Motivation for Selection of Case Studies

Deliverable 3.2

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1. Background / Introduction

Work package 3 aims to generate insights on non-technical dynamics of innovation processes in the REINVENT key sectors – steel, plastics, pulp & paper and meat & dairy. In addition to that, cross-sectoral effects, mainly with regard to finance mechanisms, which are usually not designed for specific industries, will be analysed. In-depth case studies (Task 3.3) based on a mix of methods such as expert interviews, field trips, workshops and/or research/documentary analysis are the main instruments to provide these insights. Overall 15-20 case studies – fairly balanced among the key sectors and financing – will be conducted.

The rationale of this Deliverable is to present the portfolio of case studies compiled by the work package team and to explain based on which motivation these case studies were selected. The Deliverable consists of the following sections:

- Brief presentation of criteria for selecting case studies (Section 2)
- Summary of the case studies for each REINVENT key sector and for financing and discussion of the mix of case studies within each sector (Section 3)
- Appendices with detailed templates for each case study within all REINVENT key sectors explaining the relevance of the selected cases.

The case studies are embedded in a comprehensive work process. The research protocol (Deliverable 3.1) developed in Task 3.1 constitutes the analytical framework for the in-depth case studies, including a first set of criteria for selecting case studies, a list of research themes and questions as well as templates for case study reports and management/sharing of interview data. The analytical framework offered by the research protocol was tested in pilot case studies by the WP 3 team between February and April 2018 and edited based on the experiences and comments of the project partners.

The level of analysis of the case studies focuses on specific interventions for initiating and rolling out an innovation. Furthermore, the case studies analyse initiatives framing and influencing the considered intervention. Table 1 has been extracted from the research protocol in order to exemplify the distinction of the terms innovation, intervention and initiative.

Table 1: Examples for distinction of the terms innovation, intervention and initiative

	Definition	Example 1	Example 2
Innovation	A new actor, instrument, process or practice, etc.	Meat Free Mondays	Green Bonds
Intervention	A specific instance of a wider 'innovation'	MFM in schools in London – the specifics of how, by whom, with what implications the innovation was translated in this specific instance	FrieslandCampina's use of a Green Bond to fund decarbonisation measures in their factories
Initiative	The (governance and/or market) conditions that shaped the adoption and implementation of an intervention	The actors, institutions and dynamics involved in the wider market/governance arrangements that made MFMs in London schools possible	FrieslandCampina's 2020 Sustainability Strategy (which shaped the conditions for decarbonisation)

The final selection of case studies is based on an analysis of available scientific papers as well as grey literature such as working papers, factsheets, press releases etc. Ideas for case studies were discussed in conference calls of the WP 3 team and in break-out groups with partners from different work packages during the consortium meeting in Durham from April 16 to 18, 2018. Aim of the break-out sessions with team members from different work packages was to make sure that the portfolio of case studies fits well to the overall objectives and narrative of the Reinvent project and to create linkages to the innovation database and innovation biographies to be developed in WP 2 and sectoral low-carbon pathways modelled in WP 4. The case studies will be conducted by one or, in some cases, two project partners. Responsibilities were allocated according to the know-how and experiences of the respective project partners as well as their access to interview partners, data etc. Most of the selected case studies are still in an early phase in which the case study teams explore literature on the cases, identify and contact relevant stakeholders etc. If case studies should turn out to be not feasible due to a lack of accessibility of interviewees, data etc., the case studies teams will shift towards alternative case studies.

The case study process will be accompanied by two stakeholder workshops. These workshops will not be specific to individual case studies; instead, workshops will address meta-insights and learnings from and across the case studies. Stakeholders from the four key sectors will be convened to discuss most relevant and cross-sectoral findings from the portfolio of case studies. The first workshop will be held in November 2018, where preliminary case study results will be discusses and open questions as well as relevant focus areas for the further process will be identified. Toward the end of the case study process, a second workshop will most likely take place in May 2019, with the purpose of discussing final results and essential findings of the completed case studies.

2. Criteria for Selecting Case Studies

A criteria set for the selection of case studies has been suggested in the research protocol (D3.1) and further developed through an iterative process.

The criteria cover the following aspects:

- **Carbon significance:** to capture major CO_2 mitigation potentials in the considered key sectors; the CO_2 mitigation potential for most case studies should be significant in relative terms (as compared to a reference product/process) and/or absolute terms (for the decarbonisation of the sector) – either at the current level of maturity or in the mid- to long-term when rolled out broadly. Case studies with low relative and absolute mitigation potential both in the short- to long-term can be considered in case they imply innovative aspects, which could indirectly inspire emission reduction within or across sectors.
- **Spread across value chain stages:** ensure that the portfolio of case studies covers all or most value chain stages in each key sector, from resource and production to consumption to recycling and waste.
- **Different types of innovations:** the case study pool should encompass different types of innovations and interventions including technical, social, political and economic cases.
- **Linkages to other work packages:** a fair number of case studies should be linked to work packages 2 (innovation database and innovation biographies) and 4 (long-term low carbon pathways for REINVENT key sectors); thus, the set of case studies should include both past innovations that are already mature and rolled out (focus of WP 2) and forward-looking innovations which are still at an earlier level of development and deployment (focus of WP4).
- **Scale-up:** cases should imply a certain transformative potential and opportunities for scale up within or across sectors
- **Feasibility:** cases studies need to be feasible and accessible with regard to interviewees, data etc. and can be undertaken within the time and resource budget available

This set of criteria should ensure that the case study portfolio represents a comprehensive mix of innovations and interventions in the key sectors, and that results can also be extrapolated to a wider economic context.

3. Overview of Case Studies

This chapter and its sub-chapters provide an overview of the selected case studies for each of the four key sectors.

3.1 Steel

The steel sector is a highly centralised industry, dominated by few multi-national corporations, with capital-intensive production plants and long capital investment cycles. Thus, development and scaling up of low carbon innovations in the steel industry is particularly challenging. However, due to the high current CO_2 emissions of the EU steel industry (ca. 235 Mill. tonnes CO_2/year [1]) , there is a high urgency of reducing carbon emissions. Therefore, six case studies – covering both incremental and radical as well as established and forward-looking innovations at all stages of the value chain – will be conducted for the steel industry.

At the production stage, the castrip process (combination of casting and rolling), the German Carbon2Chem project (usage of blast furnace gas for synthesis of chemical products with hydrogen production from renewable sources) and the Swedish Hybrit project (direct iron reduction based on renewable hydrogen) have been selected. Whereas the Castrip process has already been commercialised and is operational in two steel plants in the U.S., Carbon2Chem and Hybrit are industry-driven R&D projects for low carbon breakthrough technologies. Both endeavours imply significant potential of transforming steel production, either by creating a new business case for waste gas usage or replacing the conventional blast furnace process, which uses coke coal for iron reduction and is highly carbon intensive.

At the consumption stage, a light-weight steel product (Docol from Swedish SSAB) and 3D metal printing will be analysed. Docol steel is an example for an advanced light-weight steel product mainly customised for the needs of the automotive industry which consumes about 18% of EU steel production[2]. 3D metal printing could commence a new technological paradigm of metal processing as it allows for producing tailor-made steel components at small and flexible margins. The case is innovative both with regard to technical, organisational and social aspects as the technology is developed and commercialised by a Dutch start-up which – though involved in collaborative projects with the steel industry – is independent from large steel corporations. The aforementioned mostly technical case studies are complemented by a case focussing on a policy instrument for regulating steel consumption in a specific industry branch: voluntary environmental standards for reducing steel consumption in the British construction industry.

The single case studies and the motivation of analysing them in the REINVENT project will be described in more details in the following paragraphs. Table 2 summarises the most important features of the case studies. Detailed templates are to be found in Appendix 1.

[1] Derived from Lechtenböhmer, Stefan and Vogl, Valentin (2018): REINVENT WP 2.1 – Steel Industry Overview. Presentation given at REINVENT Consortium meeting on April 16, 2018. Durham.
[2] EUROFER (2013): A Steel Roadmap for a Low Carbon Europe 2050. Brussels.

Table 2: Key features of case studies for steel industry

Case	Value Stream	Contained in Scenarios	Forward-looking	Contained in Data-base	Innovation Type	Carbon Significance (Relative/ Absolute)
Castrip	Resource & Production	No	No	Yes	Technical	High/ Medium
Carbon2Chem	Resource & Production	Possibly	Yes	No	Technical with organisa-tional/ social elements	High/High
HYBRIT	Resource & Production	Yes	Yes	No	Technical	High/Up to High
MX3D	Consumption & Waste	No	Yes	Yes	Technical	Medium/ Medium
Docol light steel	Resource & Production/ Consumption & Waste	Possibly	No	Yes (other light-weight steel types)	Technical	High/ Medium
Voluntary environmental standards	Consumption & Waste	Possibly	No	No	Social	Up to High/ Up to High

Castrip is a strip casting technology, combining the casting and rolling processes in steel production to cut down on space, equipment, energy and emissions. It has a significant relative CO_2 mitigation potential as it may reduce GHG emissions of thick-slab casting or thin-slab casting by around 80% or 40%, respectively. Absolute mitigation potential is ranked "medium" as casting and rolling represent a comparatively small portion of the overall emissions of the steel industry. The technology is being operated at large scale in two steel mills of the U.S. steelmaker Nucor. So far, however, it has not deployed to other larger steel plants due to technical issues and long lifetimes of conventional casters, hot rolling mills etc. As Castrip works particularly well with Electric Arc Furnaces with lower capacities, it may support the development towards a more flexible steel industry with an increased share of secondary steelmaking from recycled scrap.

Carbon2Chem is an endeavour of 18 large German industry companies and research institutes including companies from steel, chemical, automotive and plant engineering industries. It develops a process which coverts blast furnace gases from steel production into valuable chemical products, such as fuels, plastics or fertiliser. Additional hydrogen needed to generate the desired product set will be supplied through electrolysis based on surplus electricity from renewable energies. The project starts with basic research, which shall be followed by a pilot plant and a plant at commercial scale. The German Ministry of Research and Education financially supports the project; the remaining funding stems from industry sources. Carbon2Chem implies both a high relative and absolute carbon mitigation potential and could bring down emissions of the German steel industry by 20 Mill. tonnes (total emissions in 2015: ca. 55 Mill. tonnes CO_2). However, the actual mitigation potential of the process depends on detailed process parameters. From an organisational/social perspective, the project is interesting as it is a rare example for collaboration of major corporations from different sectors. It comes with

complex questions, such as building trust and establishing new patterns of collaboration among major industry players.

HYBRIT (Hydrogen Breakthrough Ironmaking Technology) is a pilot plant for using hydrogen as a reduction agent in steelmaking instead of coke, resulting in water vapour as main emissions rather than CO_2. Hydrogen will be produced from renewable energy sources. The project is run by Hybrit Development AB – a joint venture between LKAB, SSAB and Vattenfall. The reduction process is contributing over 80% of the overall greenhouse gas emissions of steel-making. Enabling a near 100% carbon mitigation compared to coke-based iron ore reduction, the innovation would promise a massive absolute carbon significance if rolled out globally. The pilot plant will be running until 2024. If successful, a full-scale demonstration plant will be built. As the case picks up one of the few alternatives for the steel industry to go zero or near zero GHG emissions, it implies a high transformative potential.

MX3D is a 3D metal printing technology to produce large lightweight structures, such as a stainless steel pedestrian bridge in Amsterdam (to be completed in September 2018). MX3D uses Wire and Arc Additive Manufacturing (WAAM) technology, in which layers of metal (such as steel, stainless steel, different high-strength steels, aluminium, bronze) are welded on top of one another by a six-axis robotic arm, controlled through specialised software. This allows for structures of virtually any shape and size, making production highly flexible and customisable. The feed material is wire rather than powder, as in other 3D printing technologies. The carbon significance is hard to estimate due to the technology's early stage and visionary character. Relevant carbon significance depends on the specific manufacturing process, which would be replaced. With regard to absolute emission reductions, printing and customising components on site would reduce emissions from logistics, handling of material waste or overproduction. The technology is developed by a Dutch start-up, which collaborates with steel industry but is independent. Therefore, the intervention is an interesting case of innovative entrepreneurial activities in a rather incumbent industry.

