLA) and PLA Compounds (Synbra, 2016). EPS and BioFoam® can be used as insulation in construction, as packaging, etc. The switch from fossil based EPS to also bio-based PLA makes this an interesting unit of analysis as it points at a shift in focus. The contact person at Synbra has been the managing director of Synbra since 1999. The results from the interview can be seen in appendix F. The company itself is part of Synbra Holding. This is an international holding specialized in packaging, insulation and plastics. These are mostly EPS based. The products from the company get sold mostly to other companies within the Synbra Holding that produce end-products. So Synbra Technology is now also active as a biomass processor. It is connected to several European and Dutch plastics and chemical institutions, such as NRK and Plastics Europe.

Synbra is connected to several sustainability items. These are listed below.

- Synbra received the CradletoCradle certificate for Biofoam® and PLA BioBeads®.
- Deutsches Institut für Normung (DIN) is the German normative agency like NEN, which was mentioned earlier, is the normative agency in the Netherlands (DIN CERTCO, 2016). DIN CERTCO is the certification organization. For environmental issues, DIN CERTCO can accredit organizations for certificates and norms such as the EN 13432 for plastics industrial compostability, plastics bio-based content (via ASTM D 6866, CEN/TS 16137, or ISO 16620 methods), plastics biodegradability in soil (DIN SPEC 1165, CEN/TR 15822), ISCC, FSC, and PEFC. Just like the Vinçotte certification for EN 13432, the DIN EN 13432 is eligible for the European Seedling logo. Biofoam® is certified by DIN CERTCO for compostability EN 13432 and bio-based content ASTM D 6866.
- Biofoam® received a Dutch Construction award for its low environmental impact and biodegradability.
- Synbra has the Dutch VIHB system certificate. This is necessary in order to be allowed to collect waste in the Netherlands (VIHB, 2016). This is for collecting waste and recycling it. This points to some kind of cognitive sustainability factor at the company itself, as this is an extra effort. Although it could be majorly financially motivated as well.
- For the development of Biofoam® they received a grant from the Dutch government. In order to receive such grants there are negotiations and discussions with the government and there were also some sustainability criteria stated by the government.
- ISO14001 certification is granted to Synbra. This entails that an environmental management system is in place at the company. ISO14001 sustainability criteria are mainly focused on environmental impacts including but not limited to greenhouse gas balance and farm level sustainability criteria.
- Biomass processors have to abide by legislation as well and several sustainability criteria are covered in this way by Dutch legislation. However, as all manufacturers of plastics or materials in general have to abide by the same laws, these laws are not specifically for BBM. However, some examples are presented here as sustainability criteria also diffuse from this kind of legislation. There are regulations per industry sector. As biomass processors can be classified in the chemical industry some related regulations are presented in table 6.2.

6.2.1 Sustainability criteria

The major sustainability criteria that Synbra focuses on are natural resource efficiency and greenhouse gas balance. Most sustainability criteria at Synbra are **product oriented**, apart from the environmental footprints (through LCA) that also takes into account upstream carbon emissions. Synbra performed an LCA in 2010 on several relevant impact categories. All major impact categories are now addressed as well in an updated LCA in 2016, due

Regulation	Regulation on	Sustainability criteria
werken met gevaarlijke stoffen	dangerous chemicals	(eco)toxicity, labour rights
REACH/CLP	usage of chemicals	(eco)toxicity
milieuvoorschriften bij verbruik oplosmiddelen	solvents	air emissions
afvalbeheersbijdrage	waste contribution	resource efficiency
geluidsvoorschriften	noise	human rights
vloeistofdichte en vloeistofkerende vloer	soil protection	soil quality

Table 6.2: Examples of regulations in the chemical sector. The regulations presented here cover (part of) some sustainability criteria. Through these kind of regulations sustainability criteria also find their way into the BBM sector. These are not specific to BBM however, and are not taken up into the PLS of biomass processors. These are just a few examples as it can be argued that a range of other sustainability criteria are also taken into account through. An example of this is energy taxation that might diffuse the energy balance criteria into companies.

to be published shortly by GABI/PE International. Thus, Synbra also takes into account land use, toxicity, ecotoxicity, air emissions, and natural resource efficiency.

Criterion	Indication of criteria	Institutional actor	Process/product/supply chain
natural resource efficiency	compostability, bio-based content	42	product
GMO	non-GMO	20	product
greenhouse gas balance	carbon emissions	13, 17, 48	product, supply chain
toxicity	toxic chemicals	17, 48	product, supply chain
ecotoxicity	material health	17, 48	product, supply chain
energy balance	renewable energy and carbon management	17, 48	product, supply chain
water management	water stewardship	17, 48	product, supply chain
land use	farm land use	48	product, supply chain
air emissions	photochemical oxidation	48	product, supply chain
waste management	material reutilization	17	product
human rights	social fairness	17	product
natural resource efficiency	material reutilization	17	product

Table 6.3: PLS of Synbra. The sustainability criteria present at Synbra. The institutional actors are ISO (13), MBDC (17), Synbra itself (20), DIN (42) and LCA (48). These are four normative actors and one internal cultural factor. More explanation on these actors can be found in the text.

6.2.2 Mechanisms

There are no immediate regulations that they have to comply with. Only on production there are general regulations. Synbra has sought out contact with the government but they do not seem to be 'interested'. The coercive pressure does seem to be present as customers have specific demands concerning norms and certificates. This was mentioned several times that in order to appease certain customers the products have to be proven to be sustainable. The lack of certifications addressing upstream issues points to customers only asking specific numbers that, for example, a LCA can point out.

On the normative side, Synbra actively seeks certifications and norms to prove that their product is sustainable. "You have to have evidence that your product is bio-based, that it is compostable [etc]" (Noordegraaf, 2016). It is also the reason why they use LCAs. They have acquired standards and certificates for their product.

The companies' culture seems to be sustainably oriented. Out of themselves they went to Wageningen University to find out whether they could produce

more sustainably. Out of past efforts to establish recycling of EPS plastic this remark seems to be valid. **In conclusion, there is an indication that the pressure comes from their own culture (cognitive pillar) and customer side (regulatory pillar), while the most sustainability criteria diffuse into the company by the normative pillar (LCA and the one certificate).**

6.2.3 Response of company

The company actively focuses on natural resource efficiency and greenhouse gas balance of their product. It also focuses on not using GMOs and through LCA on several other product related criteria. This is rather selective as upstream sustainability impacts are neglected. Because of their sustainability oriented view, this doesn't seem to a conscious strategy, and thus not an avoidance strategy. Therefore, **the main response Synbra has, is acquiescense**. It conforms to the strict views of the Cradle-to-Cradle certificate and uses LCA to judge the sustainability of its product.

6.3 End-product seller - Company Y

Company Y (CY) decided to partake anonymously with this research. All specifics that could point in the direction of the company are therefore not included. CY is a company that imports and sells (wholesale and private) sustainable disposables and packaging (Company Y, 2016a). Products include cutlery, cooking utensils, boxes, and cups. Almost all of these are industrially compostable. Culture wise, it is a very young team and company. The contact person of the company was the founder. The results from the interview can be seen in appendix H. The portrayal of the company is centered around sustainability and the replacement of oil-based plastics. Not all products are bio-based, however, there are also oil-based but compostable products. Certificates are key to their business. The European Bioplastics Seedplant logo was said to be very recognizable by customers and therefore, the most convenient.

- Vinçotte OK compost logo and European bioplastics Seedling logo (see above)
- FSC, see section 5.2.1
- PEFC, see section 5.2.1

6.3.1 Sustainability criteria

There are not so many environmental sustainability criteria present at CY. Product specific criteria include compostability (natural resource efficiency) and non-GMO. Supply chain sustainability criteria come from the FSC and PEFC certification systems and these mostly pertain to social sustainability criteria. Environmental criteria are limited to mainly biodiversity and ecosystems protection. Important environmental sustainability criteria for the product and for the supply chain, such as greenhouse gas balance and energy balance are missing. Furthermore, no products are conform any norm that proves their bio-based content.

Criterion	Indication of criteria	Institutional actor	Process/product/supply chain
natural resource efficiency	compostability	14, 21	product
use of genetically modified organisms	non-GMO	47	product
compliance with laws	compliance with laws	43, 44	supply chain
land use rights	land tenure rights	43	supply chain
human rights	indiginous peoples rights, community relations	43, 44	supply chain
labour rights	commmunity relations and workers rights	43, 44	supply chain
land use change	no conversion of forests	44	supply chain
soil quality	protective functions	44	supply chain
waste management	benefits from the forest	43, 44	supply chain
water management	benefits from the forest	43, 44	supply chain
biodiversity	environmental impact	43, 44	supply chain
ecotoxicity	environmental impact	43, 44	supply chain

Table 6.4: PLS of Company Y. The sustainability criteria present at CY. The institutional actors are Vinçotte (14), CEN (21), CY itself (47), FSC (43), and PEFC (44). Four normative actors and one internal cultural factor are present. More explanation on the these actors can be found in the text.

6.3.2 Mechanisms

The company is oriented around sustainability. They provide the added value of sustainability. There are two ways of approaching the business. Either the pressure for adopting the criteria comes from within, as it is a sustainability oriented management team, or it comes from the clients (water and carbon footprint). There is surely a demand from the market, as the business is up and running. Thus, the mechanism driving CY to take up the sustainability criteria is likely **a mix between coercive (customer driven) and cognitive (cultural), while most of the additional sustainability criteria diffuse into the company through the normative pillar**.

6.3.3 Response of company

They bring forward almost exclusively supply chain sustainability criteria. The only product related requirement they have is that the product has to be compliant with norm EN 13432 and, thus, industrially compostable. This reflect the sustainability criterion of natural resource efficiency. Although their products are certified to comply with a lot of social criteria, criteria such as carbon emission reductions and energy use are not discussed. They are not even discussed through the certifications. It seems like the company avoids talking about these criteria and it cannot prove the environmental sustainability of their products. However, CY themselves state that they cannot get any data on these criteria and, therefore, doesn't address them. It are the suppliers themselves that cannot provide the data. CY states that it might be available in the future. When this happens, the data will probably come in form of a LCA together with the usual criteria. These criteria, or some of them, would be taken over by CY. Therefore, the response of CY is **acquiescense of sustainability criteria**. Other responses like compromising, avoiding, or manipulation don't fit as CY is very transparent and open.

Chapter 7: Comparative units of analysis

This chapter describes extra companies (units of analysis) that serve as contrast to the units of analysis in the main supply chain. In the beginning these companies were intended to be representatives in other supply chains. For Ecoboards, however, no extra companies in the supply chain wanted to partake in the case study so the entire supply chain couldn't be investigated. Company X had strict anonymity rules for which they couldn't be linked to any other company that might not have decided to be anonymous. Other entire supply chains couldn't be investigated anymore because of the limited time frame of this thesis project. Therefore, it was decided these companies would serve as extra units of analysis to add to the results of the main supply chain.

The first company, Ecoboards, represents a supply chain that starts with straw as biomass. The straw gets processed into strawpanels. These strawpanels are an alternative to compressed woodpanels. The panels in turn can serve as building materials (interior) or as furniture, but can also be sold directly in stores. There are no real biomass producers here because straw is not intensively produced. It can be more defined as a waste or rest stream of agriculture. Furthermore, currently, the straw and panels get produced in China. The following company, Company X (CX) is a biomass processor that wishes to stay anonymous. It produces bio-based materials in the business-to-business market.

7.1 Biomass processor and end-product seller - Ecoboards

Ecoboards is a company that produces wood panels from straw. It takes up sustainability as one of its core values. From the mission and values statement: "Ecoboards Europe believes that a healthy environment is not only complementary, but also critical to a healthy business. Our mission is to develop high-performance, high-value products in order to satisfy our customers' total needs. We will conduct our business with the highest ethical standards, strive for excellence in all we do, and measure success by the relationships we build in the communities where we live and work." The two founders were talked to during the interview. The results from this interview can be found in appendix D.

Products from Ecoboards actually comply with some relevant sustainability criteria for BBM, namely natural resource efficiency (recycling, biodegradability), toxicity (toxic effects during use), local production, and greenhouse gas

balance. They have also performed a LCA to determine the amount of carbon dioxide emitted. Apart from its own criteria, Ecoboards is connected to a number of standards, certificates and labels. These are itemized below.

- DUBOkeur is a certificate in the construction industry for sustainable products, resources, installations or homes (Dubokeur, 2016). Through a LCA the environmental impact of the product is compared with similar ones. Only the top products of the sector can make a claim for certification, there are numerous criteria (in LCA it is translated to environmental impact) that have to be better than the industry standard. The strawpanels have the DUBOkeur certificate. This is necessary for Ecoboards in order to prove their customers the sustainability of the strawpanels.

  Interesting is that DUBOKeur certified products are for 27% tax-deductable through the MIA/VAMIL tax reductions (nibe, 2012). Thus, through certification the products become immediately attractive. However, in practice this is apparently not the case. According to Chotkoe and Kempenaers (2016) it is only for larger projects and, thus, bigger companies.

- ECOBoards is connected to the GD bio-based building (GD153 and GD154). The GDs are active in clearing obstructions in legislation. It tries to level out the playing field between bio-based and traditional building materials. It also searches to improve knowledge exchange in the field. In practice, these GD seem to be hardly effective. There is also an effort to stimulate bio-based buying, but this seems to be hardly stimulated because the playing field between different materials is not levelled yet.

- MBDC C2C certification is to certify the product is Cradle to Cradle designed. Benefits here are that the products can help companies to acquire sought-after LEED credits. Giving Ecoboards a competitive advantage (mbdc, 2016a). However, they do not have it yet, but are eligible to it. They are waiting for the right moment to get it, at the moment they have enough certificates they find.

- NaturePlus is also a certifying agency like DUBOkeur that is focused on a sustainable building sector. The certification is called the NaturePlus label.

- Finally, Ecoboards is also connected to Vlaams Instituut voor Bio-Ecologisch Bouwen en Wonen (VIBE) but doesn't have the label yet.

- Biomass processors have to abide by certain regulations concerning manufacturing of plastics or materials. These are not specific for BBM but they are addressed shortly nonetheless. This can be consulted in the section about Synbra (see section 6.2).

7.1.1 Sustainability criteria and indicators

There are several product related sustainability criteria present at this company, of which the most important seem to be greenhouse gas balance, natural resource efficiency, toxicity, ecotoxicity. The company uses LCA to look at the performance of their product. In table 7.1, the sustainability criteria present at the company can be seen. With LCA most of the sustainability requirements and criteria that different certification systems in their environment take into account, are covered. The toxic effects of the straw panels are less and the biodegradability higher than its alternative. This is because they use different resources in their production. As they have no production inside the country, some sustainability criteria are hard to keep track of such as recycling and local production (which are actually not met yet). It is the wish of Ecoboards to make sure that their entire supply chain is checked and controlled and that all sustainability criteria, including social ones are met. As they are starting up the market currently, economic sustained growth is, evidently, the major focus point.

Criterion	Indication of criteria	Institutional actor	Process/product/supply chain
greenhouse gas balance	carbon emissions	16, 17, 25, 48	product, supply chain
natural resource efficiency	material reutilization, abiotic and biotic depletion	16, 17, 25, 48	product, supply chain
toxicity	toxic effects during use and processing for humans	16, 17, 25, 48	product, supply chain
ecotoxicity	toxic effects during use and processing environment	16, 17, 25, 48	product, supply chain
air emissions	ozone, photochemical oxidation	16, 17, 25, 48	product, supply chain
energy balance	fossil resource depletion, primary energy input	16, 17, 25, 48	product, supply chain
land use change	land use	16, 48	product, supply chain
local development	local production	15	product, supply chain
water management	water stewardship	17, 48	product
waste management	material reutilization	17	product
human rights	social fairness	17	product

Table 7.1: PLS of Ecoboards. The sustainability criteria present at Ecoboards. The institutional actors are Ecoboards itself (15), DUBOkeur (16), MBDC (17), Natureplus e.v. (25), and LCA (48). These are four normative actors or factors and one internal cultural factor influencing the company. More explanation on these actors can be found in the text.

7.1.2 Mechanisms

Ecoboards seems to collect the sustainability criteria through their own culture. The managers focus on the sustainability of their product. It is thus the cognitive pillar that establishes the sustainability criteria and indicators within the company. The regulative pillar has only little effect. As can be seen from the sustainability criteria section, most sustainability criteria that are taken into account are the same as from certifying agencies and LCA. For certain certifications LCAs had to be done and most of the criteria and additional ones come from. **It is, thus, the normative pillar which provides most of the potential sustainability criteria, but the pressure comes through the cognitive pillar.** The little coercive pressure Ecoboards feels comes from the demand and interest customers have for these kind of products.

Apparantly, the BBM as an organizational field is too fragmented (Chotkoe and Kempenaers, 2016). There are hundreds of initiatives, but no real coherence. Thus, **the organizational field is fragmented in the eyes of EcoBoards.** The fact that they see a fragmented field raises the institutional complexity for them. This entails uncertainty about what is exactly happening. In times

of uncertainty, **the cognitive pillar** is the strongest. But EcoBoards doesn't mimic other companies, but rather intensifies its focus on its own internal values. Their high visibility and ownership confirms that what they do is perceived as legitimate.

7.1.3 Response of company

Ecoboards acquiesces the product related sustainability criteria. The pressure behind taking up these sustainability criteria seems to come from within the company itself, from the managers. They put objectives for their product out themselves. For example, they wish to have a product that is almost a 100% bio-based. It seems that it are real internal cognitive values, more than outside pressures. The sustainability criteria themselves seem to diffuse in through the normative pillar though as Ecoboards is connected to several certification agencies and has performed an LCA on their product. As they are unable to produce locally or check their supply chain, they currently don't have clear social sustainability criteria.