Docol steel is a set of advanced light-weight steel products produced by SSAB mainly for the automotive sector, with a full range of grades suitable for all steel vehicle components. Docol steels offer a number of superior properties with respect to alternative steels (e.g. increased mechanical performance, comparatively green production, corrosion resistance and lifetime). It is fully commercialised. Carbon mitigation effects mainly occur in the use phase due to reduced mass of vehicle components made of light-weight steel. Generally, advanced steel types have higher cradle-to-gate emissions per kilogram due to the increased number of process steps and energy consumption. However, a reduction of 10% vehicle weight reduces use phase emissions by about 7%.[3] Consequently, light-weight steel has an incremental direct effect on reducing transport emissions.

Voluntary environmental standards for the construction industry in the UK shall encourage the use of sustainable low carbon materials and reduce the use of steel in the construction industry which is at the time being the largest steel consuming branch. The construction industry is the largest user of steel, with most of this steel going into buildings. Reduction of use of steel in this sector could thus significantly contribute to carbon reduction targets. The

[3] European Environmental Agency (EEA; 2006); Transport and Environment: Facing a Dilemma, TERM 2005: Indicators tracking Transport and Environment in the European Union Copenhagen, EEA Report No 3/2006.

case study will analyse several operational standards. It will show whether voluntary standards can drive changes in steel consumption.

3.2 Plastics

Plastics is a highly diverse industry due to the variety of polymers, a wide range of industries using plastics as material for their products and the even greater range of end-user products. The case studies focusing on the plastics industry will only be able to capture some of the plastics-consuming industries and present some examples of developing or promoting plastic-free products. By far the largest portion of plastics converter market demand derives from packaging (nearly 40%[4]), which is addressed in a case study on plastic-free supermarkets in different EU countries. The textile industry represents only small share of plastics demand. Nonetheless, the project team will analyse a case study on the development of a plastic-free outdoor jacket as the branch is highly globalised with multi-national corporations, which possess powerful leverages for significantly reducing global plastic demand. These case studies on consumer-driven industries will be complemented by a case focusing on an innovative financing scheme (Organic Growth Fund by Triodos) which supports companies that develop or promote low carbon product innovations.

With regard to the production stage, the case of Enerkem has been chosen. Enerkem converts carbon contained in waste into chemical products through waste gasification. The case study is an interesting model for producing valuable products out of waste and may help to provide some insights into the potential role of chemical recycling technologies for industrial decarbonisation.

Overall, five case studies concentrating on interventions in the plastics industry will be conducted. Table 3 summarises the most important features of the cases. Detailed templates are encompassed in Appendix 2.

Table 3: Key features of case studies for plastics industry

Case	Value Stream	Contained in Scenarios	Forward-looking	Contained in Database	Innovation Type	Carbon Significance (Relative/ Absolute)
Enerkem	Resource & Production	No	Yes	No	Technical/ Economic	Medium/ Medium
Tierra	Resource & Production	No	No	No	Technical/ Social	Medium/Medium
Plastic-free supermarket	Consumption & Waste	No	Yes	No	Social	High/Low
Triodos & Naty	Finance	No	Rather Yes	Yes	Economic	Medium/Medium
DuraPulp	Resource & Production	No	Yes	Yes	Technical	Medium/Low

Enerkem is a Canadian company that has developed a gasification technology to produce syngas from (hydro)carbon wastes, such as biomass, mixed municipal solid waste (MSW) and plastics. The syngas is converted into methanol, which is used as a platform to make ethanol or other (intermediate) chemicals. The technology was patented in 2009. A consortium of Air Liquide, AkzoNobel Speciality Chemicals, Enerkem and the Port of Rotterdam will build a

[4] Nilsson, Lars (2018): Plastics – potentials and capabilities. Presentation given at REINVENT Consortium meeting on April 16, 2018. Durham.

waste treatment/recycling facility in the Botlek area of Port of Rotterdam. One commercial plant is in operation in Edmonton (Alberta) since 2015. The chemical recycling of carbon contained in waste may reduce emissions from MSW incineration plants. Concrete emission reductions depend on the alternative use of the waste and the substituted materials. The project may help to understand both a long-term trajectory of technology development (e.g. waste gasification for chemicals products) and drivers of technology selection including the role of different stakeholders.

Plastic-free supermarkets have emerged in several EU countries such as Denmark, Sweden, Netherlands, UK and Germany. The case study will focus on Ekoplaza in Amsterdam, Iceland (UK), Løs Market (Denmark) and Gram (Sweden). Ekoplaza has opened the first plastic-free aisle in a conventional supermarket. Iceland, a British frozen food retailer, pledges to go zero-plastic within five years. Gram and Løs Market are recent examples for zero-waste supermarkets where packaging is almost eliminated. All of the supermarkets are examples of a bottom-up, entrepreneurial approach to problems of plastic pollution. Their variation in the details of their business models and settings allow for a broader treatment of the innovation while allowing key insights to emerge through comparison. Compared to conventional supermarkets, plastic-free supermarkets would lead to lower carbon emissions as they avoid production and recycling of plastic. Compared to production and distribution of foods, plastic packaging represents a rather small share of emissions within the food sector. However, alternative retail and packaging concepts could affect production and distribution networks to favour more local, sustainable and low-carbon consumption practices.

Deterra, a fossil-free technical outdoor jacket, has been developed by the Swedish outdoor clothing manufacturer Tierra. The fabric is made of castor oil, a plant that does not compete with food production. Also for details, such as a thread for sewing the garment, zippers and buttons, Tierra found fossil-free alternatives. The clothing industry has one of the most complex and dynamic vale chains of any modern product as it was one of the first industries to globalise during industrialisation. Thus, navigating sub-contractors and global value chains to create a fossil-free product is very challenging. The relative carbon significance of the intervention depends on its detailed LCA and of the product it should replace. The absolute carbon significance of the specific intervention is low as Tierra is a small company. However, if the approach of fossil-free clothing would be taken up by large companies, its carbon mitigation impact could be scaled up to a significant level.

Durapulp is a biobased cellulose fibre and polymer (poly-lactic acid) composite material for packaging, construction, as well as other types of plastic products. It is both renewable and biodegradable and a case showing how the paper sector is expanding into new domains. The material is a result of collaboration between the Swedish firm Södra and the research institute RISE (formerly Innventia). The case allows for research on the build-up of new types of capabilities within the paper sector and collaborations between the plastics and paper sectors. It is an example for the growing variety of biobased plastics and composites which is currently unfolding. The intervention itself has little carbon significance due to its limited market share. However, if conventional plastics would be replaced by biobased alternatives on a broad scale, the carbon impact would be more significant.

The organic growth fund by the Netherlands-based bank Triodos and its collaboration with Naty, a company that produces nappies and sanitary items which use bio-plastics rather than

conventional plastics, is a case which shows how an innovative financing instrument may help to promote decarbonisation in REINVENT key sectors. Consequently, the particular co-operation between Triodos and Naty is located at the interface of the financing sector and a plastic-consuming industry. The fund was established in in 2014. It was set up to offer long-term investments in mature sustainable companies in Europe. In return for an equity stake in the companies funded, the Organic Growth Fund helps provide succession and/or growth capital and seeks to engage in multiple ways with the companies that it funds. Doing so, it helps mature companies to grow from niche to mainstream actors. The fund focuses on promoting fair trade and organic foods, agriculture and consumer products. The case study's carbon significance is hard to quantify. However, green banks may create credit capital and thus have a strong leverage to finance the transition towards a green economy.

3.3 Pulp & Paper

According to the roadmap of the European forest fibre and paper industry, sectoral CO_2 emissions totalled 49 Mill. tonnes in 2015 compared to 60 Mill. tonnes in 1990. Until 2050, the industry wants to further cut down emissions to 12 Mill. tonnes of CO_2.[5] This plans requires significant innovation dynamics. The REINVENT project will conduct four case studies for the pulp and paper sector, with a focus on production, which is by far the most carbon-relevant part of the paper value chain. Three case studies will be conducted for the pulp and paper sector, with a focus on technical innovation in production, which is by far the most carbon-relevant part of the paper value stream.

One case will focus on an early part of the value chain, namely the lime kiln, and explore an intervention that allows for high emission reductions through the elimination of fossil fuels. Another case study looks at energy efficiency in the dryer section of the paper mill (dewatering). Both the lime kiln and the dewatering case should offer considerable insight into the dynamics of technology development and diffusion, as the interventions are well-established. In contrast, the Äänekoski bioproduct mill, while already in use, is a forward-looking innovation, with several processes still at a demonstration stage. This case study also offers insight into cross-industry collaboration, which could be key for the transformation of the sector, exploring its potential to diversify into new product categories.

The case of Durapulp demonstrates how the paper and pulp industry expands to the domain of plastic-substitutes for packaging, construction etc. As the final products is an alternative to plastics, the case study is allocated to the plastics industry (see section 3.2) although it is pursued by a paper and pulp company. However, it also represents a good example of cross-industrial dynamics.

All three cases are discussed in more detail below, with the most important facts summed up in Table 4. Detailed templates of the cases can be found in Appendix 3.

Table 4: Key features of case studies for paper & pulp industry

Case	Value Stream	Contained in Scenarios	Forward-looking	Contained in Database	Innovation Type	Carbon Significance
Äänekoski bioproduct mill	Resource & Production / Consumption & Waste	No	Yes	No	Technical	Yet to be Determined/ Medium
SCA Lime kiln	Resource & Production /	Yes	No	No	Technical	High/Up to Medium
Dewatering in papermaking	Resource & Production /	No	Partly	No	Technical	Medium/ Medium

A **new bioproduct mill** has been established by Metsä Fibre on the site of a traditional pulp mill in **Äänekoski** (Finland). The ambition is to produce a wide variety of bio-based products – from pulp, tall oil, turpentine and bioenergy in various forms to higher value products, in-

[5] Confederation of European Paper Industries (CEPI; 2017): Investing in Europe for Industry Transformation. 2050 Roadmap to a Low-Carbon Economy. Brussels.

cluding biocomposites and textile fibres. Many products will be produced in collaboration with other firms who will set up activities at the site of the mill, creating a set-up similar to an industrial symbiosis. This concept based on collaboration between firms from many industries makes this case particularly interesting. The pulp and paper industry has significant potential in diversifying into new product categories, which are so far fossil-based. However, this requires considerable cross-industry collaboration to bring together knowledge on products and new markets; this case constitutes an interesting example of that capacity for transformation of the pulp and paper sector.

A **new lime kiln** was installed in the **SCA Östrand mill in Timrå** (Sweden) in 2011. It is fired with wood powder from ground pellets, replacing two older oil-fired lime kilns. The intervention eliminated fossil fuel use and directly resulted in a CO_2 emissions reduction of 80%. The intervention was technically challenging and signals the ambition to become fossil-free. Wood powder firing (e.g., grinding, transport, burners, etc.) was at the time a new technology and it is interesting to study how it evolved from an innovation system perspective. It is also interesting to analyse and understand if and how it has spread. The case is placed early in the value chain and since the intervention was in 2011 there are experiences and possibly technology diffusion to explore.

Innovation for **dewatering in papermaking** is aimed at reducing the water content *before* entering the dryer section. In a paper machine, water is removed in three successive steps in the wire, press, and dryer sections. Removing water in the dryer section is particularly energy-intensive, using up to 25 times as much energy compared to the forming section. Various technologies have been developed and deployed to achieve this, of which the long nip (or shoe) press and Condebelt are currently the main examples. Future technology development is aimed at reducing the use of water (e.g. high consistency pulping), reducing water retention (in the refiner), or the long term goal of abolishing water use completely in papermaking. With current technologies, energy savings of up to about 15% are achievable for most paper grades. If the use of water can be avoided completely, the savings will be immense (in the order of 50% of paper making energy use). Efficient energy use is essential to economically move the paper mills to non-fossil heat sources, as these will all be more costly (e.g. electric boilers, deep geothermal heat). The novel technologies would allow to not only strongly reduce energy consumption, but could potentially allow paper making without heat, abolishing the need for fuel use completely. This case study shall examine the dynamics of technology development to full maturity for a large industrial process. Taking a more generic look at dewatering can also help to understand the dynamics of various (competing) technologies over a long time period.

3.4 Meat & Dairy

The meat and dairy industry is dominated by large incumbent actors on the production side, and culturally charged behaviour on the consumption side. High GHG emissions are inherent to animal agriculture, and global demand for meat and dairy products is expected to increase in the future. This is why innovation on both sides is key to achieving low-carbon transformation of the sector.

Five case studies will be conducted for the meat and dairy sector, four of which cover this important juncture of production and consumption, through a combination of social and technical innovation. The fifth case (Green Bonds) lies at the intersection of finance and the meat and dairy sector, focusing on economic innovation. The production- and consumption-related cases include a wide array of interventions with different focus areas, including a technical innovation for the meat production process (Cultured Meat), a more streamlined food value chain (Farmdrop), a dairy substitute (Oatly), and a collaborative effort to shift production and consumption from animal- to plant-based protein (Green Protein Alliance).

The case study portfolio for meat and dairy represents a mix of established and forward-looking innovations, ranging from "older" interventions that are receiving new attention (such as Oatly) to very early-stage, highly experimental ones (such as Cultured Meat). It includes interventions from large incumbents (as in the case of Green Bonds), small tech industry-style start-ups (as in the case of Cultured Meat), and multi-stakeholder partnerships bringing together corporate, governmental, and independent actors (as in the case of the Green Protein Alliance). Different GHG mitigation options are covered, including the reduction of production- and/or transport-based emissions (FarmDrop, Cultured Meat) and substitution-oriented options (Oatly, Green Protein Alliance).

The following paragraphs will describe each individual case study in more detail and provide reasoning for its inclusion in the REINVENT case study portfolio. Table 5 gives an overview of its most important features. Detailed templates for each case can be found in Appendix 4.

Table 5: Key features of case studies for meat & dairy industry

Case	Value Stream	Contained in Scenarios	Forward-looking	Contained in Database	Innovation Type	Carbon Significance (Relative/ Absolute)
Green Bonds	Finance	Possibly	No	Yes	Economic	Low/Up to Medium
Green Protein Alliance	Resource & Production / Consumption & Waste	No	No	Yes	Social/ Technical	Medium/ Medium
Oatly	Resource & Production / Consumption & Waste	No	No	Yes	Social/ Technical	High/Medium
Cultured Meat	Resource & Production /	Yes	Yes	No	Social/ Technical	Medium/High
FarmDrop	Resource & Production / Consumption & Waste	Yes	Yes	No	Social/ Technical	Low/Up to High

Green Bonds are an emerging financial instrument that can be used by private and public institutions to raise finance for 'green' activities. In 2016, Dutch dairy cooperative FrieslandCampina issued a €300 million Green Schuldschein (similar to a green bond) to fund, amongst other things, carbon reduction measures in four of its processing factories. The intervention's relative carbon impact is fairly low, as processing of milk constitutes only a small percentage of total emissions in dairy production. But as FrieslandCampina is the 5th largest dairy company in the world, the potential impact on the sector as a whole could be considerable. It also has the potential to expand to other dairy companies as well as other players in the food sector. This case is particularly interesting because the actor is a large incumbent in the industry, and because it focuses on existing dairy products and processes rather than substitution. The case is also at the intersection of finance and the meat and dairy industry.

The **Green Protein Alliance** (GPA) is an initiative of the Dutch plant-based protein producers' association Planeet, the Netherlands Enterprise Agency (RVO) and the private consultancy company New Foresight. It is a multi-stakeholder partnership that aims to change the protein consumption balance in the Netherlands to 50:50 protein in 2025 (plant:animal) by providing a space for sector organisation activities. The GPA estimates that this 50:50 goal, if achieved, will lead to the reduction of CO_2 emissions by 5200 kton. The collaboration of industrial, governmental, and independent actors make this case particularly interesting. It also provides an example of how relevant stakeholders aim to promote low-carbon innovations in order to reduce the consumption of emission intensive products.

Oatly, originally producers of oat milk aimed at the lactose intolerant and/or vegan market based on research at Lund University in the 1980s, made a decisive shift in 2013/14 to target the whole market for "milk" drinks and derivatives. The technological component of the innovation is an enzyme, which breaks down the oats to produce a liquid substance. While this was an important prerequisite, it was a compelling transition story and bold narratives that eventually helped the innovation to scale. This combination of technical and social intervention, as well as its impact on both production and consumption make this case particularly interesting. Its carbon significance is high, with a 60% decrease in CO_2e emissions compared to conventional milk. As a large portion of the dairy sector's emissions stem from the ruminants themselves, this case study is highly relevant for the transformation of the sector.

Cultured meat is an example of the new field of cellular agriculture. Through tissue engineering, cultured meat is produced by taking cells or cell lines from living animals and culturing these in vivo in order to produce maximum useable tissue output from minimal tissue input. Two examples for interventions in this field are the founding of Dutch company Mosa Meats and American Memphis Meats, both in 2015; neither exist at market scale yet. This case addresses several environmental and social issues, including land use, water use, freshwater pollution, use of agricultural antibiotics and resulting health concerns. Carbon significance can be described as medium-high, with studies suggesting that cultured meats could lead to a GHG reduction of 78-96%. If successfully commercialised, cultured meat could substitute for a significant volume of meat currently produced through traditional methods. Cultured meat holds the potential for a wholesale transformation and disruption of livestock agriculture, and agricultural land use more generally.

FarmDrop is an online Grocery platform aiming to reconnect consumers and producers by restructuring the food supply chain. FarmDrop removes intermediating supermarket retailers

and wholesale entities, replacing them with its proprietary online platform. It aims to provide farmers and producers with a higher percentage of the retail price of the items they produce. Emissions reductions result from supporting small-scale, organic producers rather than large factory farmers, reducing transportation emissions through local production and an electric vehicle fleet, and reducing food waste. The intervention seeks to disrupt both production (through disintermediation) and consumption (through changing the consumer relationship to food), adding up to a large potential transformative impact.

3.5 Finance

In addition to the cases that focus on the four REINVENT key sectors, two sectoral cross-cutting finance case studies will be conducted. The Paris Agreement identified a lack of available finance for mitigation projects as a significant constraint for achieving a low-emissions economy. Closing this gap in availability of finance for climate-relevant projects is essential for supporting low carbon innovation. Investigating sector non-specific financial innovations can help identify the role of finance in REINVENT sectors, as well as opportunities and difficulties in mobilising investment in these sectors.

The case of EIB Quotas looks at "climate finance" as an investment category, and at how target quotas for investing in climate-relevant projects could connect to actual GHG mitigation outcomes, particularly in the REINVENT sectors.

The second case looks at churches, which are at the forefront of a growing divestment movement. Several faith-based organisations have committed to divesting from fossil fuels. This case looks at how these funds are reinvested, and how they can help fund new low-carbon innovations in general and in the four key sectors of REINVENT.

The most important aspects of these two case studies are summarised in Table 6 and described in more detail below. Detailed templates are enclosed in Appendix 5.

Table 6: Key features of case studies for the finance sector

Case	Value Stream	Contained in Scenarios	Forward-looking	Contained in Database	Innovation Type	Carbon Significance (Relative/ Absolute)
EIB Quotas	Finance	No	No	Yes	Technical/ Economic	Unclear/Rather Low
Fossil Free Churches	Finance	Yes	Yes	No	Economic	Medium/ Medium

The **European Investment Bank (EIB)** is a European Union organisation that acts as a non-profit lending institution. EU member states are the EIB's shareholders and set the bank's broad policy goals. As part of the bank's Climate Strategy (2015), the EIB set a target that 25% of the bank's activity would be directed to climate-relevant projects (including both mitigation and adaptation). The target was met within its first year. There is a history of public banks such as the EIB acting as trendsetters who establish new pathways for private investors to follow. If other actors were to adopt similar targets for mitigation-related investment, the gap in the availability of finance to support low carbon innovation could be closed. There is also substantial potential for investors to scale up their commitment by increasing the ambitiousness of their quotas and targets. Examining how finance at the EIB connects to actual GHG mitigation outcomes is important for understanding the new phenomenon of "climate finance" and the significance of finance for successful innovations. The examination of this intervention also aims to identify potential opportunities and difficulties for mobilizing investment in REINVENT sectors.

Churches have taken the lead in the movement for divestment from fossil fuels: approximately 30% of organisations that have committed to divestment are faith-based organisations. This cross-cutting finance case study will look at churches in three countries (UK, Sweden, Bel-

gium) that have committed to divesting their investments (e.g. pensions) from fossil fuels. It will be interesting to see where the money that has been/will be divested, will be reinvested. In particular we are interested in finding out the extent to which the REINVENT sectors feature in the churches' reinvestment strategies, and thus the potential that institutional (re)investment has in funding decarbonisation of the REINVENT sectors. As faith-based organisations are at the forefront of the divestment movement, this case can potentially offer significant insights into the future directions that other institutional investors may be taking. Already an increasing number of European universities and local governments are committing to divest from fossil fuels. Estimating carbon significance is difficult, but the shift of millions – potentially billions - of Euros of investment away from fossil fuels into 'green' sectors, can potentially fund the development of a significant number of new low-carbon innovations. The case study should be able to provide insights into decision-making processes, and how churches decide to divest and reinvest, as well as the role of new actors, forms of agency, and materiality in achieving decarbonisation in the REINVENT sectors.