7.2 Biomass processor - Company X

The following company doesn't want to be named. Therefore their strategy, vision and mission and other specifics about the company are left out. Company X (CX) produces bio-based products and bioplastics. They use various types of biomass, including sugar cane. It is a big company active in multiple countries around the world. The global sustainability director, whom has been in office for 1 year, was interviewed. The results of this interview can be consulted in appendix G.

In terms of sustainability, CX focuses on a few key topics on today's society, such as population growth, food security, and the strife for fuel independence. CX sees that population growth is a global challenge and that renewable resources are the way to go. It has performed an LCA on most of their products. Key here is that some environmental impacts were higher than the fossil based alternatives. This is due to the extra agricultural stage in which impacts such as eutrophication, photochemical ozone creation, acidification and farm land use are relevant. But in general the Global Warming Potential (GWP) of their product did decrease in comparison to the fossil based alternative. Company CX also has several supplier codes for the countries from which they source materials. This is a rare and proactive approach. However, it is not enforced. All 'member' organizations are larger organizations and not local suppliers. The legislation, standards, norms and impact assessments linked to CX are numerous, covering a wide variety of sustainability criteria for the company and the supply chain.

- Vinçotte certification, OK compost logo and European Bioplastics Association's Seedling logo for their product. Vinçotte is a certifying agency based in Belgium. The certification means that certain materials from CX can be composted in an industrial composting system. Vinçotte has multiple logo's and certifications for compostability, bio-degradability, and bio-based content. The OK compost logo means the product adheres to

the European norm EN 13432 which adheres to the EU Packaging Directive (94/62/EEC). This norm addresses industrial compostability of packaging. Furthermore, Vinçotte OK compost certification means that The European Seedling logo is also attributed to that material.

- CX is connected to the Bonsucro initiative. However, there is currently not enough sugar from Bonsucro certified sugar cane on the market according to CX. The Bonsucro standard is detailed in section 5.2.1.
- The Supplier Ethical Data Exchange (SEDEX) is a non-profit that exchanges ethical data on supply chains for companies (SEDEX, 2016). Members store data on labour standards, health & safety, the environment and business ethics. SEDEX doesn't immediately set social sustainability goals. But does provide a platform where companies are able to visualize themselves and through audits it provides more transparancy in supply chains.
- RSPO is used to source sustainable palm oil. The RSPO standard resembles in some ways the Bonsucro standard in that it is extensive and presents a lot of social criteria.
- Biomass processors have to abide by certain regulations concerning manufacturing of plastics or materials. These are not specific for BBM but they are addressed shortly nonetheless. This can be consulted in the section about Synbra (see section 6.2).

7.2.1 Sustainability criteria

The sustainability criteria found at CX are **product and supply chain related**. They analyse their products with LCAs, thus, the product-related criteria are given in through LCA. These are greenhouse gas balance, natural resource efficiency (use of material resources), energy balance (non-renewable energy use), ecotoxicity (eutrophication, acidification), air emissions (photochemical oxidation), land use and toxicity. There are also supply chain criteria that they pose themselves. These are generic and not enforced. Most of these criteria and indicators are the same as what certification agencies such as Bonsucro and RSPO have in their standards. Thus, it might be possible that the product sustainability criteria are derived from LCAs and that the supply chain sustainability criteria are derived from normative agencies.

7.2.2 Mechanisms

It is difficult to see where the sustainability criteria come from. CX themselves say that specific things are asked by customers through the request of LCAs and

Criterion	Indication of criteria	Institutional actor	Process/product/supply chain
natural resource efficiency	compostability	14, 21, 23	product
natural resource efficiency	biodegradable	21, 23	product
natural resource efficiency	renewable resources	23	product
GMO	non-GMO	23	supply chain
food security	land available for food production	23, 24	supply chain
compliance with laws	complying with applicable laws and countering bribery	22, 23, 24	supply chain
human rights	health services, indigenous peoples' rights, fair wages	22, 23, 24	supply chain
labour rights	health, working hours, no child or forced labour	22, 23, 24	supply chain
waste management	waste produced	22, 23, 24	supply chain
greenhouse gas balance	carbon emissions	22, 23, 24, 48	product, supply chain, process
energy balance	energy use	22, 23, 24, 48	supply chain, process
water management	water use	22, 23, 24, 48	supply chain, process
land use	farm land use	48	supply chain, product
air emissions	photochemical oxidation	48	supply chain, product
ecotoxicity	acidification	48	supply chain, product
natural resource efficiency	material resources	48	supply chain, product
energy balance	non-renewable energy	48	supply chain, product
ecotoxicity	eutrophication	48	supply chain, product

Table 7.2: PLS of Company X. The sustainability criteria present at Company X. The institutional actors are Vinçotte (14), CEN (21), Bonsucro (22), CX itself (23), RSPO (24) and LCA (48). There are five normative actors or factors influencing the company and also one internal cultural factor. More explanation on these actors can be found in the text.

of specific numbers, such as water use and carbon footprint. Certifications are also asked and CX is connected with them, but currently has only the RSPO certification for production outside of Europe. Because it are customers asking for specifics (water use, energy use, carbon footprint, etc.) of products, LCAs and certifications, **the mechanism in place is coercive. Although the supply chain criteria seem to come from within the company, they are the same as major standardization organizations, and it is plausible that the sustainability criteria diffuse in the company through the normative pillar.** This is also the same for the sustainability criteria linked to products. The pressure and demand is coercive. Some criteria, such as water use, energy use, and carbon footprint are immediately demanded from customers. Other criteria are handed through the basic structure of performing an LCA, also taking into account eutrophication, acidification, resource efficiency, ecotoxicity, and land use. An LCA in this way is a professional tool that helps to identify environmental impacts either from a finished products, or while developing a product. It is, thus, also part of the normative pillar.

7.2.3 Response of company

CX acquiesces several sustainability criteria voluntary. This is mainly the case for criteria related to LCA environmental impacts. Further up their supply chain they do have the intention of establishing other sustainability criteria (mostly social criteria) and enforcing them, but this is not happening as of yet. The response of the company is thus, **part acquiescense (environmental criteria) and part avoidance (social criteria)**. By focusing their image and sustainability criteria around the product they avoid addressing impacts further up the supply chain.

Chapter 8: Analysis

In chapter 5 the organizational field in which the companies operate was outlined. This was done in multiple levels, international, European, and Dutch. It was found across the line of the three pillars in which actors reside, that natural resource efficiency (and to a lesser extent greenhouse gas balance) is the sustainability criterion when it comes to BBM. Some actors have slightly different focuses, some certification systems take up greenhouse gas balance and most consumer organizations take up end-of-life focus just like standardization organizations. The regulative pillar almost exclusively focuses on natural resource efficiency. In the normative pillar, a variety of sustainability criteria are found but natural resource efficiency, indicated by focus on the end-of-life stage and renewable sourcing, is seen the most. The mimetic pillar is varied with biomass producers focusing on criteria in legislation, biomass processors focusing on natural resource efficiency (also greenhouse gas balance and LCA), and end-product sellers with a limited focus on natural resource efficiency. In the current chapter, the case study is looked at with a focus back on what is seen in the organizational field. This analysis is structured by the research questions posed in the beginning of the research. The answers to these questions are important to gain insight into the research phenomenon and the main research question. The questions will bring out a few elements or factors that currently have a role in the BBM sector. These elements are discussed in the following chapter, the discussion. This discussion will shed light on how sustainability criteria in the BBM sector influence companies across the supply chain (main research question).

8.1 Research question 1 - Sustainability criteria

In table 8.1, all sustainability criteria present at the companies are listed, also the ones from the comparative units of analysis. The table is also edited to show what the criteria *mainly* cover, namely the product (dark gray, white text), supply chain (white) or process (light gray). The dark gray criteria point out product related criteria. Most of these are taken into account through LCA. It has to be noted that environmental impacts up the supply chain are also taken into account by using LCAs. The supply chain (white) criteria point at social, and some environmental, criteria that are taken into account mostly through certification. The process related criteria (light gray) are about the process when making the product. This is also taken into account with LCA and with the product related criteria, but a distinction has been made. This distinction is necessary as process related criteria are more specifically focused the processes

of making the product (here biomass) than on sustainable characteristics itself. It can be seen that natural resource efficiency, GMO, ecotoxicity, water and waste management, land use, labour and human rights, and compliance with laws are present throughout the entire supply chain. Although they are not at every single company when including the comparative units of analysis, and they are not necessarily enforced, or met.

Biomass producer	**Biomass processors**	**End-product**
natural resource efficiency	natural resource efficiency	natural resource efficiency
GMO	GMO	GMO
ecotoxicity	ecotoxicity	ecotoxicity
water management	water management	water management
waste management	waste management	waste management
land use change	land use	land use change
labour rights	labour rights	labour rights
human rights	human rights	human rights
compliance with laws implied	compliance with laws	compliance with laws
greenhouse gas balance	greenhouse gas balance	
energy balance	energy balance	
biodiversity		biodiversity
soil quality		soil quality
	local development	
	food security	
	toxicity	
	air emissions	

Table 8.1: The sustainability criteria that were found in the main supply chain and comparative studies. The process related criteria are highlighted in red, the product related criteria in gray and the supply chain related criteria in light blue. Up until compliance of law all sustainability criteria are the same. Local development, toxicity, air emissions and local development are not often focused upon criteria.

Sustainability criteria in the beginning of the supply chain are process related environmental criteria. Most of the sustainability criteria that SU really focuses upon are linked to legislation. Legislation in the Netherlands (and Europe) already covers major sustainability criteria. These are not necessarily focused upon in countries outside of Europe. A quick scan of legislation showed that apart from land use (change), natural resource efficiency, and greenhouse gas balance all criteria are partly covered already in legislation. The major focus on greenhouse gas balance, water management, soil quality, energy balance and biodiversity might be prevalent criteria among biomass producers in Europe.

For the biomass processor three things can be noticed. First, the major sustainability criteria are product related. There is a strong focus on natural resource efficiency (EN 13432) and greenhouse gas balance (LCA). When looking at the comparative companies, there is also a strong focus on natural resource efficiency (EN 13432) and greenhouse gas balance (LCA). Furthermore, all biomass processors perform LCAs and by doing this also look at more sustainability criteria, such as ecotoxicity, toxicity, energy balance, air emissions, land use, waste and water management. Therefore, it is concluded most sustainability criteria for biomass processors are product related and linked to LCAs, with an extra focus on natural resource efficiency and greenhouse gas balance. The focus on natural resource efficiency and greenhouse gas balance is also noted in the coercive and normative pillars.

Second, Synbra gets its resources from outside of Europe where social sustainability criteria, land use rights (including land use change), and food security are also important. No focus though goes to sustainable, certified sourcing. This also doesn't happen at Ecoboards because its not possible yet. CX does focus on sustainable sourcing with RSPO and limited un-enforced supplier codes. In the mimetic pillar, there is limited focus on sustainable sourcing, pointing out that sustainable sourcing might not be common practice yet for biomass processors in the BBM sector. In the normative pillar, it could be observed by the amount of members from the certification organizations that indeed, certification for BBM does not happen often.

Third, Synbra and CX avoid the use of GMOs. Also in the mimetic pillar it seems that GMO use is avoided. It is concluded that biomass processors in the BBM sector avoid the usage of GMOs. Concluding, natural resource efficiency, greenhouse gas balance and other sustainability criteria linked to LCA are most important, but certification of the supply chains is not a major focus point. Other sustainability criteria, such as food security and local development, are mentioned here and there, but don't seem to be prevalent.

The end-product seller has a focus on both product related and supply chain related sustainability criteria. Again natural resource efficiency is the most important criteria that comes forth by the focus on for example EN 13432 compostability. Usage of GMO is again avoided. A strong focus on the supply chain is present, with long established certification systems such as FSC and PEFC. By doing so, CY takes a leading role in supply chain certification as this doesn't seem to be a prevalent practice with other end-product sellers.

There are four general things about sustainability criteria and the supply chain that can be observed. First, immediately noticeable throughout the case study is the presence of EN 13432 or industrial compostability at Synbra and CY. This compostability focus, points out that the current supply chain for PLA is heavily focused on the compostability of PLA. Whether the PLA and other products actually get composted in the end is a different question. This focus is highly similar with the mimetic pillar in which EN 13432 is also present. Also at the comparative company producing bioplastics, CX, this norm is present. **If EN 13432 is seen as a good indicator for natural resource efficiency then natural resource efficiency is arguably a sustainability criterion that is institutionalized in BBM supply chains.**

Second, **there is a strong focus on using LCAs to prove the greenhouse gas balance with biomass processors.** Also other criteria are taken into account through this way, pointing at the normative influence of LCA. The usage of LCAs seems to be a common practice with biomass processors.

Third, **a strong focus on using non-GMO feedstocks is also present throughout the entire supply chain.** This is also noticed in the mimetic pillar. This is in strong contrast with the public focus which is not pre-occupied with GMO and BBM. The public focus is on GMO and the agri-food sector. The focus on GMO is probably the most proactive standpoint in the BBM sector. This might be good from an anti-GMO viewpoint, but not from a technological side. The case of PHA can be used as an example here. PHA goes further than the compostability criterion which is prevalent and is arguably even more sustainable than PLA (Essel and Carus, 2012). For more on this, see discussion section 9.3.

Finally, **an average focus on social sustainability criteria is noticed**

throughout the supply chain and a weak focus in the middle of the supply chain. Although supply chain criteria are present at multiple companies, the enforcement through certification (for bioplastics) is done by two companies in the beginning and the end of supply chain (SU and CY). Even the end-product seller, CY which does have supply chain certifications, mentioned that the main selling point is actually compostability and, thus, natural resource efficiency. It seems in this sense that the BBM sector is waiting to get the certification to enforce social sustainability criteria such as human and labour rights, food security and land use.

8.2 Research question 2 - Mechanisms

A representation of the mechanisms present in the case study can be seen in figure 8.1. The explanation of the figure is given below.

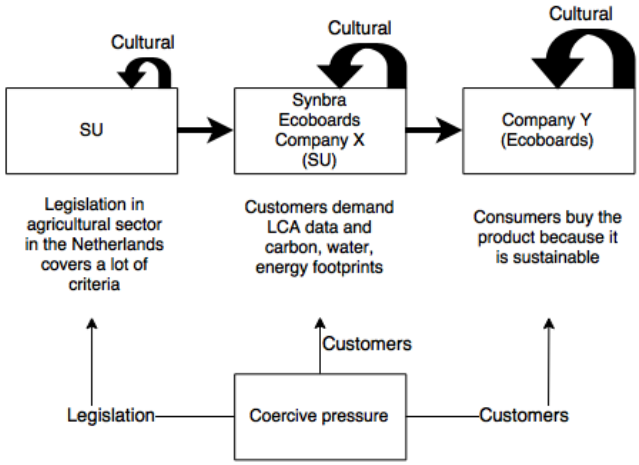

Figure 8.1: Mechanisms in case study. The mechanisms by which sustainability criteria diffuse into the companies throughout the case study supply chain. Legislative pressure in relation to BBM is strongest felt by the biomass producer as all of its activities are biomass related. Biomass processors also have some regulations to deal with but these are not BBM specific. Customer pressure was felt throughout the supply chain and grew stronger down the supply chain. This is similar for the cultural factor where the end-product seller based its entire business on sustainable BBM.

SU, the biomass producer seems to be heavily influenced by legislation and, as part of the food sector, by consumer pressure. The sustainability criteria taken up by legislation are institutionalized in the Netherlands with biomass producers. They have to comply. In this case, extra sustainability information is also asked from the customers of biomass producers and these turn to LCA, certification, or other specific numbers to represent them taking into account certain sustainability criteria such as greenhouse gas balance. However, certification of biomass production methods (for the extra sustainability criteria) in the Netherlands doesn't seem to be widely spread when looking at the mimetic pillar.

The biomass processors CX, Ecoboards, and Synbra have partly a cultural focus on sustainability. They use LCAs as a product development tool to es-

timate in advance the sustainability of the products. However, when it comes to specific sustainability criteria it is mainly demand driven. Customers ask for specific sustainability criteria and the processors address these by using LCAs or specific norms and certifications. Furthermore, through regulations that are not specific to BBM, but are nonetheless applicable to biomass processors as being in the chemical or building materials industry, some extra process-related criteria diffuse into the company. Thus, the pressure behind taking up sustainability criteria is part coercive, part cultural.

The end-product sellers, CY and Ecoboards, have a culture completely oriented around sustainability. Their core business is providing sustainable products, thus, the pressure behind adopting sustainability criteria is also demand driven. Extra sustainability criteria focused upon come mainly from the normative pillar though, through certifications.

In conclusion, in the beginning of the supply chain it seems that the pressure is coercive (legislation and customer), in the middle the pressure for adoption of sustainability criteria comes mainly from customers and in part from company culture, at the end it is also a mixture between cultural and coercive (consumer) pressure. It is through this pressure that sustainability criteria diffuse into the companies, however, it is through the normative pillar, most notably LCA and some certifications, that additional sustainability criteria diffuse as well into the companies.

8.3 Research question 3 - Responses

SU acquiesces the sustainability criteria that they are enforced to. They also try to compromise (or manipulate in a lesser extent) these criteria, but this is mainly on the terms in which these criteria come to expression than on the criteria themselves. Extra criteria such as biodiversity they do acquiesce but are not heavily focused upon.