Appendix 1 – STEEL

Innovation:	**Strip Casting process for steel (in which thin steel strip is cast directly from liquid steel, effectively combining the casting and rolling processes into one)**
Intervention:	**Castrip process**
Responsible Project Partner(s):	Wuppertal Institute (Helena Mölter: Helena.Moelter@wupperinst.org; Annika Tönjes: Annika.Toenjes@wupperinst.org)
Sector:	☒ Steel ☐ Plastics ☐ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☐ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	USA (Australia, Japan)
Short Description of Intervention and (if possible) Initiative:	In the 1980s and 90s, Australian BHP Steel (now BlueScope Steel) and Japanese IHI undertook co-operative R&D activities marked "Project M" to develop a strip casting technology for steel, a century-old idea that had never been fully realised. Their technical approach is a twin-roll process, in which liquid steel is cast between two counter-rotating rolls. Combining casting and rolling into one allowed them to cut down on space, equipment, energy, and emissions. They built a full-scale demonstration plant in Port Kembla, Australia, and with continued R&D were able to achieve technical viability casting strip of less than 2 mm thickness. In 2000, they formed Castrip LLC together with American steelmaker Nucor, with the goal of commercialising the technology. Nucor also became the first licensee of the Castrip technology, and now operates two facilities with the Castrip process. Castrip LLC formed a strategic alliance with the Industrial Solutions and Services Group of Siemens AG and Siemens Energy & Automation, Inc.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	The innovation history is interesting because the idea for strip casting goes back to the 19th century, when the innovation was much more radical and could not yet be technically realised. The Castrip consortium was one of several international collaborative efforts to develop a viable strip casting process for steel. Castrip won the race for commercialisation, and it is interesting to see which circumstances facilitated their success. It still faces some challenges with regard to up-scaling the technology to large integrated steel plants and making it commercially and technically feasible for different steel types. If these barriers can be overcome, the technology's potential (with regard to saving energy, emissions, costs, and space) is quite significant, making it an interesting case looking forward as well as back.
Relative Carbon Significance Compared to Reference Pro-	Reference Process/Product: Conventional Continuous Caster (CCC) + Hot Rolling Mill (HRM)

cess/Product:	Relative Carbon Significance: ☐Low ☐Medium ☒High *Short Explanation (Max. 100 Words):* The Castrip process can cut energy consumption by 90% and GHG emissions by 80% compared to a thick-slab casting route (CCC+HRM). Compared to thin-slab casting (a competing near-net shape casting process), it uses around 50% less energy and reduces GHG emissions by about 40%.
Absolute Carbon Significance within Sector:	☐Low ☒Medium ☐High While significant reductions are possible at the casting and rolling stages, this is a comparatively small portion of the overall emissions of the steel-making process. Exact percentages are difficult to pinpoint because a strip caster is usually combined with other lower-carbon technologies (such as an Electric Arc Furnace using scrap metal). In these so-called micro-mills (EAF + Castrip), emissions reductions are quite significant. However, when looking at large integrated steel mills, the reduction potential of the Castrip technology is comparatively small.
Maturity of Case Study:	The technology has already been commercialised and is in use at two different Nucor steel mills. It has not (yet) spread further or been adapted for larger-capacity steel plants. (The steel sector is a rather slow-moving industry with long equipment lifetimes.)
Potential for Scale up:	There are a few key barriers to the technology's scale up, including comparatively low capacity and some technical issues with regard to adapting it for different steel grades. Furthermore, existing conventional continuous casters, hot rolling mills, etc. tend to have long remaining lifetimes and are unlikely to be replaced anytime soon. Its potential to be adopted by other companies depends on how well the technology is able to overcome these barriers. If it does so successfully, its potential for scale up could be significant.
Relevance of Case Study for Transformation of the Sector:	Castrip works particularly well in combination with Electric Arc Furnaces in lower-capacity steel mills. It reduces capital costs, takes up less physical space and allows for the use of lower-quality steel scrap. All of these factors make Castrip a suitable candidate for a more flexible future steel industry with an increased share of secondary steelmaking from recycled scrap. It can contribute to a more streamlined, less energy-intensive production line, thus playing an important role in the decarbonisation of the sector.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	The case study is strategically relevant for the REINVENT project as it showcases an interesting innovation history, international collaboration, and high technical innovativeness. It has significant carbon mitigation potential for the steel sector.
Linkages to other Work Packages:	☒ WP 2 (Database) ☐ WP 4 (Scenarios)

Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	The case study seems to be feasible so far as a good amount of studies and data has been found during desk research and a few interviews have already been conducted. As to whether a sufficient number of additional interviewees can be found is unclear as of now.

Innovation:	**Using blast furnace gases from steel mills for producing valuable chemicals. The conversion process is to be fuelled by renewable energy sources.**
Intervention:	**Carbon2Chem project**
Responsible Project Partner(s):	Wuppertal Institute (Dr. Daniel Vallentin: daniel.vallentin@wupperinst.org)
Sector:	☒ Steel ☒ Plastics ☐ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☒ Social ☐ Political ☒ Economic
Location of Initiating Intervention:	*Please give country(s) (if possible)* Germany
Short Description of Intervention and (if possible) Initiative:	A consortium of 18 large German industry companies and research institutes (including companies from steel, chemical, automotive and plant engineering industries) - led by Thyssen Krupp, Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT and Max Planck Institute for Chemical Energy Conversion (MPI CEC) - has teamed up to develop a process which converts blast furnace gases from steel production into valuable chemical products, such as fuels, plastics or fertiliser. The blast furnace gases include hydrogen, nitrogen and carbon dioxide which will be converted into basic chemicals such as methanol or ammonia through synthesis processes. Additional hydrogen needed for generating the aspired chemical products will be supplied through electrolysis based on surplus electricity from renewable energies. Carbon2Chem is the first phase part of a ten-year endevaour and runs four years. It focuses on basic research with a financial volume of 50-100 Mill. EUR. The outputs of Carbon2Chem will be used for building a pilot plant (Technikum) to generate 2-5 years of operating experiences until 2025 (investment: ca. 100 Mill. EUR). Afterwards, a plant at commercial scale is planned to be set up with a total investment of more than 1 Bill. EUR. So far, only funding for Carbon2Chem – which means the first four project years – is secured; the German Ministry of Research and Education (BMBF) contributes 62 Mill. EUR. The project will be organised in a project-owned company named TREK Ltd. to promote its mission and achievements. The working process is structured in seven sub-projects and coordinated by a steering committee.

Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	The project demonstrates cross-sectoral cooperation among two major energy-intensive industry branches - steel and chemicals - plus important players from plant engineering and science. Therefore, it implies potential to showcase how the value chains of steel and chemicals production could be transformed and connected. At the same time, the project may function as a storage for surplus electricity from renewable energy sources. Collaboration among these industries and partly competing companies requires new forms of knowledge sharing, intellectual property agreements and learning. Therefore, the case study is not only interesting from a technical but also an organisational and social perspective.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Conventional blast furnace process with waste gases being emitted Relative Carbon Significance: ☐Low ☐Medium ☒High *Short Explanation:* The relative carbon significance of the Carbon2Chem approach strongly depends on detailed process parameters, e.g. whether the full blast furnace gas stream is converted into chemical products or if a certain share of the gas stream will still be emitted to the atmosphere. Currently, blast furnace gases are partly used as an energy source for rolling steel. If the full blast furnace gas stream would be used for chemical synthesis, a new energy source would be needed for the rolling process, e.g. natural gas or electricity. This would affect the carbon impact of the Carbon2Chem approach. Furthermore, it needs to be considered whether the electricity for producting additional hydrogen is fully or only partly based on renewable energies.
Absolute Carbon Significance within Sector:	☐Low ☐Medium ☒High *Short Explanation:* According to the project consortium, the Carbon2Chem approach potentially reduces annual CO2 emissions of the German steel industry by 20 Mill. tonnes. In 2015, CO2 emissions of German steel industry totalled ca. 55 Mill. tonnes - consisting of 38.5 energy-related emissions and 16.5 Mill. tonnes process-related emissions (source: German National Inventory Submissions 2017; available under: unfccc.int). Following the mitigation estimate of the Carbon2Chem consortium, the project approach could substantially reduce the emissions of the German steel industry.
Maturity of Case Study:	The first phase of the project (see above) is being conducted. This means that the project is not at commerciable scale yet. However, important experiences in setting up a cross-sectoral consortium, organising/structuring the working and exchange process and interacting with political players such as the German Ministry for Research and Education or the state government of North Rhine-Westphalia have been gained. These insights are of high interest for the REINVENT project.
Potential for Scale up:	According to the project consortium, the Carbon2Chem project is designed in a modular mode which allows for a broad diffusion of the process. It is estimated that it could be applied at about 50 similar steel production plants

	worldwide. This means Carbon2Chem could become a key technology in the steel and chemicals sectors and has potential to be promoted internationally.
Relevance of Case Study for Transformation of the Sector:	Carbon2Chem implies both characteristics of an incremental and radical innovation. On the one hand, the project consortium wants to avoid substantial changes of the conventional blast furnace process for primary steel production unlike other processes such as electric arc furnaces or direct iron reduction. On the other hand, the project has potential to substantially change the steel value chain as it creates a linkage to the chemical industry and a new business case for blast furnace gases. Therefore, the project may help to overcome incumbant industry structures and path-dependencies.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	The strategic relevance of Carbon2Chem for the REINVENT project is high as it is a rare example of collaboration among major energy-intensive industry branches and partly competing companies. Furthermore, the project addresses two REINVENT key sectors. The project is innovative both from a technical, organisational and social perspective. It offers significant carbon mitigation potential in the industry sector in the mid- to long-term and seem to have potential for scale up.
Linkages to other Work Packages:	☐ WP 2 (Database) ☒ WP 4 (Scenarios) *Comments:* Conversion of blast furnace gases into valuable chemical products and, thereby, avoiding their discharge into the atmosphere could become an interesting mitigation option in the WP4 scenario pathways.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	The case study seems to be feasible as the Wuppertal Institute has long-established contacts to many involved players from industries, science and politics, such as Thyssen-Krupp, Covestro, Fraunhofer UMSICHT and the state government of North Rhine-Westphalia. Therefore, good access to interviewees should be given. Furthermore, the project has been well covered in the public discourse on decarbonising energy-intensive industries and is proactively promoted by the participating industry companies.

Innovation:	**Direct reduction of iron ore using hydrogen as reductant**
Intervention:	**Pilot plant in Luleå**
Initiative:	**HYBRIT (Hydrogen Breakthrough Ironmaking Technology)**
Responsible Project Partner(s):	IMES, Lund University. Alexandra Nikoleri
Sector:	☒ Steel ☐ Plastics ☐ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Stage Chain:	☒ Resource & Production ☐ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	Sweden
Short Description of Intervention:	A pilot plant for using hydrogen as a reduction agent in steelmaking is about to be built by Hybrit Development AB, a joint venture between LKAB, SSAB and Vattenfall. Steel is produced by reducing iron ore, which means that oxygen in the iron ore is removed, and also by adding small amounts of carbon. In today's steelmaking iron ore is reduced with coke as a reduction agent, which results in large amounts of carbon dioxide emissions. HYBRIT will now test using hydrogen as a reductant instead, a process which will result in water vapor being the main emission, rather than carbon dioxide.
Transformative Potential	
Most Interesting Elements/Features: of Intervention:	The two most interesting elements is that coal as a reduction agent is substituted in the steel making process and that the new reductant, hydrogen, will be produced with low greenhouse gas emissions. The reduction process is contributing to over 80% of the overall greenhouse gas emissions of steel-making. Using hydrogen as a reductant has been tested before (in the 1950ies) and on lab-scale but never on a scale this large. Using renewable energy for hydrogen production also makes the intervention interesting from a power system perspective since there is potential for flexible operation and thus provision of power system services.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Crude steel (from the blast furnace production route) Relative Carbon Significance: ☐ Low ☐ Medium ☒ High *Short Explanation:* Hydrogen direct reduction replaces the blast furnace and thus the demand for coal and coke. It represents a near 100% carbon emission reduction assuming clean electricity for the electrolysis.
Absolute Carbon Significance within Sector:	☒ Low ☐ Medium ☒ High *Short Explanation:* On a short time scale the significance is very low as the initiative only concerns primary steel production in Sweden. In the long run the innovation, if adopted,

	has very high absolute carbon significance in the sector because the biggest source of CO_2 emissions in the production process can be eliminated given that electricity is produced with low greenhouse gas emissions.
Maturity of Intervention:	Projecting the pilot plant started in January 2018. Building of the plant (with a capacity of about 1-2 tons per hour) will start in the summer of 2018.
Potential for Scale up:	The pilot plant will be running tests until 2024. If successful, a full-scale demonstration plant will be built. The potential scale up is very big. On a medium term, sponge iron production (direct reduction) could be converted to hydrogen direct reduction and on a long term this innovation could be used for steelmaking all over the world (total global greenhouse gas emission reduction of about 7 %).
Relevance of Intervention for Transformation of the Sector:	As a start this intervention only deals with crude steel production in Sweden, which constitutes a small share of the market. If successful, this is one of the few alternatives for the steel industry globally to go to zero or near zero greenhouse gas emissions. This innovation could be adopted by steelmakers globally, the potential obstacles would be access to hydrogen with low climate impact (i.e. large amounts of electricity produced from renewable sources is needed). This in turn could mean relocation of ironmaking to areas with access to clean electricity.
Relevance of Case Study within RE-INVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	This is one of very few options to decarbonise primary steelmaking and perhaps the most promising. It creates a new value chain across energy, mining and steel and requires new business models. It appears to have clear links to the Paris Agreement (it was announced in April 2016) and the steel association is assessing the role of steelmaking in relation to the SDGs.
Linkages to other Work Packages:	☐ WP 2 (Database) ☒ WP 4 (Scenarios*)* *Comments:* HYBRIT is not in the database but will be very important for developing the scenarios. There are also links to WP 5 / Task 5.2 through the SDG-work of the Swedish Steel Association.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	High accessibility to internal and external documentation on the HYBRIT project as a whole. Contact already initiated with key interviewees.