The biomass processors acquiesce most environmental product related sustainability criteria (natural resource efficiency, greenhouse gas balance, water management, energy balance, non-GMO) and avoid or compromise on social sustainability criteria.

CY acquiesces the sustainability criteria. If they would have more data available on their products they would publicly address more sustainability criteria than they currently do. Usage of the FSC and PEFC certificates doesn't seem to be prevalent at other companies therefore, therefore uptake of social criteria might be voluntary and cultural linked.

In conclusion, it seems acquiescence of sustainability criteria is widely spread throughout the bio-based supply chain as long as it concerns production inside the Netherlands. Biomass producers are heavily involved with legislation and most of their activities are strongly regulated. They have no choice but to comply. However, they also tend to go into dialogue with the government concerning these criteria. This is different by the end of the supply chain where they have more flexibility when it comes to sustainability criteria. Therefore, acquiescence of social sustainability criteria might be less towards the end of the supply chain.

8.4 Research question 4 - Positive sustainability criteria

The strong focus on compostability and other end-of-life methods in the organizational field and the case study point out that natural resource efficiency is institutionalized in the BBM sector. Throughout the supply chain the biomass processors and end-product seller stated that they had to take into account sustainability criteria because customers asked for it. Natural resource efficiency had to be complied with in order to be able to sell the products. It is deemed that customer pressure together with natural resource efficiency (compostability) really (positively) affects the companies. Natural resource efficiency as sustainability criterion in the BBM sector is discussed in section 9.1.

The second sustainability criteria, that is apparently mostly at biomass processors, is greenhouse gas balance which is proven through the usage of LCA. LCA works here also as a normative tool that brings forward more environmental sustainability criteria. According to the companies in the case study, LCAs were used for several reasons but mainly to prove to customers that their product is indeed performing well. It is deemed that greenhouse gas balance as criterion performs well through the customer mechanism. Greenhouse gas balance and the usage of LCAs is discussed in section 9.2. The final main criteria that comes forth is the usage of GMO. This is avoided throughout the entire supply chain. GMO usage as sustainability criteria is discussed in section 9.3.

The presence of social sustainability criteria through certification at CY is in sharp contrast with other companies in the mimetic pillar. Therefore, it is concluded that social sustainability criteria are not heavily focused upon towards the end of the supply chain in the BBM sector. Thus, social sustainability criteria are not very successful in diffusing into the sector. Although this is not positive, it is also a result and an interesting part of the current situation. This is discussed in section 9.4.

In the next chapter, the main research question is discussed as an open question. The successful (natural resource efficiency, greenhouse gas balance, GMO) and unsuccessful criteria mentioned above will be discussed at length. However, the mechanisms through which these diffuse also have to be highlighted. The main mechanism in place is coercive through either legislation (beginning of supply chain) or customers (beginning through to end). Legislation and customer pressure are shortly discussed in section 9.5.

Chapter 9: Discussion

How do sustainability criteria in the bio-based materials sector influence companies across the supply chain?

In the previous chapter the research questions were answered. The most successful sustainability criteria were found to be natural resource efficiency, greenhouse gas balance, and GMO use. Social sustainability criteria were found to be relatively unsuccessful in diffusing into the sector. The successful mechanisms were coercive and cultural when it comes to pressure, but mostly normative for diffusion of sustainability criteria to the companies (LCA and certificates). All these points are currently influencing (or not) the supply chains in the BBM. Therefore, every sustainability criterion shall be discussed separately together with the main mechanism, coercive pressure. This informs the reader about how sustainability criteria influence the supply chains at the moment. At the end of this chapter some extra remarks and recommendations to actors are formulated, and the scientific contribution of this study is discussed briefly.

9.1 Natural resource efficiency

9.1.1 General natural resource efficiency

Natural resource efficiency is the sustainability criteria that dictates the efficient use of natural resources. Natural resources can be biotic (living and organic material) and abiotic (non-living, non-organic material). According to Guinée (2002) biotic resources are biomass, forests and animals, while abiotic resources include for example energy, iron ores and fossil resources. The very premise of the bio-based economy concerns this sustainability criterion. Replacement of the non-renewable abiotic resource which is fossil fuel with the renewable biotic resources which are biomass, is a more efficient way of sourcing materials. So, from a conceptual perspective, BBM should perform good when considering natural resource efficiency. In practice this is not necessarily true.

According to a meta-analysis of LCAs of PLA and PHA, fossil resource depletion of these plastics is considerably lower than for their fossil based counterparts (Essel and Carus, 2012). Here fossil resource depletion is a measure for abiotic resource depletion, and thus also for natural resource efficiency. When measuring natural resource efficiency, however, different perspectives can be held. For example, a researcher can look at abiotic and biotic resource depletion, land use competition, carbon footprint, and water footprint as indication for natural resource efficiency. In another study, comparing bioplastics with petroleum

based plastics, it was again concluded that fossil resource depletion of bioplastics is lower, but that at the same time ecosystems quality declined (Gironi and Piemonte, 2011). An ecosystem might be seen as a biotic resource. This points out that bioplastics might perform well with abiotic resources, but less so with biotic ones. Weiss et al. (2012) pointed in another meta-analysis of LCAs that bio-based materials usually perform better than conventional materials in terms of primary energy (abiotic resource efficiency) and greenhouse gas balance. They perform worse in terms of eutrophication (ecotoxicity/biotic resource efficiency), and stratospheric ozone depletion because of the extra biomass cultivation stages. Concluding, natural resource efficiency for BBM might mean shifting abiotic resource depletion to biotic resource depletion and impacts.

BBM on the market do not necessarily contain that much renewably sourced biomass. According to Carus (2015) some companies do not produce products that are 100% bio-based while claiming they are. An example is that of SABIC which claims their polyethylenes and polypropylenes are sustainable because they are bio-based while it is suspected this is not the case (Carus, 2014). The claim of sustainability can be made through the little sustainable biomass part that is certified, by for example ISCC PLUS, while the product in its entirety is not sustainable. This disturbs market transparency, and furthermore, these products would not perform better concerning abiotic resource efficiency. Even more, the sustainability (also including impacts such as greenhouse gas emissions and land use) of some of these products has not been proven. Some of these companies are very visible. CocaCola, for example, has received criticism for not releasing any evidence supporting its claims around their 'sustainable' PlantBottle® (Recyclingnetwork, 2013). The good news is that there are now standards in development concerning bio-based content in bio-based products in Europe. The published standard EN 16785-1:2015 uses radiocarbon method to determine the bio-based carbon content. The second part of EN 16785 (soon to be published) determines the bio-based content with a material balance method. Bio-based products shall only be called so when they always contain a minimum bio-based content. NEN is in the process of developing a European certification scheme for bio-based content based on the above norms. By the summer of 2016, companies should be able to get certification for bio-based content in products.

Although sustainability is not an inherent characteristic of the BBM sector, focus on natural resource efficiency is. There are two factors to be considered concerning general natural resource efficiency and BBM. First, the depletion of primary energy and fossil resources as abiotic resources might be less, shifting the environmental impact on biotic resources. This means that when considering BBM, special attention is necessary for the biotic resources (biomass production). This could be taken into account through certification or through local (European) production. Second, the norm for bio-based content in the BBM sector is a good step forward that might increase natural resource efficiency and market transparency.

9.1.2 Biodegradability and recycling

This research indicates that industrial compostability (EN 13432) is institutionalized in the Dutch bioplastic sector. Global market forecasts, however, show that non-biodegradable, but bio-based, substitutes will outgrow biodegradable plastics by far (Philp et al., 2013a). These are mostly bio-PET and bio-PE.

Most LCAs of bioplastics that were mentioned before, address natural resource efficiency up until the granulate stage (Essel and Carus, 2012). However, the end-of-life stage (e.g. incineration, land fill, composting, recycling) is also important. With incineration, most of the sequestered carbon is released again. Composting seems a better option. It produces fertiliser from the BBM that could be used to produce biomass, evidently closing the material loop. Song et al. (2009) states that the actual composting of bioplastics is indeed needed in order to fully achieve resource efficient materials. Thus, industrial compostability being the norm in the BBM (or bioplastic) sector seems to be beneficial towards the environment. In the Netherlands, in contrast to other countries in the EU, it is permitted to add bioplastics to green waste streams designated for composting. The composting end-of-life stage is valid in the Netherlands as a lot of waste gets composted. The government here should invest in informing the people of the seedling logo on packaging so degradable plastics end up where they belong, and that collection of green wastes happens everywhere.

However, as stated, impact assessments including the end-of-life stages are not common (Hottle et al., 2013). The ones that do, report negatively on composting. For example, Gironi and Piemonte (2011) pointed out that the overall environmental impact of conventional plastics that get recycled is still better than bioplastics that don't get recycled. It was also stated by CX (a company in this research) that one of the main barriers in the Netherlands towards sustainability is the end-of-life stage. Proving the superior sustainability of bioplastics when including end-of-life stages is difficult. Furthermore, Piemonte (2011) showed that the most important bioplastics on the market right now are more environmentally sustainable when recycled instead of when composted, incinerated or digested. Recycling of bio-based plastics such as PLA is technically possible, but not yet in practice. A study of OVAM showed that 1 bottle of PLA on 1000 bottles of PET is enough to prohibit effective recycling of the PET (Wille, 2015). As not all waste recycling facilities have the technical capacity to sort PLA from PET it is highly disadvantageous to have PLA in the recycling stream. This is also stressed by the Plastics Recyclers Europe, saying they do not want these kind of plastics in the system (Emans, 2016). The public should be informed about this with clear labelling of these alternative (biodegradable) bioplastics so they end up in the right waste stream.

PLA now ends up in the green waste streams and gets composted, ends up in the regular waste stream and gets incinerated, or ends up for recycling and distorts recycling processes. The latter is highly disadvantageous. The former, incineration and composting, entails that high volumes of PLA are needed to be produced. This increases the biotic impacts in the beginning of the supply chain (biomass cultivation). Therefore, it seems that currently, PLA is only environmentally friendly in specific situations where its digestion can either replace plastics that would be incinerated or when it would be completely recycled. The latter can occur when the current recycling plants are capable of this, or when specific recycling networks are setup for PLA. Until then, PLA and other degradable bioplastics could have a higher environmental impact than conventional plastics in the current Dutch system.

This is of course not true for all BBM. Ecoboards is a nice example of this. They can recycle their boards for a 100% and they would like to have a deposit on the boards so they can recover them more easily. Furthermore, if the quality declines to far the boards (or what is left) can be composted.

This is an example of how a BBM supply chain should be structured. It goes through all the stages of the waste hierarchy. The waste hierarchy indicates the preferred options of waste management that a product should have. These are waste prevention and re-use, preparing for re-use, recycling, energy recovery and disposal (Mauer, 2016). Composting would likely be between recycling and energy recovery. Synbra is also on the right track. They produce PLA as an alternative to styrofoam. They have already been recycling styrofoam they produce. The recycling of PLA they can set up themselves. In this way they evidently close the cycle and produce a sustainable product.

Concluding, more research is needed into the end-of-life stages of bioplastics and a discussion is needed to see whether industrial compostability is beneficial. If not, recycling of bioplastics will need to be the norm. This is especially true when realizing that bio-based PET, PE and PP can enter existing recycling structures while others like PLA have difficulties with this. PLA even creates friction between producers and the recycling industry. It is also estimated that the bio-PET and bio-PE will be the most commonly produced bioplastics in the future. This points out that more focus on recycling in European countries might still be better than the current focus on composting of bioplastics. These generalizations cannot necessarily be said about all BBM as the example of Ecoboards points out.

9.2 Greenhouse gas balance and LCA

Greenhouse gas balance and other sustainability criteria such as ecotoxicity (fertilisers, pesticides), energy balance, abiotic resource depletion (fossil resource depletion), air emissions (photochemical oxidation), land use (farm land use), and water management (water use), are all taken into account by biomass processors in the case studies through the use of LCA. This seems to be a prevalent practice. Throughout the interviews it was said multiple times by different people that in order to be able to bring these products to the market their sustainable nature has to be proven and that carbon, energy and water footprint are often asked. Thus, LCAs seem to be necessary to prove the sustainable character for bioplastics, and presumably other BBM as well, towards customers in the BBM sector.

Hottle et al. (2013) highlight that when performing LCAs on bioplastics the most focus goes to greenhouse gas balance (global warming potential) and abiotic resource depletion (fossil resource depletion). Other area's such as ecotoxicity and land use are ignored. Even more, end-of-life impacts are generally not focused upon while these have a major impact on the environmental performance (Hottle et al., 2013). Companies in the case studies also tend to mostly focus on greenhouse gas balance and abiotic resource depletion. This might be because these are two criteria where bioplastics tend to perform well. In the case study, other impacts such as ecotoxicity, energy balance, and water usage are often mentioned by the companies as well. Concluding, it seems that when performing the LCAs greenhouse gas balance and fossil resource depletion are often taken into account. Other impacts are also taken into account albeit less.

In general, more and more companies seem to adopt LCAs (Schatsky, 2011). They use it for example for modelling new manufacturing processes, in product innovation, for customers, or marketing. Results for bioplastics from these

LCAs tend to vary heavily though, pointing at a need for LCA harmonisation (Philp et al., 2013a). A strong step in the right direction is the published European guideline on performing LCAs for bio-based products, namely EN 16760 (Life Cycle Assessment). These have also been published by NEN in the Netherlands. The guidelines for life cycle inventory and end-of-life phase (FprCEN/TR 16957), which is important, are yet to be published.

The presence of LCA as a common tool in the case studies and the presence of multiple other studies reviewing or showing data on LCAs of BBM, point out that LCA is used often for BBM. This is an opportunity for the government. In the same way that biofuels need to comply with a GHG savings targets in Europe through the RED, the same can be done for BBM. With biofuels, the RED dictates that they have to have greenhouse gas savings of 35% currently (this percentage rises in the future). When this target is set, other criteria have to be kept in mind as well because impacts might shift from one impact (GHG) to another. RED has addressed this by for example stating that biomass cannot be grown on high carbon stock land or land with high biodiversity. These kind of targets can be set for BBM as well, especially because LCAs are apparently commonly used. Targets for BBM have been proposed by others before (Philp et al., 2013a). However, when these targets are too strict, a lot of bioplastics, for example PLA, won't be able to comply. This is because, as we have seen before, greenhouse emissions savings are feasible, but the impact of the extra biomass cultivation stage often increases the impact elsewhere. It might also not make sense to have a GHG target for BBM as this increases the divide in level playing field between petroleum based and bio-based materials. It might also not make sense as the primary target for BBM should actually be natural resource efficiency, replacing fossil fuel products with other alternatives. Targets through LCA for natural resource efficiency mgiht be more logical. Either way, this is a discussion that needs to happen. If targets are possible for biofuels, targets for BBM should be possible as well. One last remark is that, just like certification systems, LCAs are very costly and this has to be taken into account as well (Bos and Butter, 2014).

9.3 GMO

Concerning the academic world and GMOs. Using GMO as a sustainability criterion is not common. Some studies don't, others do treat the usage of GMOs as a sustainability criterion (Markevičius et al., 2010; Fritsche and Iriarte, 2014). Without joining the discussion about the uptake of GMO as a sustainability criterion, companies in the case study say they don't use GMOs while portraying their sustainability. Therefore, it is likely that companies themselves see this as part of the sustainability discussion, and therefore as a sustainability criterion. For bioplastics, the advice is sometimes given to not use GMO crops in the production because environmental effects are not clear (Álvarez-Chávez et al., 2012). Concerning health issues of the general public, even when GM crops are used, the processing stages when producing bioplastics will remove all traces of genetic material, making the end-product GMO free and safe to use. However, it is logical with the debate around the safety and ethics of using GMOs that most companies in the case study (and in the mimetic pillar) tend to avoid the usage of GM crops. Currently, Genetically Modified (GM) crops are not necessary

to produce BBM. All crops necessary to produce BBM can theoretically be bought in non-GMO form. The discussion around the usage of GM crops for bioplastics and BBM is practically the same as the one for GM crops and the agrifood sector. Therefore, this discussion will not go into further detail about this.

For some newer bioplastics, PHA for example, GM bacteria or yeasts can be used to produce them more cost effective. Genetic modification of these organisms in industrial (white) biotechnology is by the use of for example synthetic biology. This is not genetic modification in the traditional sense, but does alter genomes or metabolisms of microorganisms to be used in industrial installations. Synthetic biology is a discipline where molecular compounds are generated using engineering approaches in cells. This discipline can theoretically produce any organic compound, and more, that would otherwise be produced from petrochemical sources. This might be a key discipline in establishing the BBM (Philp et al., 2013b). Current problems with achieving cost-effectiveness for bio-based products can be addressed with synthetic biology. A simple example is getting rid of heavy metal catalysts, solvents and some expensive production costs for PLA by producing it in an *E. coli* strain.

Thus, synthetic biology, just like other disciplines based on genetic engineering, offer many benefits. However, in Europe the public discourse on genetic engineering in the agricultural industry has already been ongoing for a long time (Levidow and Carr, 2009). This was mostly linked to the food sector. The public discourse on synthetic biology is not fully ongoing yet, but likely there will be questions about biosafety and biosecurity. These latter topics might be less critical in industrial settings than in agricultural settings. Legislation on synthetic biology will probably not entail extra additions to the legislation of genetic engineering for now (Philp et al., 2013b; EPTA, 2011). Although this might change of course with the public discourse in the future.

To conclude, the industry proactively denounces GM crops, as might be necessary due to legislation or from a marketing viewpoint. However, the usage of GM crops or GM micro-organisms (synthetic biology) might be necessary to achieve the next step in resource efficiency for BBM. Actively portraying the avoidance of GMOs as a sustainability criterion might therefore be too hastily. Careful considerations have to be made but clear communication and informing the general public is central. Good news on this part is that in the Netherlands already early engagement and informing of societal actors is ongoing concerning synthetic biology by the Rathenau Instituut (Rerimassie, 2016). This institute has a normative influence back on society.

9.4 Social Sustainability Criteria

Social sustainability criteria in the Netherlands are mostly enforced by law. There are labor and human rights regulations. However, most biomass for BBM in the Netherlands is produced outside of the Netherlands. Social sustainability criteria are not always taken into account because of this. In contrast, environmental sustainability criteria are often taken into account due to the usage of LCA which looks at the entire supply chain. The biomass processors in this study only have a limited focus on certified sustainable sourcing, while the end-product seller has a strong focus on certified sustainable sourcing. The fo-

cus of the latter might not be prevalent in the Netherlands though. There are internal and external benefits for companies to adopt certifications as stated by Van Dam et al. (2012). Mostly, certificates can improve internal efficiency, external market demand (legitimacy of product), complying with policies or engaging competition (premium price, tender). According to these benefits, it is possible that sustainable sourcing of biomass for BBM will come in time due to certain policies, increased competition or market demand.

- Market demand from customers for social sustainable sourcing is difficult to visualize or predict. Most certificates that are specific for biomass for BBM such as RSB and NTA 8080/81, have a very limited amount of certified companies. CY pointed out that for selling its products, the product specific (EN 13432) criterion and ecolabel is needed and the (social) certification systems less. Therefore, market demand will likely not drive the uptake of social sustainability criteria.

- Increased competition is likely to happen because of the limited amount of companies producing new BBM. However, as has been stated previously, customers in the business-to-business market ask mostly for environmental footprints. Also because the BBM sector uses relatively small amounts of biomass in comparison to feed, and food, it is unlikely this will gain a lot of attention from customer and consumers (Scarlat et al., 2015). The uptake of social sustainability criteria therefore will likely not be competition driven.

- It is possible to link the NTA 8080 to subsidies in the Netherlands. Companies that want to be eligible for subsidies need a fully certified supply chain according to NTA 8080. This is done for bioenergy and biofuels on a national level with SDE+, and on European level with the RED. This seems to be the most straightforward and strongest method. It might happen in the future through a reformation of the RED. Thus, drivers for the uptake of social sustainability criteria for BBM will likely occur on European level. The Dutch government can take a leading role in this as well by linking subsidies for BBM to the NTA 8080.

As has been noted there are several certification systems available to prove sustainable sourcing, namely NTA 8080/81, RSB, Bonsucro FSC, PEFC, and ISCC. NTA 8080 is a norm dictating sustainability criteria and NTA 8081 is the accompanying certification system (see section 5.2.3). The system was set up by NEN (Dutch), and it is also this organization that is mostly responsible for the CEN/TS 411. The NTA 8080/81 has been benchmarked (as a biofuel/bioenergy certification system) as being a more strict certification system in comparison to Bonsucro, RSB, RSPO, RTRS, and ISCC (Van Dam et al., 2012). These are all EU-recognised in the RED. NTA 8080/81 has a quota for greenhouse gas emission reduction considering biofuel or bioenergy, but not for BBM. So far, the certification of BBM by NTA 8080/81 is also minimal. **This points at the Netherlands being a European leader when it comes to setting up (social) sustainability criteria for biomass for bioenergy, biofuels or BBM, but not yet influencing the BBM supply chain towards sustainable sourcing. This could be done through links with subsidies and legislation.**

Apart from these possible influences on the uptake of certificates, there are also certain barriers perceived by entrepreneurs. Most notably, certificates are very expensive (Bos and Butter, 2014; Van Dam et al., 2012). This was also stated as a major hurdle by CY and Ecoboards. Here, companies at the end of the supply chain have to pay a lot for certifications, even for product specific once like composting certificates (EN 13432). However, when it comes to biomass related certification (includes social criteria), the beginning of the supply chain bears the most costs, while receiving the least external benefits (Van Dam et al., 2012). This is troubling when the most costs are carried by (supposedly poorer) farmers outside Europe, but this was also visible inside the case study. Suiker Unie does not provide any premium prices for farmers that adopt sustainable practices because it is not feasible in the long run. The farmers have a lot more work when they want to adopt these practices. The end-product seller, however, sells its products at premium prices, providing sustainable sourced materials. **Thus, certification organizations themselves could figure out how to distribute these costs better.** For more information on other problems (and benefits) that companies in the Netherlands encouter with certifications, consult Charlemagne et al. (2015).

As NTA8080/81 was not present in the supply chain, but the presence of Bonsucro was observed, an interview with a Bonsucro representative was held. The result of this interview can be consulted in appendix I. It was found that there weren't many companies in BBM supply chains that are certified, but the interest in certified buying seems to be increasing. Due to the RED, Bonsucro has definitely seen an increase in biofuel sellers in Europe that wants to source certified. This is a good indication that such a similar directive will be successful in increasing social sustainable sourcing in the BBM sector. Working through consumers (on-product certification) only works in specific cases for sugar. Either producers don't want to point out for their consumers that they use sugar or the product is a mixture in which the entire product cannot be certified by Bonsucro. It is unlikely that for BBM consumer demand will make a lot of difference as well. The social sustainability of the products is not visible to consumers. Therefore Bonsucro is really working on the biomass producer side and not with consumers. They are trying to create more shared value along the supply chain, convince producers that it is worth it, and develop other programs outside of certification to establish sustainable produced sugar cane.

In conclusion, the Netherlands has a leading role in Europe when it comes to sustainability criteria for BBM in certifications. However, the amount of certificates granted specifically for BBM is limited. It is difficult to predict how this will develop in the future. This is a complex problem. The aid of multiple actors is needed:

- The government could help increase uptake of certificates by linking NTA 8080 to subsidies. It could also push on European level to extend the RED to renewable materials as well.

- Certification organizations need to address the costs and benefits (distribution) across the supply chain. Whether certification will be visible to consumers is something that depends on the product itself. This development needs to be monitored to see if consumer demand can't be incorporated in some way.

- Consumers need to realize that buying certified products actually does make a difference and can influence the supply chains immediately. Consumer awareness is important.
- Companies can increase their legitimacy quite rapidly and efficiently by getting certificates. Choosing the right certificate and portraying it could be beneficial.

9.5 Coercive pressure

9.5.1 Legislation

Legislation linked to sustainability criteria for BBM was mostly observed in the beginning of the supply chain. The Netherlands has already invested in environmental policies for a long time and has received praise from, amongst others, the OECD (OECD, 2015). The environmental policies already address sustainability criteria such as (eco)toxicity (pollutants), greenhouse gas balance, waste management, water management, and biodiversity (OECD, 2015). The Netherlands has apparently decoupled greenhous gas emissions, waste generation and pollutants from economic growth (OECD, 2015). When it comes to agriculture several policies were named in section 6.1. These policies translate several sustainability criteria into coercive measures. The government changes targets in order to achieve its sustainability goals. It has notably cut down ammonium emissions, fertiliser and pesticide use in the past. It is expected targets will become stricter in the future. Because of the good understanding between the Dutch agricultural sector and the government and their shared achievements it is deemed this factor does not need further explanation.

9.5.2 Customer pressure

Out of the analysis it is evident that customer pressure in the bio-based materials market has an influence on the adoption of criteria. All companies got specific demands from their customers, namely specific environmental impacts such as carbon footprint and water usage, or specific norms and certificates. Because the end-product seller in the main supply chain (CY) is able to sell products, the customer demand went all the way through the supply chain from consumer to biomass producer. Because this is a theoretical supply chain, it is not certain that in actual supply chains (or supply chains not concerning PLA) the consumer pressure also effectuates pressure on the entire supply chain. However, the presence of the compostability norm throughout this supply chain and the consumers recognition of the Seedling ecolabel points out that consumer's demand effectuates through the supply chain.

Thus, consumer demand seems to have an effect in the case of PLA. This remark cannot be generalized towards all BBM, although Ecoboards also stated that the demand for these kind of products is incredibly high and cannot be ignored. It is positive that sustainable consumption in the Netherlands could drive the development of bioplastics. However, Martens and Spaargaren (2005) pointed out that the Dutch government has no measures focused on citizen-consumers. Starting from the seventies there was a realization that less consumption is important, this developed into the thought that consumers are

the critical pawn in environmental policy into finally, the fixation that sustainable consumption is a technological issue connected to producers of products. Martens and Spaargaren (2005) do claim that sustainable consumption has been embedded to some extent in Dutch society and that they anticipate an increasing relevance of consumption policies in environmental politics.

> "...there is little merit imposing obligations on citizen-consumers, who not only lack the power to influence the organization of production and consumption, but also cannot—and arguably should not—be held responsible for issues that arise out of the "treadmill of production and consumption" (Schnaiberg, 1980)...At the same time, it is equally important to avoid simply discharging citizen-consumers from responsibility for the impacts of their consumption practices. This is not intended as a moral statement; our point, rather, is that we cannot properly comprehend modern consumer societies by examining producers alone...Specific policies are geared toward improving market access, promoting transparency of product information, and strengthening the legal position of consumers in disputes with producers. More broadly defined social concerns regarding consumption such as sustainability—appear only when reliable information about a product's environmental dimensions is an issue. However, the degree to which the Ministry [of Economic Affairs] focuses on sustainability as a broader aspect of consumer policy is rather limited...A guiding philosophy that the market is the most efficient way to distribute goods has remained largely unchallenged, and the EZ [Ministry] confines its interventions to the occasional imposition of ecological taxes to limit pollution. As such, the Ministry seeks to coordinate its activities with European-level regulations." (Martens and Spaargaren, 2005).

There are several ways to ensure market pull for bio-based products and innovation according to Carus et al. (2015), such as targets and quotas, public procurement, labels, and taxes on fossil carbon. Targets and quotas are currently set with the RED on European level but this is only for bioenergy and biofuels. Carus et al. (2015) pointed out that member states are not very happy with the RED and that reform, including (targets for) BBM is wanted after 2020. Public procurement is "the purchase by governments and state-owned enterprises of goods, services and works."(OECD, 2016). Currently, there is no setting in the European Union for public procurement of BBM. However, in 2013 a Commission Expert Group for Bio-Based Products was setup that developed recommendations on public procurement in 2016 (Commission Expert Group, 2016). Open-Bio (see section 5.2.2) is also on European level to stimulate markets through public procurement, labelling and standardization. Public procurement in the Netherlands is organized by the Ministry of Economic Affairs with "duurzaam inkopen". A part of this is based on bio-based products. PIANOo is the expertcentre for tenders. It advises governments on social responsible purchasing. Part of that includes buying bio-based products. The Netherlands is, thus, a leading country again when it comes to procurement.

However, Ecoboards and CY stated that public procurement is not noticeable. Ecoboards has the most experience with this because public procurement for building materials does exist. Ecoboards states that there are not enough products to choose from for public procurement to work. Whether or not public procurement makes a difference (yet), it is a valid tool and deserves attention.

Labels support buying decisions of consumers. A few labels were noticed in the case study to be prevalent, such as Vinçotte OK COMPOST (EN 13432), Seedling logo (European Bioplastics, EN 13432), Better Biomass and Cradle-to-Cradle®. The most prevalent are product specific labels concerning end-of-life (composting). This is highlighted in section 9.1. There is not one label for bio-based products. Multiple separate labels might not be convenient. The collection of criteria such as bio-based content into existing known sustainability certification and labelling schemes might be useful. An example of this is the EU Ecolabel. Extensive research has already gone into the potential of adding a bio-based products category with the EU Ecolabel. This study has determined it is technically feasible to do this (Eder and Dammer, 2015). It further suggested the new norm on bio-based content should be taken in as well together with a target for bio-based content. A study of the EU Ecolabel showed that Dutch citizens are not positive towards the EU Ecolabel (Meeusen et al., 2015). This might be a problem. Clear informing of the general public might be necessary here. In conclusion, attention is given on European level to the correct labeling of bio-based products.

A tax on fossil carbon seem to be the strongest possible way of market pull. It was stated multiple times by almost every company that such a tax is wanted. However, enabling this only in the Netherlands would result in market distortions (Carus et al., 2015). The Netherlands did experiment with a tax on packaging in 2008 but discontinued the tax in 2013 because it was not effective. The taxes simple shifted down the supply chain until consumers had to pay extra for nearly all their products. This measure should be reevaluated by the Dutch government. Premium prices are a big gap for bio-based materials and this gap could be closed by taxes.

In conclusion, there are indications that consumer demand drives the development of PLA in the Netherlands. The Seedling ecolabel seems to be recognizable and, thus, effective in the Netherlands. The governments approach in the Netherlands with 'sustainable consumption', is rather focused on the production side. There are however straight forward ways to help consumer demand make a difference in the new developing market of BBM. Targets in legislation are deemed to be strong incentives. Public procurement might not be as effective as it sounds. On the other hand, labels are recognized and could contribute in an easy way. Finally, negative taxes on sustainable products or taxes on unsustainable variants might be a strong, but controversial measure.

9.6 Final Remarks

9.6.1 Mandate 492

Mandate 492 covers a lot of the above factors that currently play in the field, bio-based (carbon) content, LCA, market demand and certification. Together with the Knowledge Based Bio-based Products' Pre-Standardization and Open-

Bio there have already been a lot of efforts towards the market formation of bio-based products in Europe. The final stages of these works are happening at the moment of writing this report. The effects of these efforts should be followed up in the coming years. For more information, the NEN, Nova-Institut and TU Berlin have a lot of reports on the market formation.

9.6.2 Keeping the industry

For EcoBoards it seems that the only way to meet their requirements are investments. The investment climate is not good enough however. They can't start producing locally (and thus not reclaim products and meet circular economy requirements) because they don't have the capital. They have permits, proof of sustainable production, products, but there is no money. Apparently investment funds don't seem to invest in bioeconomy because it is not strict in one sector, for example the horticulture sector. That is why Ecoboards is falling between the cracks. Their business doesn't fit into the investment scheme. This non local production might stand in the way of sustainability. This is especially true when considering social sustainability criteria that are legally tracked in Europe, but not outside of it.

> "I see an entire research country of fragmented organizations that don't cooperate but that are all working with biomass like it is the new gold.[...] But it is too fragmented. [...] Connecting, cooperating there is the power." (Chotkoe and Kempenaers, 2016)

Synbra has the feeling that the establishment of the BBE in the Netherlands, and to some extant Europe as well, will be difficult. Just like Ecoboards and SU, Synbra recognizes the variety of bio-based projects in the Netherlands and that the Netherlands has a very strong position when it comes to R&D. Synbra estimates, though, that the majority of these projects do not get commercialized within the Netherlands. According to Synbra the Netherlands misses a lot of opportunities and the extensive focus on R&D is only useful when commercial projects (factories) get setup as well afterwards. Similar to Ecoboards there were some remarks on China's ease to develop products and adjust legislation. Also for Synbra it looks like the BBE will be established by other countries in the EU and out of it, rather than in the Netherlands. Furthermore, the trust in the industry policy is very low. An example of frustration is that biofuels get subsidies while the 'more sustainable' bio-materials barely do. On the other hand, there seems to be a certain form of immobility in the industry itself as big companies are afraid of bad publicity, and therefore don't seem to be investing in drastic changes.

> "Do you know what a big problem is with big companies? It is fear." (Noordegraaf, 2016)

SU acknowledged that there are a lot of projects that look at viability and commercialization. SU sees that there is a lot of R&D projects as well and that when it comes to knowledge on technological level a lot is possible and the Netherlands have a strong position. SU itself wants to invest in business and research consortia and thinks there is real value in cooperation. This is especially the case with bio-based as it is a complex and highly technological field.

It looks that on European level they do understand that there is not a level playing field for BBM, but it is a slow understanding. Apparently in Denmark, they are changing this. Subsidies for bioenergy are discontinued, and they work through taxes (Chotkoe and Kempenaers, 2016). Subsidies are going to bioenergy because that reduces the dependency on fossil fuels. This is a power struggle. It is not about sustainability. Use of biomass for bioenergy makes the biomass more expensive. This is a major barrier in order to produce BBM. Affordable access to biomass plays a crucial role in keeping high value industries in Europe (Carus et al., 2015). For example, some customers might opt for other alternatives still because the Ecoboards get imported from China (Energieprovincie, 2016).

9.6.3 Certification gap

Most certificates are using a business-to-business perspective. This is specifically the case for Bonsucro which has only around 4 end-products with their label. These kind of certification systems (e.g. RSB and Bonsucro) start from the biomass producers and through chain-of-custody certification work their way down the supply chain. However, certification at the end of the supply chain is not common. When Bonsucro was contacted (Seixas, 2016), they also stated that it is not easy to include the consumers into the process and that Bonsucro rather focuses on the upper supply chain and business-to-business than on consumers. RSPO, FSC and PEFC are exceptions. At the end of the supply chain other types of certificates and labels are present for business-to-consumer segments. However, labels that prove compostability (e.g. European Seedling logo) do not necessarily prove the product is sustainable as was outlined in the discussion about natural resource efficiency. It is clear there is a gap here and faith in consumer pressure for sustainable development has left the private sector. This was also very nicely formulated by Bonsucro: "That is the right way. Because you can have the consumer have the choice whether to buy sustainable or unsustainable, or you should have everything sustainable and sustainable be the default. So there is no choice, and I think this is a better option. Sustainable should be the default and not a choice. The business-to-business potential of making things sustainable is way higher than with consumer choice."(Seixas, 2016). Because most BBM are also mixed products, especially in the case of bioplastics, the consumer awareness around social sustainbility matters and certification might not break through. This is why other type of drivers need to be looked at to stimulate the business-to-business market to take up these certification systems.