Innovation:	**Robotic 3D Metal Printing**
Intervention:	**MX3D**
Responsible Project Partner(s):	Wuppertal Institute (Helena Mölter: Helena.Moelter@wupperinst.org; Annika Tönjes: Annika.Toenjes@wupperinst.org)
Sector:	☒ Steel ☐ Plastics ☐ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☐ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	The Netherlands
Short Description of Intervention and (if possible) Initiative:	MX3D is an Amsterdam-based start-up using Additive Manufacturing technology to "print" large lightweight structures. Most notably, a stainless steel pedestrian bridge is set to be completed in September 2018 and installed across one of the city's many canals in the near future. MX3D uses Wire and Arc Additive Manufacturing (WAAM) technology, in which layers of metal (such as steel, stainless steel, different high-strength steels, aluminium, bronze) are welded on top of one another by a six-axis robotic arm, controlled through specialised software. This allows for structures of virtually any shape and size, making production highly flexible and customisable. The feed material is wire rather than powder, as in other 3D printing technologies. The printing time is comparatively fast at > 2 kg/hour per nozzle. MX3D has a number of industrial and public partners, including ArcelorMittal and the Municipality of Amsterdam. The start-up aims to build larger bridges, complete buildings and ships in the future. At the moment, structural tests are being performed on the finished bridge span, which was completed in April.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	3D printing is a disruptive technology on the rise, with various techniques, materials, and applications. It is expected to experience significant growth over the next decade and play an important role in different manufacturing industries. What makes MX3D particularly interesting in this regard is the WAAM technology and the freedom it provides to print large-scale structures with high material efficiency. This intervention does not stem from any of the large steel or manufacturing companies but from a small software-based start-up (although MX3D is partnered with ArcelorMittal, amongst others, it is fully owned by founders and staff). This is unusual in these industries, where technical innovation usually originates in the R&D departments of big industrial players. From an organisational perspective this case is interesting because of the company's numerous partnerships with both industrial and public actors, as is well represented by the Amsterdam canal footbridge project.

Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Conventional manufacturing technologies (casting, CNC milling, etc.) Relative Carbon Significance: ☐Low ☒Medium ☐High *Short Explanation:* As the technology is still in early stages, there is little information about its relative carbon impact. Moreover, it is difficult to define an exact reference process, as there are different manufacturing processes for different applications. However, it can be said that MX3D technology enables high material efficiency and freedom of shape, the combination of which carries a strong potential for decreasing material consumption. Compared to other additive manufacturing technologies, MX3D's WAAM technology also results in reduced power consumption. Another relevant factor is the decentralisation of the manufacturing process: the robotic printer can be put to work on site, reducing the need for transportation of large factory-made parts.
Absolute Carbon Significance within Sector:	☐Low ☒Medium ☐High *Short Explanation:* While the absolute carbon significance is difficult to assess at this point, MX3D is active in sectors that are important steel processors, such as automotive and construction. If a large number of parts are no longer produced in factories but customised and printed on site, this will prevent a lot of material waste from conventional manufacturing and unused spare parts from overproduction and could significantly affect the industry's carbon impact.
Maturity of Case Study:	MX3D appears to be in early stages of commercialisation, but is at the same time still in a testing phase (there is a "learning by doing" approach to it). They have completed several experimental sculptural projects, their current bridge project being the most demanding project to date. It is well underway and, if all goes well, the footbridge will actually be put into place for public use. Engineers and researchers are currently performing load tests to assess the bridge's structural integrity. MX3D is developing rapidly and is likely to take further steps toward full commercialisation during the REINVENT project, making it an interesting, highly topical case.
Potential for Scale up:	The potential for the technology to spread to different industries, companies, and purposes appears to be high. There are no known limits to size or geometrical features of the printed structure, making it applicable for many different purposes. The software can be adapted and customised so that no training or expertise is necessary to operate it. The printers are small and flexible, and can be operated using different steel grades. First tests show no significant disadvantages in strength or ductility of the welded material. Operating costs compare favourably to other additive manufacturing technologies (stainless steel wire is 10x cheaper than stainless steel powder). However, the technology is still to be rolled-out and proven at large scales.
Relevance of Case Study for Transformation of the Sector:	Additive manufacturing is a disruptive technology that will change the way certain steel products are manufactured. It allows for greater flexibility and customisation, on-site manufacturing rather than factory mass production, and in consequence change the steel supply chain. It has the potential to reduce the sector's carbon impact at the stage of end-product manufacturing and transport. MX3D is relevant as it is pioneering large-scale 3D metal

	printing that will affect the way big steel structures are manufactured, offering significant potential for efficiency improvements in material use, product design, and logistics.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within REINVENT Project and overall Pool of Case Studies:	This case study is relevant to the REINVENT project as it represents a radical innovation at the end-product/consumption stage of the steel value chain, rounding out the overall picture of steel case studies that are more focused on iron- and steelmaking. It is also highly topical and developing rapidly, promising efficiency gains that could translate into a significantly reduced carbon impact.
Linkages to other Work Packages:	☒ WP 2 (Database) ☐ WP 4 (Scenarios*)* *Comments (Max. 50 Words)*
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	This is a rather public-facing case with considerable news coverage, about which a fair amount of information (both scientific and non-scientific) is freely available. Different additive manufacturing techniques, including the WAAM technology employed by MX3D, have been receiving a lot of attention from the scientific community, providing a solid context for the case study. Between the start-up and its numerous industry, public, and research partners, as well as experts from outside of the project, there should be a sufficient number of potential interviewees.

Innovation:	**Advanced light-weight steel products for automotive sector**
Intervention:	**Docol steel products by SSAB**
Responsible Project Partner(s):	Lund University, Duncan Kushnir
Sector:	☒ Steel ☐ Plastics ☐ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	Sweden / Global
Short Description of Intervention and (if possible) Initiative:	The Docol line of steels is produced by SSAB, a leading global producer of advanced steels. Docol steels are targeted at automotive use, with a full range of grades suitable for all steel vehicle components. Docol steels offer a number of superior properties with respect to alternative steels (e.g. increased mechanical performance, comparatively green production, corrosion resistance and lifetime). Steel also compares favourably to other structural materials in the transport sector. SSAB can tailor steel grades to OEM specifications.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	Steel has long been the go-to material in the transport sector, but the ongoing need for lighter materials has induced innovation and competition both between steel types, and between steel and alternative materials such as aluminium or carbon fibre. Steel has significant advantages with respect to production impacts, cost, recycling and product lifespan. Advanced steels suitable for vehicle light-weighting are therefore very interesting for the viability of more efficient transport options. In addition, every structural component of the vehicle could therefore be made of steel, whereas alternative materials have significant disadvantages in some components. The viability of steel also has implications for how much light-weighting can be cost effective in a vehicle. The case study is thus interesting from both the perspective of direct emissions reductions, and from the organisational perspective, where the interplay between steel producers, component designers, and vehicle manufacturers is critical to fully utilizing the innovation.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Standard Automotive Steel / Other structural light-weighting materials Relative Carbon Significance: ☐ Low ☐ Medium ☒ High

	Short Explanation: Advanced steels typically have higher cradle-to-gate emissions per kilogram than basic steel due to the increased number of process steps and energy consumption therein. However, the better mechanical properties allow a part of similar or better specification to be produced with less mass. This means that the emissions per unit of functional service or per part may actually be lower and must be evaluated on a case-by-case basis. The primary gain will however be in the use phase, where lower vehicle weights can produce emissions savings more than an order of magnitude larger than the production emissions over the lifetime of the vehicle. With respect to alternative light-weighting materials (Aluminium, Carbon Fibre, etc.), steel has significant lifecycle advantages due to lower production emissions and efficient recycling.
Absolute Carbon Significance within Sector:	☐Low ☒Medium ☐High *Short Explanation:* The transport sector produces approximately 14% of global emissions. The primary adopter of these steels would be road transport, which in turn represents 71% of all transport emissions (IPCC 2014). All else held constant, a reduction of 10% in vehicle weight reduces use phase emissions by approximately 7% (EEA, 2006). Light-weighting via advanced steels thus has an incremental direct effect on reducing transport emissions. If one were to increase the scope under consideration, it can be argued that light-weighting is also a prerequisite for enabling radical transformations such as electric drivetrains while maintaining vehicle performance at levels that will drive adoption.
Maturity of Case Study:	Docol Steel is a full commercial offering, with OEM grades available for custom order. Adoption of advanced steels in the automotive industry has been ongoing for decades and is forecast to continue.
Potential for Scale up:	In principle, the entire chassis of a vehicle could be comprised of advanced steel, and thus the potential is very large. In practise, in a typical consumer vehicle, 12% of the vehicle mass is already made of AHSS or UHSS steels, up from 4% in 1975 (WSI, 2011). All other steels represent 43% of the vehicle mass, giving a first order approximation of the potential if high strength steels were to replace all other steel in the vehicle. The full potential is difficult to estimate, as other materials are not replaced on a 1:1 basis. Nevertheless, the use of such steel could be multiples higher than it is today.
Relevance of Case Study for Transformation of the Sector:	The increasing adoption of light-weighting materials in the transport sector is of critical importance to sectoral emission goals for meeting IPCC targets. In addition to the direct impacts of steel use on vehicle production and performance, newer steel grades also offer the potential for radical redesign of various car elements. It is hard to overstate the relevance of steel for the transport sector.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within Reivent Project and	An advanced steel for transport case study is relevant for several reasons: (1) The very large absolute emission reduction afforded by the scale of the application. (2) The direct importance of steel and related industries to society. (3)

overall Pool of Case Studies:	The critical importance of considering systemic factors such as full lifecycle emissions, and the cost effectiveness of interventions. (4) Because the adoption of advanced steels in transport is ongoing and sufficiently large that must be considered in evaluations of both the steel and transport sectors.
Linkages to other Work Packages:	☒ WP 2 (Database) ☒ WP 4 (Scenarios) *Comments:* Different types of light-weight steel are included in the database (though not Docol steel products); the study will aim to produce results suitable for both the database and integration into scenarios.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	There is a large array of literature data and models regarding the production of materials and lifecycle impact in the transport sector. The main actor SSAB is available for consultation during the case study process. Therefore no impediment to the case study exists.