> "There is significant debate over this topic. Experts and larger companies regard certification as a business to business (B2B)

> requirement, emphasizing that an increasing amount of companies require it from their partners (Box 3.4). Certification has been described, in essence, as a must-have for companies – both small and large – that want to ensure they stay in business in the years to come. For SMEs, however, certification is not yet regarded as an "industry standard". They do acknowledge the growing demand from the customer side, but also emphasize that they still have customers who opt for uncertified products" (Charlemagne et al., 2015)

9.6.4 Cradle to Cradle

Two companies were certified by or connected to MBDC. The major idea behind this certificate is natural resource efficiency. There is a gap in between bio-based or renewable products and circular economy. Although they are linked. Bio-based only talks about the primary resource, which is biomass. When eventually these bio-based products get recycled or composted the circle goes round and a circular economy is achieved. However, these do not help with (plastic) litter. It is only when the biomass is produced in a completely sustainable way (without deforesting, ILUC, with respect to human rights, etc), citizens are fully aware of what to do with the plastic (need for labels), all plastic gets either recycled or composted (labels, company and government support), that the system reaches a sustainable equilibrium.

9.6.5 Cultural factor

The cultural factor should not be neglected in the end. Synbra, CX, CY and Ecoboards are all companies that fit into the stereotypical picture of a BBE. Because they affiliate with trends that go on here they have a natural tendency to think about what products to bring on the market and how these products perform. In hindsight, including these companies into the case study might have overestimated the focus on sustainability. On the other hand, it might be so that companies linked to BBM have a natural tendency to think about how their products perform.

9.6.6 Recommendations for actors

In this section, recommendations to the actors involved in this research are made. Only the main recommendations are repeated here. More can be found in the discussion. Concerning sustainable development there were two main points that came forward out of the discussion. These are necessary to consider when talking about sustainability for the BBM sector. First, producing BBM might shift the impacts of production from abiotic resource depletion to biotic resource depletion. In Europe and the Netherlands, focusing on certified biomass sourcing and local production is key for sustainable development in the BBM sector. Second, the end-of-life stages of bioplastics and BBM are most important. Biomass sourced products will always have a higher biotic and social impact due to biomass cultivation. This means that using less of these resources

is the most direct way to sustainability. Less use entails less consumption, more reuse, and more recycling. These should be the clear focus points of BBM. The current focus on biodegradability might not be the most efficient way towards sustainability in the sector. In other words, bioplastics should be used for specific niches and not just to replace oil-based plastics. If bioplastics such as PLA become mainstream, the public should be informed on separation, new recycling paths for these plastics have to be setup, or the current recycling plants have to adapt to this situation. This should preferably be done on European level.

European Institutions. There are several problems that have to be addressed on European level. The playing field for fossil versus bio-based needs to be leveled out and biofuel and bioenergy versus bio-based products as well. Mandate 492 is a very good initial step, this has to be build out further. Also a reformation of RED to include BBM might be a useful step. It might not be necessary to immediately put heavy environmental criteria on the production of BBM, such as GHG targets. There are two factors that can help with the sustainable development in Europe, first, stimulating local (European) use of biomass, and two, a more intense focus on the sustainability impact of BBM end-of-life stages in Europe.

Dutch government. These recommendations are also useful for the Dutch government. Biodegradable bioplastics should preferably be collected with other green waste streams and then composted. This is almost established in the Netherlands. The government should inform the people more on the end-of-life phase so the collection happens correctly, and invest more on collecting the green waste streams separately from other trash. However, plastics that can be recycled should be recycled. The government should have a mediating role here in which either the current recycling industry adapts, a separate collection system for these plastics gets setup, or if the latter don't work, containing the production volumes of biodegradable plastics to those situations where it makes sense.

The MIA/VAMIL link to for example DUBOkeur can be useful if the size of the allowed projects gets smaller. This would stimulate more small and medium enterprises (KMO). Also a similar system to the SDE+ for bioenergy and biofuels could be setup for BBM. Through this way, targets can be set up for BBM that ensure sustainable development.

Normative agents. They have to shine the light ahead. Be very strict and point at the problems. It doesn't matter always what the responsibility is of the specific agent. A scholar working on LCAs might not think about the impact of it, but LCAs do work as normative tools as well.

Companies. Sustainability is dependent on the system in which it is seen. Products that are sustainable in one system are not in the other. That is why the end usage of BBM is incredibly important. PLA might be convenient or sustainable for packaging of fruits and vegetables in supermarkets (easy composting), but it is currently not sustainable for high-volume production of plastic bottles (due to absence of recycling). On the design side, end-of-life stages is also important. The waste hierarchy can be used to create smarter products

with a lower environmental impact. The major benefit of the BBM sector developing now is that it can be very proactive and build upon usable historic cases in order to setup sustainable production and produce sustainable products.

Consumer organizations. Consumer organizations are right in pointing out that it is not the consumers responsibility of buying sustainably. However, there is an asymmetrical information distribution when it comes to sustainability and a lot of products. Consumer organizations should address this. They should also strive for more clear unified labelling of products in Europe. The possible end-of-life stages for products are known so these kind of labels should be possible to be created. From their it should be the task of the consumer organizations to further inform and encourage people to sort their trash.

Certification systems. Certification systems such as RSB and ISCC are very extensive and focus on a wide variety of sustainability criteria. The fact that they are endorsed by the major environmental organizations is convenient for companies that are certified by these systems. They can also be linked to other certification systems in the way that RSB system accepts FSC certified biomass. It seems logical that certification systems focused on specific biomass feedstocks align their vision with RSB and ISCC. If RSB and ISCC then check these certification systems and make it easier and cheaper for companies that have these certifications to also get RSB and ISCC certified then this will make it easier to implement sustainability in supply chains. This will also make it easier for companies to get complete certification of all their product characteristics, that are at the same time backed by NGOs. This shifts some of the coercive pressure from NGOs on companies towards the certification agencies. Furthermore, RSB should also invest in accepting other certification systems such as Vinçotte and DIN CERTCO to establish the bio-based carbon content, biodegradability, and compostability of products. This gives additional requirements on top of the sustainability criteria for biomass producers, making the case of sustainable bio-based products and materials more concrete. And, also very important, this could close the certification gap between biomass producers and consumers.

9.7 Scientific contribution

In the introduction is was mentioned that sustainability criteria can function as a communication object between science, policy, and society. When looking at the organizational field of BBM in the Netherlands (and Europe) it was indeed found that these criteria can be found to be present at all institutional actors in some form or the other. Insight was gained into how sustainability criteria are currently positioned in the field. **This points at the capability of case study analysis together with institutional theory to support Industrial Ecology studies in describing the working of sustainability criteria as boundary objects in society.** Both the case study analysis and institutional theory added specific insights to this work.

Institutional theory proved useful to look at the context. It was stated in the beginning of this research that sustainability criteria and indicators development for bioenergy and biofuels needs to be context specific. This is especially important to improve effective communication of results towards policy makers.

Because bioenergy and biofuels are closely related to BBM a lot of overlap in problems and sustainability assessment exists. Therefore, this research tried to proactively perform a context analysis for the BBM sector in which the influence of sustainability criteria on the BBM sector itself is looked at. Insight into how sustainability criteria and LCA currently operate in the BBM sector were found and were relevant in the current discussion. **Therefore, the institutional pillars proved to be effective in describing a context in which sustainability criteria and assessments function.** Using institutional theory by Industrial Ecologists or other scholars to describe or analyse the context for criteria (and possibly indicators) for sustainability assessments deserves further attention.

Case study analysis was used to gain insight into the 'how' and 'why' of the usage of sustainability criteria. Current practices to identify important sustainability criteria for bioenergy and biofuels mainly revolve around expert surveys and questionnaires. It is shown here that generic sustainability criteria (e.g. natural resource efficiency), which might be seen as important criteria by a lot of experts in relation to LCA usage, might not reflect true sustainability issues (e.g. end-of-life effects for BBM). An expert survey for BBM, thus, doesn't create the necessary insight to select sustainability criteria, let alone interpret sustainability assessments. What is missing are specific insights into how and why these assessments are done or sustainability criteria are selected. The case study performed in this research added insight into the 'how' and 'why' of sustainability criteria and LCA. **Therefore, it is suggested here that when studying sustainability criteria, detailed case study analysis of companies provides complementary results to expert surveys and questionnaires.**

The outcome of this research is to be used as a holistic overview of how sustainability criteria currently influence the BBM sector in the Netherlands. As this sheds light on a specific sector in a specific geographical time frame, **the methodology utilized in this work proved to be useful to gain insight into the context (institutional theory) and the 'how' and 'why' (case study) of these sustainability criteria**. It can be used as pre-research before selection of sustainability criteria or before a sustainability assessment of a specific case. Furthermore, it can be used to analyse a system or type of product for which sustainability assessments are continually performed. In this case, the boundary conditions have to be further restricted to limit the amount of institutional actors and information. This type of contemporary sketch of a system or product can help support decision making based on sustainability assessments and help interpret sustainability within an existing system.

Chapter 10: Conclusion and Limitations

10.1 Conclusion

This research started from the research gap that it is not known how sustainability criteria influence the supply chains of bio-based materials. In order to understand how the sustainability criteria from actors of society influence the companies in supply chains, the phenomenon of sustainability criteria influencing companies was outlined. This phenomenon consisted of mechanisms through which actors (internal or from the environment) put forward sustainability criteria that elicit responses from the companies. The main research questions was then 'How do sustainability criteria in the bio-based materials sector influence companies across the supply chain?'. In order to gain insight in this very general question and the phenomenon, four research questions were devised.

- Which are the sustainability criteria currently influencing companies in BBM supply chains?
- Through what mechanisms do the companies perceive the sustainability criteria?
- What are the different responses to the sustainability criteria that companies have?
- Which sustainability criteria and mechanisms influence sustainable processes and production positively?

For mechanisms and responses, a theoretical framework was necessary. It was found that institutional theory was adequate. Theoretical mechanisms in institutional theory were from the three pillars (regulative, normative and cognitive pillar), namely coercive, normative and mimetic. Theoretical responses were acquiescense, compromising, avoidance, defiance, and manipulating. These responses are ways of dealing with the pressure from the pillars. Before the case study was performed, the organizational or institutional context in which the companies operate, BBM sector in the Netherlands and Europe, was investigated. It was found that natural resource efficiency (related to end-of-life stages of BBM) is heavily focused upon in all three pillars. Greenhouse gas balance is also an important criteria and it are mainly biomass processors which address this through the usage of LCAs. It is the normative pillar that, unsurprisingly, distributes a wealth of other sustainability criteria into the sector. These are

not all deemed as important and are not all taken into account especially when it comes to social criteria.

An open exploratory case study with some comparative units of analysis was performed. Three companies, representatives of a theoretical PLA supply chain in the Netherlands, make up the main supply chain. Two other companies that produce bioplastics and straw panels respectively were interviewed. Sustainability criteria they take into account, mechanisms they are subject to, actors they are in contact to, and finally, indications for their responses were collected. During the analysis the criteria, mechanisms, responses, and positive criteria were discussed by the respective research questions. Concerning sustainability criteria and the BBM supply chain four things were observed that could sometimes be related back to the organizational field.

- Biomass processors and end-product seller heavily focused on natural resource efficiency because of end-of-life norms and certificates. A focus on natural resource efficiency is also seen in the regulative and normative pillar.
- Greenhouse gas balance is focused upon throughout the supply chain and is mostly calculated with an LCA. The LCA also works as a normative tool and imports more sustainability criteria with its usage.
- There is a focus on not using GMO feedstocks. This is also seen in the mimetic pillar mostly with biomass processors.
- Finally, sustainable certified sourcing does not seem important. This is also noticed in the mimetic pillar. Certification systems in the normative pillar also did not cover a lot of companies (globally). This might be a common 'non-practice'.

When analyzing the mechanisms in place, the coercive (legislative and customer) pressure was abundant. The cultural factor also plays a role but is difficult to judge. It were also these two pressures that seemed most successful in diffusing the sustainability criteria into the companies as this was mentioned by the companies themselves. The four itemized notes on sustainability criteria and the coercive mechanism were discussed after the analysis.

From the discussion other literature gave more insight into what actually is going on in the supply chain or the research phenomenon. When looking at natural resource efficiency concerning BBM, three viewpoints were outlined in the discussion. First, special attention for the biotic resources (biomass production) has to be given because impacts might shift from abiotic resource depletion to biotic resource depletion (not just biomass that gets harvested). Second, the norm on bio-based content, that currently is in development, is important for the BBM market. Finally, extra attention has to be given to the end-of-life stages of bioplastics. It might turn out that due to lock-in of the system (existing technologies and societal practices on recycling are focused on conventional plastics), recycling of bioplastics is not feasible and that they are not an environmentally friendly alternative to conventional plastics. Fortunately, the companies in this current research take most of this into account. Ecoboards works on a recollection and recycling system. Synbra likely will use the PLA for non-consumer products that can be recollected by themselves and recycled. CY

works on specific business models with clients in which the BBM render extra benefits and are disposed of properly.

Apart from natural resource efficiency, greenhouse gas balance also seems to be taken into account in the BBM sector. BBM tend to perform well with these two and it is a selling point for companies. They prove it through the usage of LCAs. On European level efforts are being made to harmonize LCAs for bio-based products. The fact that companies in the BBM sector tend to use LCAs to prove greenhouse gas balance, makes setting targets in European policy easier, i.e. extend RED with targets for BBM as well. However, it might not make sense to set targets for GHG balance but rather for natural resource efficiency. This is because BBM should not be incinerated at end-of-life, making the GHG balance not so important. Although the fabrication of carbon negative products would be highly beneficial to combat climate change. This has to be investigated.

It seems to be common practice to denounce the use of GMOs. Setting the usage of GMOs up as a sustainability criterion by the sector itself, might be too hastily as this might affect future developments towards technological progress and sustainable development. The Netherlands is preparing to engage in the debate about synthetic biology, which companies should join as well.

Social sustainability criteria are not taken into account that much yet by the sector. When looking at how certifications can help stimulate the uptake of these criteria, linking it to subsidies and legislation might be the strongest way. This is being done for biofuels and bioenergy and could be done for BBM. The Netherlands is one step ahead when considering the NTA 8080/81. There are still a lot of issues with certifications such as high costs. Extra attention has to be given to this. A way of circumventing the need for certification is local production within Europe. This is not so self evident.

Finally, the most successful mechanism, the coercive mechanism, was split in legislation and customer pressure. Legislation on agriculture is well organized in the Netherlands and wasn't further discussed. As customer pressure is felt in the BBM supply chain, the viewpoint of the government was briefly discussed. Up until 2005 (Martens and Spaargaren, 2005) the government was mainly focused on the production side of the sustainability issue. This is still true today, but the government has made investments on green public procurement. Other measures proposed in this paper, include targets and quotas through legislation or subsidies, taking up bio-based products in general known consumer labels, and imposing taxes on most polluting plastics or products.

In conclusion, this study has highlighted several factors and sustainability criteria that currently influence the BBM supply chains in the Netherlands. It was found that the Netherlands has a leading role in some ways, such as defining sustainability criteria for biomass for BBM and green public procurement. However, there are still a lot of opportunities that could be explored, such as putting targets on sustainability criteria. Extra attention has to be given to biomass production outside (certification) the Netherlands, GMO debate, social sustainability criteria, and consumer demand.

10.2 Limitations

This research had some limitations. The major limitations that could be identified are itemized below.

- The first limitation of this research is that all information of the organizational field, and most information of the case study companies, is public information. It is likely that more sustainability criteria diffuse through other channels and that there are a lot more influences through lobbying and other organizations. But these influences are difficult to find through public information. It is also impossible to acquire 'behind the scenes' information of most organizations, including companies.
- There are only a few companies included in the case study so nothing presented in this report is conclusive. The study is mainly based on the bioplastic PLA in the end. At the beginning of the research this was not the intention. Limiting the scope to bioplastics might have been better. The focus on compostability in the BBM sector was probably because the main supply chain was PLA, which is compostability. PLA is one of the main bioplastics in the Netherlands. However, when looking at other bioplastics such as bio-PET, compostability might not have been a focus point. Bio-PET is also forecasted to have the biggest market-share or growth of bioplastics. This might be good because it is recyclable in the current system. Recycling of conventional plastics (or conventional bioplastics such as bio-PET) might be environmentally better than composting other bioplastics.
- The companies interviewed are somewhat leaders on sustainability, thus results might be skewed.
- Sustainability criteria are almost by definition normative. That most criteria actually diffuse from the normative pillar is logical. This study could have limited itself to a benchmark of the certification systems, but as has been pointed out, this would show mostly social sustainability criteria, with only two real targets for environmental criteria (bio-based content and greenhouse gas balance).

10.3 Recommendations for future research

10.3.1 Survey

As stated before, expert surveys or questionnaires are used a lot to rank the importance of sustainability criteria for biofuel and bioenergy. Natural resource efficiency is generally not graded that important with biofuels. The most important sustainability criteria seem to be greenhouse gas balance and energy balance when considering biofuels and bioenergy (Buchholz et al., 2009; Markevičius et al., 2010). Biofuels and bioenergy have a clear end-of-life in which everything gets incinerated. BBM have multiple end-of-life options which is why natural resource efficiency might be more important for them. A survey where companies, NGOs, consultancy agencies and such rank the sustainability criteria for importance for BBM, might shed more light on the difference between sustainability

criteria for bioenergy and biofuels and those for BBM. This is important as the quota put forward in legislation or the relevance of the sustainability criteria might be different. Clear differences have to be made then between the focus on sustainability criteria for bioenergy/biofuels and those for BBM, although the criteria might be the same. An expert survey following the current case study analysis should focus also specifically on the complementarity between the two research methods.

10.3.2 Institutional Theory

It has been shown that a broad research into sustainability criteria and the BBM sector, using institutional theory to structure the research, has been useful to gain some insights on sustainability criteria in the nexus of society, policy and science. This research is the first practical Industrial Ecology research on sustainability criteria as boundary objects that uses institutional theory. Institutional theory has proven itself valuable for structuring of the research. However, the current research lacked clear characteristics or aspects of organizations and institutional actors that could be used in case studies. Institutional theory does not provide ample metrics to measure aspects of the organizational field or institutional pillars in the field, heavily limiting its usefulness in any practical case study. These should be provided by the field of institutional theory and organizational dynamics. Future research in Industrial Ecology on boundary objects should focus on how institutional theory and organizational dynamics can provide an analytical framework for the field of Industrial Ecology. Institutional theorists might keep the formulations specifically vague to ensure inclusiveness, but this makes the theory unusable for Industrial Ecologists. Granted that an analytical framework based on institutional theory might constrict the power of institutional theory, it should be possible to formulate some (qualitative) indicators. Following points could be addressed:

- A clear list of institutional actors which contribute to each pillar in society should be provided.
- Indicators of pressure influences by actors should be provided. For example, concerning sustainability criteria, the influence of coercive pressure from governments can be analysed by looking at quota in legislation which cover sustainability criteria. Quota in legislation are thus an immediate indicator for coercive pressure.
- The responses formulated in chapter 4 are not easily manageable without indicators as well. An indicator for the response of compromising could be lobbying practices, although there doesn't seem to be a consensus on this. Using a Public Relations company to write sustainability reports might be seen as an indication of decoupling or avoidance, but again this is not explicit with institutional theory.

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Appendices

Appendix A: Case study protocol

This appendix contains the case study protocol. The following sections describe how the investigator has to do the collection of data from the case studies.

A.1 Overview of case study projects

For an overview of the case study and the units of analysis, chapters 6 and 7 can be consulted.

A.2 Field procedures

The interviews are semi-structured. According to Cohen and Crabtree (2006), semi-structured interviews are best when the chances of speaking to the interviewee a second time is low. It is based on open-ended questions. Because of this the interviews are best recorded as taking notes while engaging in conversation that tends to diverge is difficult. The benefits according of these types of interviews are that the interviewee has the chance to express its views, while the interviewer can steer the conversation with his pre-formulated questions towards the topics (s)he wants.

First contact is made through sending mails to either information desks of the company or knowledgeable representatives. After the first contact, a date to have the interview is set. Then, using a voice recorder and some pre-made specific questions (to that case or unit of analysis), the interview is held. Some more specific questions are also formulated depending on the background of the company. During the interview the interviewer takes some notes. Afterwards, the interview is listened to again by the interviewer to answer the case study questions as accurate as possible. Relevant quotes from the interview are shown to make the answers stronger.

A.3 Case Study Questions Companies

A.3.1 Introduction

How does the company define itself? (culture) Does it feel as a visible player in the bio-based economy? (culture) What is their perception of other institutional actors? (institutional context) Thus, what is the role of the government, of the

NGO's, other companies, etc.? Is there more revenue being in the biobased supply chain?

A.3.2 Mechanisms - Research question 2

Where do the criteria come from?

Regulative

Are there any regulations or laws for BBM that you have to comply with? Do your customers have any specific wishes regarding the products? Does the company have specific wishes towards suppliers? Do they feel criticized?

Normative

Do you receive any subsidy or tax reductions by the government? Do you have any certificates or labels for you products? Would you like more? Do you see a benefit to certificates and labels?

Mimetic

What are other organizations the company looks at? Who or which department keeps itself busy with sustainability assessment? Which of these came up with the criteria? What is the atmosphere like within the company? Are there research institutes you have contact with? Are there NGOs you have permanent contact with? You know of any professional associations which people employees to? Do these suggest improvements?

A.3.3 Responses - Research question 3

Does the company assess its sustainability? What is the manner in which they assess themselves? Which sustainability criteria do they use? Are there other sustainability criteria that are not on the PL? Which sustainability criteria can the prove that they meet?

Do you mind if I contact suppliers or costumers of you?

Appendix B: List of institutional actors

ID	Name Actor	Type	Source of evidence if present	Full name	Region	Regulative	Normative	Mimetic
1	CDB	committee	vision document	Commissie Duurzaamheidsvraagstukken Biomassa	netherlands		x	
2	CDB	committee	biomassa in de chemie	Commissie Duurzaamheidsvraagstukken Biomassa	netherlands		x	
3	RSB	standardization agent	[RSB-STD-02-001 (Version 1.4)]	Roundtable on Sustainable Biomaterials	international		x	
4	RSB	standardization agent	[RSB-STD-01-001 (Version 2.1)]	Roundtable on Sustainable Biomaterials	international		x	
5	Rijksoverheid	government	collection of laws present in text	Rijksoverheid	netherlands	x		
6	RVO	government	MIT subsidy	MIT-regeling Topsectoren Chemie en Energie	netherlands	x		
7	RVO	government	BBEG (TSE)	Biobased Economy en Groen Gas Innovatie	netherlands	x		
8	RVO	government	MIA + VAMIL	milieu-investeringaftrek/afschrijving milieu-investeringen	netherlands	x		
9	RVO	government	Green Deal	Green Deal	netherlands	x		
10	NEN	standardization agent	NTA 8080-1:2015 nl	Nederlands Normalisatie-Instituut	netherlands		x	
11	NEN	standardization agent	NTA 8080-2:2015 nl	Nederlands Normalisatie-Instituut	netherlands		x	
12	CEN	standardization agent	CEN/TC 411 Biobased products	European Committee for Standardization	Europe		x	
13	ISO	standardization agent	ISO 26000, ISO 14000, ...	International Organization for Standardization	international		x	
14	Vinçotte	certifying agent	EN 13432	Vinçotte	international		x	
15	Ecoboards	company	http://www.eco-boards.eu/about/	ECOBoard Europe B.V.	Europe			x
16	DUBOkeur	certifying agent	http://dubokeur.nl/	DUBOkeur	netherlands		x	
17	MBDC	certifying agent	mbdc (2016b)	McDonough Braungart Design Chemistry	international		x	
18	Suiker Unie	company	sustainability report 2014	Suiker Unie	netherlands			x
19	L&G	programme	http://lean-green.nl/	Lean and Green programme by Connekt	netherlands		x	
20	Synbra	company	http://www.synbratechnology.com/	Synbra Technology bv	netherlands			x
21	CEN	standardization agent	EN 13432	European Committee for Standardization	europe		x	
22	Bonsucro	certifying agent	production standard	Bonsucro	international		x	
23	CX	company	undisclosed	Company X	international			x
24	RSPO	certifying agent	Principles and Criteria	Roundtable on Sustainable Palm Oil	international		x	
25	Natureplus e.v.	association	award guideline GL0000 Basic Criteria	Natureplus	international		x	
26	CoE BBE	partnership	https://www.coebbe.nl/	Centre of Expertise Biobased Economy	netherlands			x
27	JTI BBI	public private partnership	Europa Nu (2016)	Joint Technology Initiative (JTI) Biobased Industries	europe			x
28	BIC	consortium	http://biconsortium.eu/	Bio-based Industries Consortium	europe			x
29	BEUC	consumer organisation	http://www.beuc.eu/	European Consumer Organisation	europe	x		
30	ANEC	consumer organisation	ANEC (2016)	ANEC	europe	x		
31	CB	consumer organisation	Consumentenbond (2016b)	Consumentenbond	netherlands	x		

Table B.1: Actor list part 1

ID	Name Actor	Type	Source of evidence if present	Full name	Region	Regulative	Normative	Mimetic
32	GW en Co	consumer organisation	Goede Waar (2016)	Goede Waar en Co	netherlands	x		
33	KM	consumer organisation	Kritische Massa (2016)	Kritische Massa	netherlands	x		
34	MC	consumer organisation	Milieucentraal (2016)	Milieucentraal	netherlands	x		
35	KdW	consumer organisation	kro ncrv (2016)	Keuringsdienst van Waarde	netherlands	x		
36	DN	consumer organisation	Duurzaam Nieuws (2016)	Duurzaam Nieuws	netherlands	x		
37	Veldleeuwerik	partnership	http://teler.veldleeuwerik.nl/indicatoren/	Skylark foundation	netherlands		x	
38	SAI	non-profit	SAI (2016)	Sustainable Agriculture Initiative	international		x	
39	IRS	foundation	IRS (2016)	Institute for Rational Sugar Production	netherlands		x	
40	CLM	consultancy	CLM (2016)	Centre of Agriculture and Environment	netherlands		x	
41	LIF	environmental agency	La Isla Foundation (2016)	La Isla Foundation	international	x		
42	DIN	standardization agent	DIN CERTCO (2016)	Duurzaam Nieuws	german		x	
43	FSC	certifying agent	Forest Stewardship Council (1996)	Forest Stewardship Council	international		x	
44	PEFC	certifying agent	PEFC (2010)	Programme for the Endorsement of Forest Certification	international		x	
45	ISCC	certifying agent	ISCC (2016b)	International Sustainability & Carbon Certification	international		x	
46	NRK biobased	company	http://nrkbiobased.nrk.nl/	NRK biobased	netherlands		x	
47	CY	company	Company Y (2016a)	Company Y	netherlands			x
48	LCA	tool	/	Life Cycle Assessment	international		x	
49	FC	company	https://www.frieslandcampina.com/	Friesland Campina	international			x
50	Südzucker	company	http://www.suedzucker.de/en/Homepage/	Südzucker	international			x
51	NatureWorks	company	http://www.natureworksllc.com/	NatureWorks	international			x
52	Novamont	company	http://www.novamont.com/eng/	Novamont	international			x
53	Metabolix	company	http://www.metabolix.com/about	Metabolix	international			x
54	Robenburg	company	http://www.biopolymers.nl/	Robenburg biopolymers	international			x
55	Filament-shop	company	http://www.filament-shop.nl/	Filament-shop	netherlands			x
56	123-3D	company	https://www.123-3d.nl/	123-3D	netherlands			x
57	lay3rs	company	http://www.lay3rs.nl/	lay3rs	netherlands			x
58	Huhtamaki	company	http://www.huhtamaki.com/	Huhtamaki	international			x
59	NPSP	company	http://www.npsp.nl/index.asp	NPSP	international			x

Table B.2: Actor list part 2

Appendix C: Sustainability criteria used in this study

In the following table, the sustainability criteria used in this research are derived. This table doesn't give a definitive list of sustainability criteria, that is not within the scope of this research. Rather, the 'umbrella' sustainability criteria are necessary to streamline this research because of the exhaustive wealth of principles, criteria, and indicators out in society. The 'umbrella' criteria are a compilation and selection from the work of Fritsche and Iriarte (2014); Markevičius et al. (2010); Fritsche et al. (2012). Markevičius et al. (2010) presents a more extensive list of sustainability criteria but it becomes clear when looking at societal demands that these are not as specific as the sustainability criteria presented by Markevičius et al. (2010). In order to come up with the umbrella criteria the list itself may seem to be inconsistent at times. Concessions between the different criteria have to be made, but in the end the umbrella criteria cover every aspect from the other referenced works. Sometimes a sustainability criteria or impact is chosen to represent something separate as it is important enough to be considered alone. Food security is a basic human right, but it is not within the human rights umbrella criteria as it is too important when considering biomass production and use. On the other hand, some umbrella criteria (e.g. human rights) cover a lot of other sustainability criteria as for this research it is deemed that using the criteria separately will not give more information. A couple of examples:

- Ecotoxicity for freshwater aquatic impact category of LCA is linked to the water sustainability criteria of Fritsche and Iriarte (2014) and the use of chemicals, pest control, and fertiliser sustainability criteria of Markevičius et al. (2010). The umbrella criteria used to cover these criteria is ecotoxicity while one could argue this has to be water management. However, water management is covering sustainability criteria such as dessication (LCA), water (Fritsche et al., 2012), water management (Markevičius et al., 2010), and water use (Fritsche et al., 2012). In practice, water management also entails waste water management which is linked to ecotoxicity.

- The umbrella criteria 'Energy balance' covers depletion of abiotic resources, resource efficiency, energy balance, and sustainable resource use. Although this could be described as natural resource efficiency, the energy balance of a system is an important sustainability criteria in itself. That's why it is a sustainability criteria on itself.

- Land use change, food security and land use rights are two different sustainability criteria here. Land use change entails every kind of direct and indirect effect of using land. Land use change has an impact on greenhouse gas balance and biodiversity, but as a direct consequence of biomass production, it should be considered individually. Food security only focuses on stable supply of food for all people. It has to be separate from land use change as it is important enough in itself to be monitored individually by for example food price changes. Land use rights is a social sustainability criteria specifically focusing on rights of local citizens for housing, recreation, other resource supplies (e.g. fuelwood), and property rights.

Beware that economic sustainability criteria are not taken into account throughout this research. Finally, these umbrella criteria should **not** be used as absolute sustainability criteria for the BBM sector as the criteria are formulated in terms of this research. The resulting sustainability criteria are: biodiversity, energy balance, natural resource efficiency, greenhouse gas balance, land use, air emissions, toxicity, human rights, labour rights, ecotoxicity, water management, food security, compliance with laws, GMO, waste management, and soil quality.

LCA impact categories (Guinée, 2002)	Fritsche and Iriarte (2014)	Markevičius et al. (2010)	Fritsche et al. (2012)	umbrella criteria
Depletion of abiotic resources	resource efficiency	energy balance	sustainable resource use	energy balance
Depletion of biotic resources	resource efficiency	natural resource efficiency	sustainable resource use	natural resource efficiency
Impacts of land use, land competition	Fuelwood and land tenure security	land availability other than food production	social use of land	land use rights
Impacts of land use, land competition	Food security	property rights and rights of use, food security		food security
impacts of land use, loss of life supporting function	biodiversity protection	Species, ecosystems protection, exotic species	biodiversity	land use change
impacts of land use, loss of biodiversity	biodiversity protection	Species, ecosystems protection, exotic species	biodiversity	biodiversity
Climate change	GhG savings	greenhouse gas balance	climate protection	greenhouse gas balance
Stratospheric ozone depletion	air emissions	hazardous atmospheric emissions	limited airborne emissions	air emissions
Photo-oxidant formation	air emissions, healthy livelihoods	hazardous atmospheric emissions	limited airborne emissions	air emissions
Human toxicity	healthy livelihoods and labor conditions	use of chemicals, pest control, and fertiliser	healthy livelihoods and labor conditions	toxicity
casualties	healthy livelihoods and labor conditions	standard of living, respect for human rights	healthy livelihoods and labor conditions	human rights
casualties	healthy livelihoods and labor conditions	working conditions for workers	healthy livelihoods and labor conditions	labour rights
freshwater aquatic, sediment ecotoxicity	water	use of chemicals, pest control, and fertiliser	/	ecotoxicity
marine aquatic, sediment ecotoxicity	water	use of chemicals, pest control, and fertiliser	/	ecotoxicity
terrestrial ecotoxicity	soil	soil protection	/	soil quality
Acidification	water, soil, air emissions	use of chemicals, pest control, and fertiliser	limited airborne emissions	ecotoxicity
Eutrophication	water, soil	use of chemicals, pest control, and fertiliser	/	ecotoxicity
dessication	water	water management	water use	water management
/	food security	food security		food security
/	healthy livelihoods and labor conditions	compliance with laws	healthy livelihoods and labor conditions	compliance with laws
/	healthy livelihoods and labor conditions	participation	healthy livelihoods and labor conditions	human rights
/	healthy livelihoods and labor conditions	cultural acceptability	healthy livelihoods and labor conditions	human rights
/	healthy livelihoods and labor conditions	social cohesion	healthy livelihoods and labor conditions	human rights
/	healthy livelihoods and labor conditions	respecting minorities	healthy livelihoods and labor conditions	human rights
/	healthy livelihoods and labor conditions	visual impacts	healthy livelihoods and labor conditions	human rights
noise	healthy livelihoods and labor conditions	noise impacts	healthy livelihoods and labor conditions	human rights
/	healthy livelihoods and labor conditions	environmental hazards and climate change	healthy livelihoods and labor conditions	biodiversity
/	biodiversity protection	crop diversity	biodiversity	biodiversity
/	/	use of genetically modified organisms	/	GMO
/	resource efficiency	waste management	sustainable resource use	waste management
/	soil	soil protection	soil quality	soil quality

Table C.1: Sustainability criteria from biofuel and bioenergy assessment papers and from LCA. These are bundled into the 'umbrella' criteria used in this study.

Appendix D: EcoBoards

D.1 Introduction

How does the company define itself? (culture) Two founders (Waldo and John) have different focusses. Waldo looks more at the economic side while John is more focused on sustainability. Both do identify with the green movement.