Appendix 2 – Plastics

Innovation:	**Chemical recycling of hydrocarbon wastes (e.g. plastics, biomass)**
Intervention:	**Enerkem - Waste to Chemicals Rotterdam**
Responsible Project Partner(s):	Wuppertal Institute (Katja Pietzner, Clemens Schneider, Stefan Lechtenböhmer) Utrecht University (Ernst Worrell)
Sector:	☐ Steel ☒ Plastics ☐ Meat & Dairy ☐ Paper ☒ Cross-Sectoral
Value Stage Chain:	☒ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☒ Economic
Location of Initiating Intervention:	Canada, The Netherlands (Rotterdam harbor)
Short Description of Intervention:	Enerkem (Canada) has developed a (fluidized bed) gasification technology to produce syngas from (hydro)carbon wastes (e.g. biomass, mixed municipal solid waste/MSW, plastics). The technology was patented in 2009. Since the 1990's various projects have looked at gasification of biomass and wastes to produce syngas (e.g. in U.S., Europe). In the Enerkem process, the syngas is converted to methanol. Methanol is used as a platform to make ethanol or produce other (intermediate) chemicals. A consortium of Air Liquide, AkzoNobel Specialty Chemicals, Enerkem and the Port of Rotterdam, will build a waste treatment/recycling facility in the Botlek area of the Port of Rotterdam. One commercial plant is in operation in Edmonton (Alberta) since 2015
Transformative Potential	
Most Interesting Elements/Features: of Intervention:	The waste-to-chemicals project consists of the recuperation of carbon contained in waste, followed by its conversion into (bio)fuels or chemicals. It would allow increased efficiency in processing MSW to produce chemicals or fuels. If the chemicals are used as materials the carbon may be stored long term and not emitted to the atmosphere.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Waste incineration, petrochemically produced methanol Relative Carbon Significance: ☐ Low ☒ Medium ☐ High *Short Explanation:* The chemical recycling of carbon means that emissions from MSW incineration plants may be avoided while replacing (fossil) fuels or petrochemicals (dependent on the use of the product). It is estimated that the technology can produce about 600 l Methanol per tonne of RDF (Refuse Derived Fuel). GHG emission reduction depends on the alternative use of the waste and the substituted petrochemical material.

Absolute Carbon Significance within Sector:	☐Low ☒Medium ☐High *Short Explanation:* It is estimated that the technology can produce about 600 l Methanol per tonne of RDF (Refuse Derived Fuel). GHG emission reduction depends on the alternative use of the waste, the efficiency of the conversion, the substituted petrochemical material, as well as the composition of the MSW/RDF. Various LCAs have been done for the production of (bio-)ethanol using the technology
Maturity of Intervention:	A first commercial plant has been in operation in Edmonton (Alberta, Canada) since 2015/2016. The project has not yet started; the project development agreement has been signed by the consortium in February 2018. The initial investment of 9 Mill. EUR has been made, but the projects total estimated costs amount to 200 Mill. EUR. Planning aims at completion by 2020.
Potential for Scale up:	This project is the first of its kind on European ground using the Enerkem technology. However, this technology was developed and is already being used in Canada. So there has already been a technology transfer, which could be undertaken again. MoU exists to transfer technology to China.
Relevance of Intervention for Transformation of the Sector:	This project would represent a further step in chemical recycling of MSW and the gasification of waste for the production of chemicals. Competing technologies for the chemical recycling of plastics are under development.
Relevance of Case Study within RE-INVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	The case study could help to understand both a long-term trajectory of technology development (i.e. waste gasification for chemicals production) but also the specific international drivers for technology selection (i.e. the Enerkem process, role of stakeholders). The case study may help to get some more insights into the potential role of chemical recycling technologies within the energy transition (and hence the impact of a specific part circular economy initiatives on the transition).
Linkages to other Work Packages:	☐ *WP 2 (Database)* ☐ *WP 4 (Scenarios)*
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	We have access to the people of Enerkem (both Canada and Rotterdam), as well to the European partners (AkzoNobel, Port of Rotterdam). Insights in process efficiency are still a bit fuzzy, while estimating climate impacts will depend on many assumptions.

Innovation:	**Bio-based technical plastic fibres**
Intervention:	**Deterra, a fossil-free technical outdoor jacket**
Responsible Project Partner(s):	Lund University – SVET (Political Science) Ludwig Bengtsson Sonesson, Mark Cooper, Johannes Stripple
Sector:	☐ Steel ☒ Plastics ☐ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☒ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	Sweden
Short Description of Intervention and (if possible) Initiative:	After COP21 in Paris, the team at a small Swedish outdoor clothing manufacturer, Tierra, had a novel idea – "can we make a fossil free technical outdoor jacket?". Through a long process, they sourced a fabric (called EVO) made from castor oil, a plant that lives in semi-arid environments and reportedly does not compete with food production. This involved a long value chain through Borås, Italy and India. They also had to find fossil-free alternatives to details such as the thread used to sew the garment, zippers and buttons. For the stuffing, they used wool. The intervention is a part of a larger initiative to decouple the production of clothes from fossil fuels, whether through recycling or by using bio-based alternatives. The outdoor clothing and accessories sector has also been identified as a particularly innovative and progressive part of the market when it comes to switching to more sustainable materials.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	The clothing industry has one of the most complex and dynamic value chains of any modern product. It was also one of the first industries to globalise during industrialisation; transitioning away from conventional production methods and materials is likely ridden with both complexity and inertia. The fossil-free jacket is an exciting case because it examines how Tierra (a small actor within the sector) navigated the jungle of sub-contractors and global value-chains to create a fossil-free product. Understanding the development of this product is likely to yield insight into how the clothing industry could be remade to reduce its reliance on petroleum-based fibres. The clothing industry is currently facing significant external pressure to reduce its reliance on petroleum-based inputs, reduce the volume of waste it generates, eliminate micro-fibre plastic pollution from its products, and improve its working conditions. The industry, however, lacks a clear strategy to respond to these issues and is "plagued by uncertainty" about the appropriate solutions to these issues.
Relative Carbon Significance Compared to Reference Pro-	Reference Process/Product: Virgin Nylon-6 from Fulgar Relative Carbon Significance: - 26% CO_2-eq (EVO:7.36 kg CO_2-eq vs 9.97

cess/Product:	CO_2-eq). ☐Low ☒Medium ☐High *Short Explanation:* Fulgar (the company who makes the yarn for the fabric the Deterra jacket is made from) did an LCA of three of its nylon yarns; recycled, virgin and bio-based Nylon. This was published in a press release; we have yet to get hold of the actual document. To note, however, is that this case study has also discussed the uncertainty of LCAs – depending on what assumptions you make you could get wildly different results.
Absolute Carbon Significance within Sector:	☐Low ☒Medium ☐High *Short Explanation:* Short term, this intervention has a very marginal effect on the sector's decarbonisation. Tierra is a small company with a niche customer base. In the medium term, however, the initiative could stimulate a move away from clothing (and textiles more generally) produced with virgin fossil fibres toward recycled or bio-based alternatives, which would yield a significant impact on carbon emissions and plastic waste from clothing. Although the relative carbon significance of this innovation is -26%, the large volume of nylon fibres produced means that innovative fabrics and solutions such as Deterra could be scaled up by other actors to achieve more significant impact.
Maturity of Case Study:	At the time of writing, the jacket has been on the market for a year, won several awards and the company is now in the process of developing the next line of Deterra-clothing. The intervention has reached maturity while the initiative is still in its early days – but is accelerating fast.
Potential for Scale up:	Biopolymers such as the EVO-yarn have the potential to scale within this niche, to applications in other outdoor clothing or active wear. However, a large-scale production line of these fabrics (which would be necessary for say, a fast fashion company) would require a substantially higher volume of the raw material, castor oil. At the moment, that growth seems unrealistic. However, if one or more of these companies succeed in creating a closed-loop virgin fossil free system that could become the model followed by high-volume retailers such as H&M and Nike.
Relevance of Case Study for Transformation of the Sector:	At the moment, the clothing industry faces several crises, including the volume of waste it generates, the volume of greenhouse gas emissions it generates, and the persistence of issues around working conditions in clothing factories. In response, the industry is exploring many different avenues that might secure its future existence under conditions such as higher raw material prices for conventional fibres rise (either due to fresh water scarcity in the case of cotton or rising oil prices in the case of polyester). Biopolymers, especially based on sources that do not compete with food production, could be a way to retain the quality and functionality of materials while reducing consumption of fossil fuels. At present, the two likely pathways for oil-based fibres are bio-based or recycled fibres; understanding the potential and the obstacles for the bio-based fibre pathway will also yield insights relevant for the recycled fibre pathway.

Relevance of Case Study within REIN-VENT Project	
Strategic Relevance of Case Study within REINVENT Project and overall Pool of Case Studies:	Within the literature on plastics, textiles remain one of the less explored applications. We know a lot about plastic bags and some packaging, but need more knowledge on how poly-materials function in the complex textile industry. There are many interesting geographic dynamics at work, since textiles have very long value chains with global impacts.
Linkages to other Work Packages:	☐ *WP 2 (Database)* ☐ *WP 4 (Scenarios)* *Comments:* Patagonia's extensive work with recycled poly-materials was in the database, but due to distance and trouble getting interviews we had to redirect the case study and find an intervention which was closer and more accessible.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	The Swedish outdoor industry has proven very easy going and organizing interviews and study visits have so far not been problematic. One hinderence is in the staunch protection of information within the fashion indstry – competition is fierce so data on emissions, sustainability, etc. are almost never public. The same goes for tracking supply chains – the companies themselves often don't know exactly where their products get made, hence it is hard for us to track.

Innovation:	**Plastic-free supermarkets**
Intervention:	**Gram (Malmö), Løs Market (Copenhagen), Ekoplaza (Amsterdam), Iceland (UK), and others**
Responsible Project Partner(s):	Lund University – SVET (Political Science) Jacob Hasselbalch, Karl Holmberg, Johannes Stripple
Sector:	☐ Steel ☒ Plastics ☐ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☐ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☐ Technical ☒ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	Denmark, Sweden, Netherlands, United Kingdom
Short Description of Intervention and (if possible) Initiative:	Several European supermarkets are adopting a range of measures to reduce or eliminate plastics in retail packaging. Gram and Løs Market are recent Scandinavian examples of zero-waste supermarkets where packaging is almost eliminated, meaning that customers bring their own vessels and containers and buy the exact amounts they require. Ekoplaza in Amsterdam received much media attention in February and March 2018 for opening the first plastic-free aisle in a more conventional supermarket. Iceland is a British frozen foods retailer that in January 2018 pledged to go plastic-free within five years. These specific interventions have been chosen for the media attention they received (Ekoplaza, Iceland) and geographical proximity (Gram, Løs Market). All of the supermarkets are examples of a bottom-up, entrepreneurial approach to problems of plastic pollution. Their variation in the details of their business models and settings allow for a broader treatment of the innovation while allowing key insights to emerge through comparison. There are additional examples across Europe that may be drawn on for further scrutiny, for example in Germany, Spain, and Italy. We will also interview a number of conventional supermarkets on their packaging and plastics perspectives to identify the potential for plastic reduction measures within conventional supermarkets as well as potential barriers or downsides that the exemplar and first-mover actors may not identify.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	All of these supermarkets are responding directly to problems of plastic pollution and doing so in a bottom-up, direct manner. There is no overall policy or sector-level steering involved either from politicians, NGOs, or industry representatives. The interventions may be loosely affiliated to or inspired by the Zero Waste Alliance, a movement working on reducing and eliminating waste, but the relationship with the Alliance varies between stores. More generally, these supermarkets are responding to the increased political and media attention to plastic pollution as well as the significant share of plastic waste arising from the packaging of food and household items. These supermarkets are employing different strategies for how they respond to these

	pressures and position themselves favourably compared to competitors. This makes the intervention an interesting target of analysis as it provides direct insight into the scope and dynamics of social and market-based pathways to decarbonisation of consumption and retail.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Supermarkets Relative Carbon Significance: ☐Low ☐Medium ☒High *Short Explanation:* The reference process/product for this case is conventional supermarkets and the extensive use of plastic as a packaging material for food and household products. Plastic packaging represents the single biggest use of plastics (at 40% of demand), and most of this packaging is used in retail, consumer-facing products. Compared to conventional supermarkets, plastic-free supermarkets could generate significantly less – or almost zero – waste, both for the supermarket itself and for the consumer. This would lead to lower carbon emissions during the production and recycling of plastic, but also less plastic waste deposited in landfills and as ocean pollution.
Absolute Carbon Significance within Sector:	☒Low ☐Medium ☐High *Short Explanation:* Plastic packaging does not represent a very significant source of emissions within the food retail or general retail sectors. Most emissions are generated in the production and distribution (logistics) of foods and fast-moving consumer goods. However, plastic-free supermarkets have transformative potential in how the reduction or elimination of plastic packaging could impact production and distribution networks to favour more local, sustainable, and low-carbon consumption practices.
Maturity of Case Study:	The maturity of the case study is low. Most of the initiatives are very recent (past couple of years), meaning that the potential for plastic free supermarkets to flourish and either displace traditional supermarkets or motivate traditional supermarkets to emulate these plastic-free systems is yet uncertain. However, given the variety of plastic-free and plastic-reduction initiatives among European food retailers, it should be straightforward to collect sufficient experience and insight through interviews and site visits for the purposes of the analysis.
Potential for Scale up:	The potential for scale up is high. Supermarkets are broadly similar worldwide, employing the same types of business models and existing in the same web of relationships between producers/suppliers, distributers, and consumers. The intervention should be relatively easy to translate from supermarkets in one market to another. The economics and social dimensions of plastic packaging are likely to share significant commonalities between national contexts.
Relevance of Case Study for Transformation of the Sector:	Plastic-free supermarkets represent one potential pathway for decarbonizing and transforming supermarkets and their existing high-volume, high-waste use of plastic. Other pathways might still include plastics but in a closed-loop, circular economy paradigm. The feasibility and potential of the plastic-free model is important to assess in order to better understand the different alternatives for the reduction of plastic packaging waste.

Relevance of Case Study within REIN-VENT Project	
Strategic Relevance of Case Study within Reinvent Project and overall Pool of Case Studies:	Because supermarkets are broadly similar, the case study may provide insights useful for modelling work on the plastics sector. Findings from the case studies of different forms and locations of plastic-free supermarkets may produce insights that can be fed into econometric models to assess the relative costs and benefits of going plastic-free, as well as what this might mean for decarbonisation of the plastic sector in total. Other cases within the plastics sector include consumption, but this case is distinct for focusing specifically on the reduction of consumer-facing plastic waste.
Linkages to other Work Packages:	☐ WP 2 (Database) ☐ WP 4 (Scenarios)
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	The case study is highly feasible. The team already has contacts in the relevant sector and the targeted supermarkets are deemed highly approachable given their media exposure. Going plastics-free is a piece of 'good news' that they are happy to talk about.

Innovation:	**Green Banks**
Intervention:	**Triodos' Organic Growth Fund (+ Naty – plastic-free sanitary items)**
Responsible Project Partner(s):	Durham University, Bregje van Veelen & Harriet Bulkeley
Sector:	☐ Steel ☒ Plastics ☐ Meat & Dairy ☒ Paper ☐ Cross-Sectoral
Value Chain Stage:	☐ Resource & Production ☐ Consumption & Waste ☒ Finance
Type of Intervention (Technical / Social / Political / Economic):	☐ Technical ☐ Social ☐ Political ☒ Economic
Location of Initiating Intervention:	The Netherlands/Sweden
Short Description of Intervention and (if possible) Initiative:	In 2014, Netherlands-based green bank Triodos established its Organic Growth Fund, as a sub-fund of its SICAV II fund. The fund is open to professional, and some private investors for investment. It was set up to offer long-term investments in mature sustainable companies in Europe. In return for an equity stake in the companies funded, the Organic Growth Fund helps provide succession and/or growth capital and seeks to engage in multiple ways with the companies that it funds. The fund focuses on promoting fair trade and organic foods, agriculture and consumer products. One of the companies the fund invests in, is Naty, a company that produces nappies and sanitary items which use bio-plastics rather than conventional plastics. In the case of Naty, the funding is used to help consolidate Naty's shareholder base. While the Organic Growth Fund is the intervention that we will focus on, we will look at Naty as one example of how such a fund can promote decarbonisation in the REINVENT sectors.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	The choice to focus on Green Banks was made as banks can create credit capital (rather than simply (re)allocating capital), and are thus an important player in financing the transition to a green economy. Triodos was established in 1980 and is potentially the most well-known fully green bank in Europe, investing only in projects that have a social or environmental benefit. Their Organic Growth Fund is interesting as it provides long-term capital to mature companies, which can potentially help transform these companies from niche to mainstream actors. We chose to look at their investment in Naty, as Naty's activities fit most closely with those that REINVENT is interested in, and is part of a recent move of companies and campaigns that seek to address the plastics-content of sanitary product.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Investment funds which are not explicitly green Relative Carbon Significance: ☐ Low ☒ Medium ☐ High

	Short Explanation: Currently uncertain, but likely to be medium. The fund helps provide long-term investment into 'green' companies, enabling them to further develop their activities, and improve production processes, which is expected to have a positive environmental impact. Nonetheless, not all companies funded through the Organic Growth Fund focus explicitly on reducing emissions, but seek to address a multitude of environmental issues.
Absolute Carbon Significance within Sector:	☐Low ☒Medium ☐High *Short Explanation:* As the Organic Growth Fund focuses on mature companies, there is substantial potential for the companies that are funded this way to upscale their activities and become mainstream. While the Organic Growth Fund currently only funds a small number of companies (and will thus have a small absolute impact), if such a fund was more widely adopted it could have a much bigger significance. We seek to further stablish the potential absolute carbon significance of the intervention through addressing the following questions through the case study research: What if all banks had such a scheme? What if all of the funds available from this kind of scheme was invested in REINVENT sectors?
Maturity of Case Study:	The Organic Growth Fund was established in 2014 and engagement with/financing of Naty is ongoing. The products that Naty produces are widely available across different European countries.
Potential for Scale up:	There is a growing interest in green investment and there are now several sustainable/green investment funds. In this case study we are interested to find out what the potential is for all banks (not just 'green' ones) to have a green/low-carbon investment funds, and what the potential is for all such funds to be invested in REINVENT sectors. As there is also a growth in attention for the plastics used in sanitary items (e.g. the Women's Environmental Network Plastic Free Periods campaign), and there are now many small companies working in this area, a more in-depth look at Triodos' investment in Naty offers an interesting opportunity to explore the carbon-saving potential if (1) more green investment funds existed, and (2) they would invest in more companies working on reducing use of plastics.
Relevance of Case Study for Transformation of the Sector:	The case shows how finance can help mature companies consolidate their activities. These are companies with long-term financing needs that may not necessarily be met by traditional financial actors and instruments. This case can thus show whether green banks can help companies consolidate their activities and transform from niche into mainstream actors.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	This is the second case study within the pool of case studies that considers the role finance plays in shaping the conditions of possibility for decarbonisation. The role of 'green banks' is interesting not only because as banks they can create credit capital, but also because Triodos operates across a number of the REINVENT sectors, investing in agriculture, plastics-alternatives and low-carbon buildings.

Linkages to other Work Packages:	☒ WP 2 (Database) ☐ WP 4 (Scenarios) *Comments:* The Triodos Organic Growth Fund is also included in the WP2 database.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	We are currently in the process of setting up fieldwork. We will be attending two relevant events in the next few weeks which will be an opportunity to network and identify potential participants.

Innovation:	**Bioplastics**
Intervention:	**Durapulp composite material**
Initiative:	**Bioeconomy initiative**
Responsible Project Partner(s):	ULUND, IMES, Fredric Bauer
Sector:	☐ Steel ☒ Plastics ☐ Meat & Dairy ☒ Paper ☐ Cross-Sectoral
Value Stage Chain:	☒ Resource & Production ☐ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	Sweden
Short Description of Intervention:	Durapulp is a biobased cellulose fibre and polymer (poly-lactic acid) composite material for packaging, construction, as well as other types of plastic products. It is both renewable and biodegradable and is a case showing how the paper sector is expanding into new domains. The material is a result of collaboration between the Swedish firm Södra and the research institute RISE (formerly Innventia). The paper industry has invested little in innovation over a long period of time, but this innovation shows that paper industry actors can be important players for low carbon innovation beyond their traditional domain. The case allows for research on the build-up of new types of capabilities within the paper sector and collaborations between the plastics and paper sectors.
Transformative Potential	
Most Interesting Elements/Features: of Intervention:	Durapulp shows both how the paper industry can develop new capacities and capabilities to engage with the development of biobased material beyond their traditional fibre products. The material combines a biobased polymer (PLA) with cellulose fibres, a physical and knowledge-based integration of two types of materials. The material is biobased and biodegradable. It is interesting and has transformative potential in that what is traditionally a paper company moves into plastics/polymers
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: PE packaging Relative Carbon Significance: ☐ Low ☒ Medium ☐ High *Short Explanation:* Although completely renewable the polcylactide (PLA) needed for the Durapulp is commonly produced from corn which has significant associated carbon emissions. Improved practices and processes in agriculture and processing of corn to PLA may decrease the carbon footprint of Durapulp further.

Absolute Carbon Significance within Sector:	☒Low ☐Medium ☐High *Short Explanation:* This is one of many cases of new biobased plastics and composites so the case by itself has little significance. It is a small piece in a broader development of biobased plastics which is a necessary part of the transition from fossil feed-stock.
Maturity of Inter-vention:	Commercial scale production of Durapulp is available, but applications are still few. Methods are still being refined to allow for quicker and more energy efficient moulding and shaping of objects using the material. Packaging for meat products using Durapulp is being tested.
Potential for Scale up:	As knowledge about the material, its properties and possible applications diffuse the potential is large. The range of possible applications is still not known, but seems to range from single use packaging to long term construction, in which it would have a long lifetime and large volumes could be used. There are questions about the recyclability of the material (i.e., mechanical recycling).
Relevance of Inter-vention for Trans-formation of the Sector:	Although interesting, it is but one product and cannot alone transform neither the plastic nor the paper sector as a whole. The innovation is an indicator that paper sector actors are able to move beyond their traditional domain and can as such inspire others in the sector, but its direct relevance for a large transfor-mation is small. It also presents a challenge for other plastics producers to take on in terms of low carbon materials, which could potentially have an impact on their innovation strategies moving forward.
Relevance of Case Study within RE-INVENT Project	
Strategic Relevance of Case Study with-in Reivent Project and overall Pool of Case Studies:	We have concluded that decarbonisation of the paper industry is not a tremendous challenge and that it interesting to look at the emerging interventions and innovations in the bioeconomy, not least to challenge the use of fossil feedstock for plastics. It is a paper company that goes beyond its traditional domain.
Linkages to other Work Packages:	☒ WP 2 (Database) ☐ WP 4 (Scenarios) *Comments:* Durapulp is in the database. The case in itself is not highly relevant for WP4 but the idea of fossil-free materials (including plastics and paper) raises questions and challenges for WP4 in terms of volumes of and access to biogenic carbon.
Feasibility of Case Study (e.g. Access to Data, Interview-ees etc.):	Good contacts with company officials at Södra as well as at RISE are promising for conducting interviews. Other types of data are still not identified.

Appendix 3 – Paper & Pulp

Innovation:	**Biorefinery**
Intervention:	**Äänekoski bioproduct mill**
Responsible Project Partner(s):	Lund University, Fredric Bauer
Sector:	☐ Steel ☐ Plastics ☐ Meat & Dairy ☒ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	Äänekoski, Finland
Short Description of Intervention and (if possible) Initiative:	Metsä Fibre has established a new bioproduct mill on the site of a traditional pulp mill in Äänekoski. With a total investment sum of €1.2 billion, it constitutes one of the largest investments in biorefineries by the pulp and paper industry so far. The ambition is to produce a wide variety of bio-based products – from pulp, tall oil, turpentine and bioenergy in various forms to higher value products, including biocomposites and textile fibres. Many products produced at the bioproduct mill will be produced in collaboration with other firms who will set up activities at the site of the mill, creating a set-up similar to an industrial symbiosis.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	Of particular interest in this case is that the bioproduct mill has from the beginning been conceptualised as a place for collaboration between firms from many industries. The ambition of Metsä Fibre has not been to take care of all product steps on its own, but rather to invite partners with specific technical and market knowledge to co-locate at the mill site. This is also evident in the flexible approach to the products to be produced at the mill: this will partly be determined by the collaborations which are established. Metsä Fibre has also established a new innovation company, Metsä Spring, which will focus on developing new bio-based products at Äänekoski and other mills owned by the company.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Difficult to fill out since the mill is producing a portfolio of products – which will most likely be further expanded in the immediate future. Relative Carbon Significance: ☐ Low ☐ Medium ☐ High *Short Explanation:* The relative carbon significance is difficult to determine at this point, but should become more apparent during case study research.