Does it feel as a player in the bio-based economy? (culture) They feel visible towards customers. Organisations want to buy their product. They are building their company around sustainability, using the concepts of bio-based economy, circular economy and even blue economy. But they do not define themselves as being one type of company in particular. "you see in the biobased world, the word is constantly changing. From biobased to circular, from circular to wood-plastic composites."(Chotkoe and Kempenaers, 2016)

What is their vision on the BBE in the Netherlands? There is enormous push to portray the Netherlands as a bioeconomy. They feel that the Netherlands does portray itself well and that Ecoboards does get some attention as being bio-based. But they feel the Netherlands is not the leader as it should be. "How it looks now, it will be probably countries outside of the European Union that are gonna jumpstart...The developing countries are starting faster than that something will happen here." (Chotkoe and Kempenaers, 2016) Furthermore, they feel they are being neglected and that bioenergy is distorting the market very hard. Bioenergy makes biomass more expensive so that biomaterials do not get a chance economically.

What is their perception of other institutional actors? (institutional context) Thus, what is the role of the government, of the NGO's, other companies, etc.? "The other side, I see an entire research country of fragmented organizations that don't cooperate but that are all working with biomass like it is the new gold.[...] But it is too fragmented. [...] Connecting, cooperating there is the power."(Chotkoe and Kempenaers, 2016) The bioeconomy as a whole does try to establish itself as an organizational field. But the actors are too fragmented. There is no clear line at the moment.

D.2 Mechanisms - Research question 2

D.2.1 Regulative

Are there any regulations or laws for BBM that you have to comply with? No. They are a part of Green Deals. But this doesn't do anything, it costs more money than it brings up. There are meetings upon meetings but

nothing gets done. They talk do about instating obligatory LCAs but it goes to slow. The best thing that could come out of the Green Deals is the instalment of obligatory LCAs.

Do your suppliers or customers have any specific wishes regarding the products? No. Customers are ready. EcoBoards finds very positive feedback from their customers. A lot of people want to start projects with them, but to actually get funding is difficult. The customers of Ecoboards make endproducts. A short talk with them revealed that they ask a higher price because their material (EcoBoards) also have a higher price. These endproduct producers, are also ecologically minded. They design, most of the time, ecological oriented products. They find a market segment in which people appreciate this and are willing to pay the extra price. Although it is feasible, it is not always easy to find these people. A price lowering should be possible in the long run, or should be established by the government. Although a higher price makes it more difficult to sell, both EcoBoards as their customers find that the demand is growing steadily and is not going to stop. "You can't stop it [the demand] anymore. It is happening." (Chotkoe and Kempenaers, 2016).

Do you receive any subsidy or tax reductions by the government? No.

D.2.2 Normative

Do you have any certificates or labels for you products? Yes. Only DuboKeur is useful for us. MIA/VAMIL is only for the bigger and richer companies. It's only for bruto profit and only for large projects. And even then it is not clear and transparent enough. They propose instead of MIA/VAMIL to have negative taxes on the purchase of their products. FSC only costs money, but doesn't really do anything. They think their standards are too low. They can't even get an FSC label, because their 'wood' isn't wood. They fall between the cracks. Some countries also only want to import wood that has the FSC label, so they can't even import to those countries, although no tree was cut down for the ecoboards. "That is a gaffe. That is labelbusiness"(Chotkoe and Kempenaers, 2016).

Didn't know of RSB. They are ready to get some certificates. But it doesn't make sense to start certification of products locally all over the world. Then they have to do it over and over again. One international certificate is necessary. "Every country has something else. No, we want one certification that counts for the entire international world."(Chotkoe and Kempenaers, 2016). "They are busy with that. There will be a point system.[...]the sum of the points will classify the products as 'very healthy' or 'very good'. Red or Green.[...]An uninitiated person needs to understand it. [...]And then they can put taxes on it. They can put negative tax on it. [...] For every product there should be an LCA. Some organizations are already busy with it. So it's already there. And then it should be an obligation to do an LCA." (Chotkoe and Kempenaers, 2016).

Would you like more? Do you see a benefit to certificates and labels? No. They only cost money at the moment. Certificates really have to start turning in profit, otherwise there is no use. Even with certificates or labels you can't ask higher prices. Customers want the products, but they don't want to pay triple the price.

D.2.3 Mimetic

What are companies you look up to? Economic wise the Chinese companies. But in terms of sustainability they feel they are quite progressive. They construct their own identity and behave according to their own values. It so happens that the buzzwords (bioeconomy, circular economy) fit. But it are rather values they have internalized as managers. Thus, the major development of the criteria used in the company, is from internal actors.

D.3 Responses - Research question 3

Does the company assess its sustainability? Yes, LCA. They think it should be obligatory for all products.

Which sustainability criteria seem to be important to the interviewees? All previously identified criteria in the PL are important. Plus they want to control the supply chain and make sure it complies with sustainability using their own standards. However, it is not possible yet.

Are there other sustainability criteria that are not on the PL? No. But their focus lies heavily on the ones previously identified.

Which sustainability criteria are proven to be met? GhG (Carbon footprint, GWP), toxic effects during use (formaldehyde), biological degradability. Criteria that are not met are recycling, local production and circular economy. These are technologically feasible, but are not possible at the moment. This can only be done if they can start producing in Europe. But there are barriers in the way. They do try to develop a circular business model. The best example is the suggestion for 'Statiegeld' or deposit on products. Their customers can bring back rest streams of the boards or old broken products and get money for it.

Do you mind if I contact suppliers or costumers of you? No.

Appendix E: Suiker Unie

E.1 Introduction

How does the company define itself? Agri-food sector. The entire concern under the Cosun concern is agri-food oriented.

Does it feel as a player in the bio-based economy? More biomass producer or processor? Primarily agri-food company. But Cosun is also going for the bio-based sector. Furthermore, they see themselves as delivering the building blocks to other companies. So they are both biomass producer as processor. They were always busy with sugar and valorizing waste- or secondary streams. They also feel that biobased and circular economy goes hand in hand.

What is their perception of other institutional actors? (institutional context) Thus, what is the role of the government, of the NGO's, other companies, etc.? "I know there are a variety of different projects. Technology wise there is alot possible. But the cost price is the most important factor at the moment. And that's why the projects are not taking of."(de Crom, 2016) They actively look for cooperation in the field. "We don't do it alone. I think that biobased asks alot of cooperation. So knowledge institutes like Wageningen and other consortiums we try to see how we can help starting from agricultural primary products to building blocks in the chemical industry. [To do this] you have to have that intense cooperation."(de Crom, 2016) They refer to the Topsector initiatives. "[What we do with the consortiums] doesn't get communicated to the outside world. We also don't want to say on which platform we heavily invest, but we are connected to the topsectors."(de Crom, 2016)

Is there more revenue being in the biobased supply chain? Does saying you are providing biobased products create more revenue? As Suiker Unie not really. Suiker Unie always had a lot of sidestreams that they tried to valorise. They also have a manager biobased. But inside the Cosun concern they started a company/department that is named Cosun Biobased Products 2 years ago. So it is definitely a business aspect were they see possible value. However, the low oil prices at the moment make it difficult to break through in this sector.

When asked if the farmers themselves can get higher value for their products by producing sustainably: "It [give premium prices for sustainable farmers] has been done a few years ago. But this is not what we want. It will not be good to keep paying premiums for sustainable products. In the end our goal is to have all cultivation on a high level [of sustainability] and we don't feel there needs to be paid more. In a few years this will be the standard, and if you don't

comply it just ends. In the long term, this is more about delivery insurance than premium... I'm not saying this [Veldleeuwerik type standards] will be the standard [in Europe] but in the end you need leaders to get the standard up." "In order to cover costs I can imagine that premiums get given, but in the end this is a temporary solution."

E.2 Mechanisms - Research question 2

Where do the criteria come from?

E.2.1 Regulative

Are there any regulations or laws for BBM that you have to comply with? Not specific. But the European 'package' in Europe for Circular Economy is something being followed for example. The issue here is that the Netherlands is already doing more than what is in that package. Netherlands is ahead of Europe in that way. "European legislation offers more possibilities, for example there are discussions on what defines a waste stream. But for us this not enough. Of course you have to deal with multiple member states and these are not all in the same stage. That is difficult for us." One specific thing mentioned is the 'Kaderrichtlijn afvalstoffen' article 5 that addressed when something is a byproduct and not waste. That is important for their sector, biomass processors. However, now there is a lot of focus on the risks. "How they are going to judge the risks that is not clear. It is difficult. Are they going to use LCAs? The moment you choose to use LCAs you'll encounter a lot of different problems."(de Crom, 2016).

Furthermore, there are national legislations they follow up strictly and go into discussion about. Examples are the usage of neonicotinoides, the manure legislation, waste legislation, legislation on digesters. For example, the digestate of the digesters is actually fertiliser. But they can't use it as such because manure is the main thing used. They also have a form of chalk fertiliser that could be very good. But they can't use it because of the manure legislation. They have to follow up legislation very accurately to be able to valorize bystreams.

One way they eagerly make use of is the Green Deals. They participate in about three or four Green Deals. They also had multiple in the past. For example, on the circular economy they have one Green Deal. They need changes in the legislation concerning the waste and manure legislation to be able to become circular.

Do your customers have any specific wishes regarding the products? "From big customers there come questions [about the sustainability of their products]. They have a societal interest. We have buyers [companies] that have a worldwide image. They have a societal accountability. They get addressed by NGOs of course and then they look at their supply chain, to their suppliers, and ask how it is organized in their supply chain."

Does the company have specific wishes towards suppliers? Yes, they buy some sugar (from sugar cane) from outside of Europe. In 2020 they want to buy all their sugar from sugar cane according to a certain standard. The one that covers the most issues right now is Bonsucro. It is very broad and comprises a lot of criteria. "We think this is the highest possible standard at the moment."

(de Crom, 2016). So they want to implement this for all their purchases. Then they want to leave the checking of this to the certifying agent itself and not do it themselves. They want this certification because the sustainability of their products is questioned by their big customers.

Do they feel criticized? From time to time there are some criticisms from NGOs and consumer organizations.

E.2.2 Normative

Do you receive any subsidy or tax reductions by the government? Suiker Unie receives some subsidies on national level and European level. The extent of this was not mentioned. "And from the Topsectors the subsidies get divided. Also on European level there is a lot available. And we are there well established. "(de Crom, 2016)

Do you have any certificates or labels for you products? Would you like more? ISO 26000 and ISO 14001 is to give a framework for CSR within the organization. It obliges you to do a stakeholder analysis, to bring certain issues to light, give priority. It is for internal structuring, but it is also for external contact to prove that they do have structures in place. "It is the broadest directive and it covers everything."(de Crom, 2016)

On European level, with SERS they also talk about sustainability. Sustainability partnership (SERS, ...) they have gathered best practices in Europe and they report on it. Also connected to SAI platform Sustainability Agricultural Initiative. Here all big companies in the food sector come together. They discuss together about sustainability and about sustainable standards. It is very much focused on the cultivation.

They are also connected to the Veldleeuwerik initiative and certificaiton. Veldleeuwerik is an initiative of multiple companies, under which Heineken for example. It is for farmers in the Netherlands, for sustainable cultivation (not only for sugarbeet). They have sustainability programs for themselves. These get monitored. These are the leaders of sustainable cultivation in the Netherlands. And these work under the Veldleeuwerik standard. Suiker Unie has a product that is specifically linked to the Veldleeuwerik farmers and certificate/logo. Big customers know the logo. In English it's called Skylark. And they are very enthusiastic about it. But is is very difficult to get it as a standard because it asks a lot from the cultivators. "We stimulate as many farmers as possible to participate with it, but that means for those farmers that they have extra work. They need more workhours to do it and some farmers find it important, some don't... It [the criteria from Veldleeuwerik] really asks a lot from them."

Lean & Green is for logistics. Furthermore they have Fair Trade certification for some products.

Do you see a benefit to certificates and labels? "It [having a sustainable focus] is just a license to produce."(de Crom, 2016)

Are there research institutes, NGOs or professional associations which you talk to? They talk to Wageningen. Concerning NGO's: "When there is critique we respond to specific criticisms in which we are named. We don't have a fixed connection with NGOs where we talk. That happens more out of the branche organisations. For example, the fnli [Federatie Nederlandse

Levensmiddelen Industrie] they have a lot of contact with NGOs. But that is more about other matters."

E.2.3 Mimetic

What are companies you look up to? "DSM, coca-cola, Unilever, Acso are very high on the sustainability Dow Jones index. They have very high visibility. Those are the gurus of sustainability. On the other hand, there are a lot of shareholders behind it. In the end, for them its also about the financial interest from shareholders... the question is if [sustainability] is driven from society or from financial aspects. I think the financial driver [not having questions from shareholders] is the biggest." These very large companies that are either suppliers or customers ask for certain standards and thus, push sustainability.

Who or which department keeps itself busy with sustainability assessment? There is one group that has representatives of all departments. They have different expertise and they go into discussion around certain subjects.

Which of these came up with the criteria? None

E.3 Responses - Research question 3

I have noticed you keep track of numbers on energy and water usage, carbon footprint (LCA?). And on bietenstatistiek even a lot more... How do you assess your sustainability in general? (Does the company assess its sustainability?) Plant and Planet program is mostly internal. There are four pillars. They can use it as a framework and communication tool. To give certain themes a place within the company.

What is the manner in which they assess themselves? They don't have a communication program for it. They just keep track of the numbers. They are obliged to keep track of certain numbers (by European legislation, E-PRTR) and they report some of them.

They do LCAs for a number of projects. But that is to show that the biobased alternative is better for the environment than what is done now. This is done through SERS. They have done big LCA studies recently. But these are average numbers of Europe. In comparison the results of Suiker Unie are better than those of others in Europe. But they don't want to use it for marketing. "Well, you do see with biobased, the projects we are doing, that LCAs are done everytime. This is because you can only convince the market on the moment you can prove that the new product is better than the current existing product... Big companies even have separate departments for this that only do LCAs."

For Carbon Footprint they use certain allocation methods (like ISO 14046). Those norms give the scopes. These allocation methods can be done in a lot of different ways. This is why they can't really be used to compare different products. There is a lot of discussion around fixing (by law) the way these things are done. But allocation is very much process dependent.

Which sustainability criteria do they use? Not specifically a response to. This is more looked at within the Cosun concern. Carbon footprint is something that gets asked from customers.

Are there other sustainability criteria that are not on the PL? No specific response.

Which sustainability criteria can they prove that they meet? Suggestion to look at the Cosun year report although that is aggregated data. If people want to know what happens they will try to find how it is.

Do you mind if I contact suppliers or costumers of you? FNLI Food. Branche organization

Appendix F: Synbra

F.1 Introduction

How does the company define itself? Do you remember when you decided to go biobased? Why did you choose for PLA? In 2006, they decided. It was because of Al Gore's Inconvenient Truth. They decided from themselves that they had to do something and contacted Wageningen University. Out of this contact they established that PLA was the way to go.

Does it feel as a visible player in the bio-based economy? They feel like they are a rather small company although they have a 300 million euro turnover.

What is their view on the BBE in the Netherlands It looks like the setup of the biobased economy in the Netherlands will be difficult. "I think it will be quite difficult, because the Netherlands has missed some chances to do it themselves... There are a lot of bio-based initiatives that are thought of in the Netherlands, but that get commercialized abroad... Other countries, in the EU and outside, give active support to the companies that invest. But the Netherlands say this is not possible because it is state support. We think of the ideas and the foreigners run with it." (Noordegraaf, 2016) Jan Noordegraaf refers to two other companies that now start producing biobased products abroad. These companies do get investments. "We didn't have a choice because we're a European company. I'm going to wait and see what happens in the Netherlands... We do have a good position because we did invest in building a factory here. We have a headstart."(Noordegraaf, 2016)

What is their perception of other institutional actors? (institutional context) Thus, what is the role of the government, of the NGO's, other companies, etc.? "There is no industry policy. There is only a focus on R&D... But in the end there also factories that have to be build." (Noordegraaf, 2016)

Is there more revenue being in the biobased supply chain? If it is cheaper yes. Otherwise, no. People still buy the cheapest product.

F.2 Mechanisms - Research question 2

Where do the criteria come from?

F.2.1 Regulative

Are there any regulations or laws for BBM that you have to comply with? "Everything is voluntary." Noordegraaf (2016) has searched contact with the government but they are not interested. It doesn't fit in their election scheme because effects are too long in the future.

The only thing the governments has to do is put taxes on oil based polymers and give that money to alternative producers. Another similar thing is that biofuels get enormous subsidies, but biomaterials not, while biomaterials are more sustainable. They have to give subsidies to sustainable energy technologies, not specific to biofuels. They could also give a value to CO_2.

Do the customers have any specific wishes regarding the products? Customers have specific demands concerning norms and certificates. More on this is in the normative section. On a broader level, industry wide there seems to be a big fear of bad publicity with bigger companies. "Do you know what a big problem is with big companies? It is fear."

Does the company have specific wishes towards its suppliers? PLA, for example, is derived from sugar from sugar cane. This is internationally traded. Do you have any demands concerning the production of sugar cane? Synbra themselves also have demands for their suppliers. They buy sugar or lactides that fit within the Bonsucro certification scheme. This way they know that human rights and everything is in order across the entire supply chain.

F.2.2 Normative

Do you receive any subsidy or tax reductions by the government? Were there any requirements connected to receiving grants? They got the EOS kto subsidy, granted by Senter Novem (now Agentschap NL) for developing Biofoam. "[The sustainability of the product], I think, has played a role with awarding the subsidy. There are several criteria and sustainability is one of them." (Noordegraaf, 2016)

Do you have any certificates or labels for you products? Can you ask more money because of this certificate? They have the C2C certificate from MBDC. "It looks like this if over the hype. It's now 'Circular Economy' that is gaining attention [and not the certification]. C2C is the same as Circular Economy. With C2C we can certify ourselves. With the Circular Economy this is not necessary. They [other companies] don't pay for the certification because they can just say that they are Circular Economy." (Noordegraaf, 2016). Sullivan principles for the stewardship industry has been looked at. Cradle2Cradle certification demands that these Sullivan principles are met.

ISO 26000 norm is for 'maatschappelijk verantwoord ondernemen' which means CSR. 24th of April they'll get it. ISO 26000 and 140000 are more for internal organization, but the demand from it comes from clients. "Customers have sometimes as criterion that they give points when they have the norm. So it is stimulated through certain people and customers that also work for their employers." (Noordegraaf, 2016). Same with doing LCAs, it is customer driven.

"There are a bunch of product certifications. Such as compostability DIN 13432." They have a bunch of these European norms. DIN CERTCO is specific for bio-based content and Synbra also has this norm for its PLA.

Concerning the Green Deals: "Nothing came out of that. Because the government has 'Green Deal tiredness'. There are too many. They can't be supported anymore. So the government didn't have time to do anything. Their job in our Green Deal was the inventarization of bottle necks and get rid of them [but they didn't]."(Noordegraaf, 2016)

"Another thing is sustainable buying [green procurement] that gets said by governments. That is awesome, but in practice there is nothing that gets done. Because the people that have to buy only get one product choice to buy from." (Noordegraaf, 2016). Noordegraaf (2016) feels that there is too much shortsightedness. To illustrate he refers to the insurance companies that don't want the installations of solar panels because in short term it doesn't make sense for them. It are the insurance companies that stop the greening of the energy sector.

Do you see a benefit to certificates and labels? It has to be proven that your product meets certain criteria. "You have to have evidence that your product is bio-based, that it is compostable, etcetera." (Noordegraaf, 2016).

F.2.3 Mimetic

What are companies you look up to? Coca Cola gets mentioned. China gets mentioned because the government is more active to stimulate these kind of products and legislation. They will go ahead of the Netherlands (Europe) as sustainable producers according to Synbra.

Who or which department keeps itself busy with sustainability assessment? They have specific people in place that look at different aspects. For example, people that work specifically on the products, HSE coordinator, etc.

Are there research institutes, NGOs or professional associations which you talk to? "That is interesting. We have searched actively for contact with NGOs (Milieucentraal and Natuur & Milieu). They have their own values and criteria. And it doesn't matter what you say, you can't have a conversation with them. Sometimes it does work. But if they've made their mind up, they don't listen to arguments. We are open but at a certain point you can't continue." (Noordegraaf, 2016). With WNF they have a good relationship. They have the certification from them but didn't have to adjust anything from their product. "Companies search for this. Companies have a stronger position when you are backed [by a NGO]." (Noordegraaf, 2016). Here the case of Danone gets mentioned where the packaging is backed up WNF.

Do these suggest improvements? Not really, Synbra already met the criteria with their product.

F.3 Responses - Research question 3

Does the company assess its sustainability? LCA: "The LCA is also voluntary. And with the results you can inform certain stakeholders that value the numbers. But it's not obligated. But if you want to sell sustainable products, you can't go without [LCA]." (Noordegraaf, 2016). They, thus, have a product oriented sustainability assessment and company oriented CSR program. They

seem to be looking at a lot of different aspects. Mostly to prove to customers that they are doing what they can.

Appendix G: Company X

G.1 Introduction

How does the company define itself? (culture) They were always bio-based and always produced bio-based. It is beneficial that it is now a trend as well. But it is nothing new for them.

What is their perception of other institutional actors? (institutional context) Thus, what is the role of the government, of the NGO's, other companies, etc.? They don't really need support from the government because they are already producing bio-based and make profit from it. The government does play a key role in financing, risk reduction, R&D, and changing some legislation to make some products possible to produce. Also for bio-plastics, there is no possibility currently to recycle them, but the government could play a role there. For CX the government mostly plays a role when looking at future products/future business.

Recycling of bio-plastics is not possible yet. Therefore, other plastics that do get recycled might have a better sustainability profile than bio-plastics in the long term. This is one of the major barriers according to CX to achieve sustainability in the sector.

Bio-fuel versus bio-materials. There is no level playing field. The profit margins are not there yet for bio-refining. They mention that a CO2 or fossil fuel tax might be a potential solution.

Is there more revenue being in the bio-based supply chain? They always had a business that was bio-based. They have the products up and running and make their money with it.

G.2 Mechanisms - Research question 2

Where do the criteria come from?

G.2.1 Coercive

They do look at which trends and focus points the governments address, and how they overlap with what they want to do. So it does make an impact.

Are there any regulations or laws for BBM that you have to comply with? No, no regulations specific for BBM. The products have to be safe by law, but on bio-based nothing. This changes when they want to bring about new product lines or new supply chains, for example with the use of waste for production. Waste legislation has specific regulations that do affect what they

do then. For biorefining, they do think that the government can play a key role in changing legislation and R&D. They do have a slight inclination that the investment climate in the Netherlands for production is not incredibly beneficial.

They haven't heard about Green Deals.

Do they feel criticized? Which organizations demand that you are sustainable? This is very limited because they are business to business. When they talk to customers they do feel there is a demand for sustainability. And from these questions, they do see that NGO's have an impact on their customers.

Do these suggest improvements? Do they have specific requests? What are the focal points that are always addressed? When products are derived, or contain components of, certain biomass sources, then there are often questions to have it certified. For example, products that contain palm oil have to be RSPO certified. For PLA, it is not yet clear what certificate will help. Mostly, the questions here, because of sugar, are specific on water use, deforestation, human rights, competition with food, etc. LCA is also asked a lot.

Are there NGOs you have permanent contact with? For a stakeholder analysis they had contact with Natuur & Milieu. For stakeholder analysis, for their sustainability policy, they need contact with NGOs. They indicate what important subjects are.

Do your customers have any specific wishes regarding the products? It helps that there is market pressure. "Audits [of their own suppliers] are more proactive. But there are also questions posed that are an extra stimulans for us to also do it. It helps us, for that goal we want to achieve, that there is pressure from the market."

Does the company have specific wishes towards suppliers? They think the entire sugar cane supply chain should be sustainable. But before all sugar cane production is up to standard, they use their supplier code instead of a certificate. The supplier code of conduct is not checked yet. They are going to use questionnaires in the future. And perhaps do audits themselves to see whether suppliers are compliant. They can't enforce anything yet.

G.2.2 Normative

Do you receive any subsidy or tax reductions by the government? For R&D they look specifically at what happens in their environment, subsidies, energy prices, and such. This is part of the business case. The government does talk about carbon emissions and such. And in the future, new legislation might include certain criteria. Other national governments (outside the Netherlands) do demand that LCAs get done before production. This is a hint that it is possible to legally enforce companies to think about their impacts.

Do you have any certificates or labels for you products? They have RSPO and other certificates (such as Vincotte). This is mostly because customers ask this specifically. They are connected to Bonsucro, but not certified yet. Bonsucro is not everywhere, only 4% of sugar cane land use is Bonsucro certified. They want, eventually, that all sugar cane is up to similar standards as Bonsucro. Right now, the suppliers are not there yet. In the meantime, they wait and think it is valuable to do audits themselves and guide the process. Not by getting a certificate.

Are norms important? Norms are very important, especially when it comes to bio-based content. Some companies name their products 100% biobased, but are in reality only a few percent bio-based. To make the market competitive, it is necessary that this gets resolved legally.

G.2.3 Mimetic

What are other organizations the company looks at? No company gets mentioned. SABIC is the only company that gets mentioned in the interview, but not as one they look up to.

Who or which department keeps itself busy with sustainability assessment? They have a manager that deals with sustainability issues globally. This involves, among others, doing LCAs and stakeholder analysis.

G.3 Responses - Research question 3

Does the company assess its sustainability? What is the manner in which they assess themselves? LCA. They perform LCAs as a tool for new potential products (internal), and for customers on existing products.

Which sustainability criteria do they use? Carbon footprint, resource efficiency, energy use get mentioned, eutrophication, acidification, toxicity, water use, and land use.

Appendix H: Company Y

H.1 Introduction

How does the company define itself? (culture) The people at the company are very young. They seem to be driven by sustainable entrepreneurship.

What is their perception of other institutional actors? (institutional context) Thus, what is the role of the government, of the NGO's, other companies, etc.? They don't have any contact with the government. They do have customers in the government (municipalities, provinces, etc) but this is all catering related.

Green procurement by the government does not seem to have a lot of effect, although they do have customers in the government.

They do see the usefulness about carbon taxation, but don't invest in the dialogue with the government or research institutes. They feel that this is a simple way to reduce negative externalities.

Is there more revenue being in the biobased supply chain? Everything that is biobased is more expensive. Everything they sell has a higher cost, buying price, but they do it in order to really provide sustainable products. Therefore, they search for consumers that acknowledge these sustainable products. Furthermore, they also search for specific customers that get real value added by using the product. An example is a zoo that composts its disposables on site and doesn't have to pay for getting rid of the waste. This is a positive case for everyone and this is an example of business cases Company Y is always searching for.

H.2 Mechanisms - Research question 2

Where do the criteria come from?

H.2.1 Regulative

Are there any regulations or laws for BBM that you have to comply with? No

Do they feel criticized? No

Do your customers have any specific wishes regarding the products? "Customers frequently ask a certificate for compostability. And which resources are used." (Company Y, 2016b). So customers ask for specific certificates and sometimes also specific ecological impacts (carbon and water footprint).

Does the company have specific wishes towards suppliers? They now use statements from suppliers about whether the products are bio-based or not, but this is not enforced. The norm for bio-based content would be very interesting and they would ask it from their suppliers.

Concerning compostability they search specifically for suppliers that deliver certified compostable products as this is what their business case builds upon.

It is difficult to get the ecological footprint that customers sometimes ask. The suppliers they only have LCAs on the product, the way it gets used also has an impact. Suppliers also don't always have LCAs on their materials or products. For bioplastics usually there are LCAs, but for other kind of bio-based products not. An additional thing is that larger plastic resin producers do have LCAs, but the companies that convert the resin into viable end-products do not. It is not known then how they can communicate this data.

H.2.2 Normative

Do you receive any subsidy or tax reductions by the government? No subsidies or taxes.

Do you have any certificates or labels for you products? Would you like more? Do you see a benefit to certificates and labels? FSC, PEFC, and the OK Compost Vinçotte logo and European seedling logo conform with norm EN 13432.

There is not one umbrella certificate for bio-based products. There are for compostability, for resource use, but not for bio-based products. To show customers that the products are indeed bio-based they use statements from their suppliers to show that it is bio-based, but there is no certificate.

Concerning compostability: "The seedplant logo is leading in this. It is also the only certificate that is known with the consumer and with our clientele."

Certificates are also very expensive, especially for a starting company. The seedplant logo which is essential for their business costs thousands of euro's.

Which norms are important to you? A norm on bio-based content would be beneficial in their eyes. EN - 13432 compostability is essential to the business.

H.2.3 Mimetic

What is the atmosphere like within the company? The people at the company seem afiliated with the green movement. They do feel that they are in a transition period and that some concessions have to be made when it comes to sustainability. But in general they want to provide good customer service and give customers the opportunity to buy sustainable products.

H.3 Responses - Research question 3

Does the company assess its sustainability? What is the manner in which they assess themselves? They don't perform LCAs themselves, they can ask it from some suppliers.

They do want to be able to support some claims about carbon and water footprint.

Which sustainability criteria do they use? The most questions they get are carbon and water footprint from customers, so they mostly focus on these as well. They also think about the social impacts when buying their products (especially south-east Asia). It would be useful if they had a social LCA. Compostability, however, is their primary focus. Closing of resource loops is essential for them. It doesn't even have to be bio-based, as long as it is compostable.

Some Asian factories can often produce things more cheap, but these are not certified. It would be disadvantageous to use these kind of suppliers. Everything has to be certified compostable.

Appendix I: Additional Interview Bonsucro

The lack of certification for social sustainable sourcing in the supply chain was noted. Because this is accounted for in the sugar beet sector in the Netherlands, but not outside of the Netherlands a representative was searched for this. PLA is often made from sugar cane in stead of sugar beet. Sugar cane comes from Latin-America, Australia or Asia. Social sustainability criteria are not always covered in some of the countries in these area's. Therefore, Bonsucro was contacted to gain insight into how social sustainable sourcing in the sugar cane sector, and by proxy the PLA supply chain, would be established. The contact person was Rafael Seixas, a business effectiveness manager at Bonsucro.

Do you feel there is growing awareness around certificates and Bonsucro? Espcially when it comes to Bio-based Materials.

Yes, recently there is more interest by companies in BBM supply chains instead of food or ethanol supply chains. These BBM are varying products such as bioplastics and cosmetic. The people interested in this sector is increasing. A problem, however, is that producers using fossil based resources don't have to get the certificates and this creates an unequal playing field.

Did Bonsucro feel through the establishment of the RED that more companies wanted to get certified? Through RED there was definitely an increase in the amount of European companies interested in getting certified.

How far does the chain of custody go? Does it get to business-to-consumer or is the certificate almost always used for B2C? As I see it now there are not a lot of on-product certificates, why is this? They have some on-product certification but not a lot. For example there is an icecream in Brazil which uses the Bonsucro logo on the pack of the icecream. Some cases of imports of biofuel in Europe under the RED by some of the big buyers of ethanol in Europe. It is gaining traction.

It doesn't make sense to have on product certification for sugar cane because most brands don't want to remind the consumer that there is sugar in the product. The consumer incentive to build the certification is not realistic. For ethanol for example there is no indication of the sugar at the gas station because what you buy is a mixture. There is no incentive for that, so it is a business to business tool. It might be nice for one type of producer but it is incapable to reach the whole of the spectrum of producers. For example, for smallholders or producers that are not in an international supply chain the argument for certification is very weak. That's why Bonsucro wants other types of programs as well outside of certification.

How about the situation in the Netherlands. Are there a lot of

companies in the Netherlands as members?

There's not a lot of interest for Bonsucro certification in the Netherlands.

And there is a trend of producing bio-based materials chemicals outside of Europe. Most of them will in the future be produced in Asia. Do you think these companies will ask for the on-product certification?

There are a lot of producers in China and Thailand that are now looking at getting certification. In Brazil it is the most advanced though for Bonsucro. This is their main operating country.

Apart from the high costs associated with these certificates, why do you think companies would be reluctant to have Bonsucro certification? What are barriers?

Overal trade policies, suppliers change risk, and public targets (pressed by NGO). Supplier change risk involves the unwillingness of producers to switch suppliers. This always entails a risk. Also they can't commit to one certification system because of uncertainty because of availability.

According to a bench-mark by the Dutch government, the costs are mostly carried by farmers while the external benefits (such as premium prices) are reaped at the end of the supply chain. How do you think the costs can be distributed more evenly? Certification costs they wouldn't call high. Other costs are being compliant with laws. They would say it is a cost of certification, but in the eyes of Bonsucro it is not really a cost. That's why there might be an overstatement of costs.

There is an added value throughout the supply chain. There might be brand benefits at the end. There is an indicator on added value in the Bonsucro system and they try to track what the added value is of certified production through the supply chain. The added value has been decreasing but that is mainly due to prices, overall market prices.

The shared value is very important but it is difficult to monitor. From the producer side there are also benefits that are not always very visible. But they are equally important as making money such as first access to market. It is a license to trade. There are also benefits in terms of efficiency. The bonsucro calculator helps with this. With this tool you can see the tradeoff between criteria and by using it the business itself can improve. It might not be seen as a benefit by the user, but overtime it will bring benefits.

Sometimes there is also no confidence with the biomass producers in certification. This is just a lack of trust in the certification system and not a direct cost.

If, from one day to the next, there is large demand for Bonsucro certified sugar, will there be enough at hand? Bonsucro has been growing steadily and there is enough certified sugar cane available. The producers are mainly from Brazil, Australia, India, and Honduras. The sugar sector is very regulated. Almost every government in the world has regulations on sugar and on sugar trade. In Brazil you pay a tax on that sugar. Because of that a buyer doesn't buy directly from Brazil. Another problem is that companies want to keep their suppliers because there is trust. And they don't want to take the risk to change their supplier to a certified supplier. In the end it really depends on where the company is located and what it produces.

What would be standing in the way of real sustainable development?

The cost side of certification (fee will be removed for biomass producers and this might increase the scale), also the membership fees of buyers will increase to give them more costs. This is based on bilateral agreements with buyers. Bonsucro becomes more a service center to the sugar cane sector.

Convincing producers that it is good. They are launching programs. Commitment from producer side and market uptake/acceptance of the products are also barriers. Short term reward system for producer should be in place. Long term there are a lot of benefits in terms of risk mitigation and efficiency improvements.

What is your view on the chronic kidney failure syndrome

This is a real crisis happening at the moment. They are trying to see how they can deal with and incorporate this. These kind of crisis can help the consumer awareness around the label. For example with RSPO. This label was build around orangutan problems. There was a public crisis. With fairtrade there was also a public campaign. In sugar cane there hasn't been such a crisis. The development happening now with chronic kidney failure is also unlikely to draw attention from consumers as certification doesn't go down the supply chain all the way to the consumer.