Absolute Carbon Significance within Sector:	☐Low ☒ Medium ☐High *Short Explanation:* The mill also produces 2.4 times the energy needed to run the facility, thereby increasing the share of renewable energy in Finland by more than two percentage points.
Maturity of Case Study:	Intermediate. The mill has been inaugurated in 2017. Some production processes are up-and-running – others are not yet. E.g. a demo plant for testing the textile fibre production is yet to be established.
Potential for Scale up:	Each biorefinery is likely to be unique – however, learning from the organisational form and collaboration patterns in the case of Äänekoski can inform other parts of the industry.
Relevance of Case Study for Transformation of the Sector:	High. The pulp and paper industry has significant potential in diversifying into new product categories, which are so far fossil-based. However, this requires considerable cross-industry collaboration to bring together knowledge on products and new markets; this collaboration has so far been insufficient (Bauer et al., 2018).
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	The case is of particular interest for understanding opportunities and challenges for cross-sectoral collaboration in the bioeconomy.
Linkages to other Work Packages:	☐ WP 2 (Database) ☐ WP 4 (Scenarios)
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	On the one hand, the bioproduct mill is a very high profile project within the pulp and paper industry, which might imply that other researchers might be interested in analysing it – thus, there might be competition for access. On the other hand, it is quite well-described in industry media etc. so there is a good starting point for analysing the case. Also, an interview carried out some years ago before the investment decision was made may be of use, and can potentially be used as a starting point for contacting the core actor.

Innovation:	**Bioenergy (wood powder) as fuel for lime kiln**
Intervention:	**Investment in new lime kiln at SCA Östrand**
Responsible Project Partner(s):	ULUND, IMES, Lars J Nilsson
Sector:	☐ Steel ☐ Plastics ☐ Meat & Dairy ☒ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☐ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	Sweden
Short Description of Intervention and (if possible) Initiative:	The SCA Östrand mill in Timrå produces 420 kton bleached sulphate pulp and 90 kton CTMP annually. The new lime kiln, installed in 2011, is fired with wood powder from ground pellets (from an SCA pellets factory Bi-oNorr) and replaces two older oil fired lime kilns using 17 000 m3 of oil per year (about 46 kton CO2). The investment reduces carbon dioxide emissions by 80%. A new recovery boiler was built in 2006/2007 and at that point the idea was born to perhaps double the production in the next 10 years. The lime kiln in 2011 was built to allow for this expansion. SCA decided in 2015 to double the capacity and the expansion will be completed in 2018.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	The intervention signals the ambition to become fossil-free and it is a technically challenging intervention (to handle explosive wood powder). It is done in the context of expanding production and involves buying pellets from within the SCA-group. Wood powder firing (e.g., grinding, transport, burners, etc.) was at the time a new technology and it is interesting to study how it came about from an innovation system perspective. It is also interesting to see if/how it has spread.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Oil fired lime kiln Relative Carbon Significance: ☐ Low ☐ Medium ☒ High *Short Explanation:* Switching to wood powder as fuel for the lime kiln eliminates fossil oil use. It is also possible to switch to bio-oils (e.g., tall oil). In the case of Östrand it was an 80 % reduction in emissions. Remaining emissions are probably from oil used in the recovery boiler and possibly some support/extra for the lime kiln when needed.
Absolute Carbon Significance within Sec-	☒ Low ☒ Medium ☐ High *Short Explanation:*

tor:	The innovation is applicable to lime kilns in sulphate pulp mills with chemicals recovery process, which is only a share of the European pulp and paper industry. Primary pulp production is more common in the Nordics and less common on the continent.
Maturity of Case Study:	The lime kiln has now been in operation for seven years. At the time of installation it was a relatively new and untried technology. There is now ample experience as well as information of whether it has spread to other pulp mills. The case is sufficiently recent so that interviewees can be identified.
Potential for Scale up:	The technology can be scaled up to essentially all sulphate pulp mills in the world. However, we have no number at this time on the potential emission reductions from such a scale-up.
Relevance of Case Study for Transformation of the Sector:	Remaining fossil fuel use in the European pulp and paper industry is from producing process heat (e.g., NG based heat only boilers and CHP mainly outside the Nordics) and from remaining oil use in pulp making (e.g., for recovery boilers and lime kilns) and indirect emissions from electricity.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	It is a clear and timely case placed early in the value chain and since the intervention was in 2011 there are experiences and possibly technology diffusion to explore. It would have been interesting to have a case on fossil free process heat but high temperature heat pumps are still at the development stage and too immature.
Linkages to other Work Packages:	☐ WP 2 (Database) ☒ WP 4 (Scenarios) *Comments:* This case was not in the database and total EU emissions from lime kilns are probably relatively small. It could also be interesting to explore whether the technology has applications outside of the pulp and paper industry.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	We probably have good access through a former colleague who has worked extensively with the pulp and paper industry as well as SCA, but this remains to be explored.

Innovation:	**Dewatering in papermaking**
Intervention:	**Long Nip Press, Condebelt Press**
Responsible Project Partner(s):	Utrecht University (Ernst Worrell)
Sector:	☐ Steel ☐ Plastics ☐ Meat & Dairy ☒ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☐ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	Germany, Finland
Short Description of Intervention and (if possible) Initiative:	Water is removed in three successive steps in a paper machine in the wire, press, and dryer sections. Up to 25 times as much energy is required to remove water in the dryer section compared to the forming section. Innovation is aimed at reducing the water content before entering the dryer section. Various technologies have been developed and deployed to achieve this, of which the long nip (or shoe) press and Condebelt are currently the main examples. Future technology development is aimed at reducing the use of water (e.g. high consistency pulping), reducing water retention (in the refiner), or the long term goal of abolishing water use completely in papermaking.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	Normally, pressing occurs between two felt liners pressed between two rotating cylinders. Extended nip presses use a large concave shoe instead of one of the rotating cylinders. The additional pressing area adds dwell time in the nip and allows for greater water extraction (about 5-7% more water removal) to a level of 35-50%, reducing steam demand up to 15% (depending on e.g. the paper grade) and increasing production capacity by up to 25%. In the Condebelt process, the press cylinders are replaced by two belts, increasing the press surface considerably, resulting in savings of 15%. While the technologies have been developed in the 1980's, the applicability of the technology has increased to include more paper grades. All large paper machine suppliers (e.g. VoithSulzer, Metso) offer long nip press technology, while Condebelt technology is offered for a few paper grades by Metso. Still, there is potential for further deployment of the technologies. New initiatives of e.g. the Dutch and European paper industry have identified new drying technologies (e.g. osmotic or electro dewatering, or supercritical techniques) or replacing the use of water completely, by a medium (e.g. alcohol, supercritical CO_2) that is easier to remove (as water removal is energy intensive).
Relative Carbon Significance Compared to Reference Pro-	Reference Process/Product: Standard paper machine Relative Carbon Significance:

cess/Product:	☐Low ☒Medium ☐High Savings in energy use of up to about 15% achievable for most paper grades. If the use of water can be avoided completely, the savings will be high (in the order of 50% of paper making energy use).
Absolute Carbon Significance within Sector:	☐Low ☒Medium ☐High While the technology allows to debottleneck an existing paper machine and hence increase paper production, the absolute effect is still medium.
Maturity of Case Study:	Long nip and Condebelt press are commercially available, and offered by all major paper machine suppliers. Technology is mature. Novel dewatering (or avoiding water use) are at early R&D stages.
Potential for Scale up:	Technology is commercially available. Use of the long nip technology was limited to a few paper grades, it can now be applied for most paper grades. Condebelt drying is still only available for a few grades. Novel technologies are in R&D stage, and would need to go through the whole development cycle.
Relevance of Case Study for Transformation of the Sector:	Efficient energy use in the paper machine is essential to economically move the paper mills to non-fossil heat sources, as these will all be more costly (e.g. electric boilers, deep geothermal heat). The novel technologies would allow to not only reduce energy consumption completely, but could potentially allow paper making without heat, abolishing the need for fuel use completely.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	The long nip and Condebelt drying process have been studied a lot, but most recent innovation studies are over 10 years old. A new case study would allow to study the dynamics of technology development to full maturity for a large industrial process. Taking a more generic look at dewatering can also help to understand the dynamics of various (competing) technologies over a long time period.
Linkages to other Work Packages:	☐ WP 2 (Database) ☐ WP 4 (Scenarios)
Feasibility of Case Study (e.g. Access to Data, Interviewees):	Earlier studies are available for some of the technologies. Good access to industry, manufacturers and some of the R&D institutes.

Appendix 4 – Meat & Dairy

Innovation:	**Green Bonds**
Intervention:	**FrieslandCampina issuance of a Green Schuldschein**
Responsible Project Partner(s):	Durham University, Bregje van Veelen & Harriet Bulkeley
Sector:	☐ Steel ☐ Plastics ☒ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☐ Resource & Production ☐ Consumption & Waste ☒ Finance
Type of Intervention (Technical / Social / Political / Economic):	☐ Technical ☐ Social ☐ Political ☒ Economic
Location of Initiating Intervention:	The Netherlands
Short Description of Intervention and (if possible) Initiative:	Green Bonds are an emerging financial instrument that can be used by private and public institutions to raise finance for 'green' activities. In 2016 Dutch dairy cooperative FrieslandCampina issued a €300 million Green Schuldschein (similar to a green bond). The use of proceeds was informed by the company's 2020 Sustainability Strategy, which consists of three pillars: better nutrition for the world's consumers, a good living for our farmers, now and for generations to come. Within this case study, we focus on the third pillar; particularly the way in which the Green Schuldschein contributes to the company's goal of climate-neutral growth through funding carbon reduction measures in four of the company's processing factories. The issuance was supported by various international banks, and the intermediary Vigeo Eiris provided a second opinion that assesses the management of proceeds.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	Green Schuldscheine are still a relatively rare financial instrument, and FrieslandCampina is the first dairy company to have issued one. Furthermore, as FrieslandCampina is the fifth largest dairy company in the world and controls most of the Dutch market, it is an important player whose actions can make a substantial impact in the sector. It is thus interesting to see how successful the issuance was and whether we can expect more companies may follow in the future.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Milk/dairy products produced by other companies Relative Carbon Significance: ☒ Low ☐ Medium ☐ High *Short Explanation:* No quantified data available, but processing of milk contributes only a small percentage of total emissions in dairy value chain (estimated 70-80% of emissions are farm-based). While most likely successful in reducing emissions in processing factories, the intervention does not target greatest emission source. Furthermore, FrieslandCampina indicated that carbon reduction

	projects would have happened anyway, even without issuance of Schuldschein. Therefore, carbon impact that is there cannot necessarily be attributed to the financial innovation.
Absolute Carbon Significance within Sector:	☒Low ☒Medium ☐High *Short Explanation:* As above, the carbon significance is not quantified, accurate assessment is thus difficult. As the innovation does not target the most carbon-intensive part of the value chain, the impact is likely to be low. Nonetheless, due to the importance of FrieslandCampina within the dairy sector, the cumulative impact could potentially be 'medium'. Note: the assessment of the relative & absolute carbon significance is based on having completed the case study. Prior to conducting the case study, the expectation was that the impact could be medium-high.
Maturity of Case Study:	The case study is still ongoing, although most projects funded through the Schuldschein have been completed. Vigeo Eiris will conduct a post-issuance review later in 2018 to assess the actual use and management of proceeds.
Potential for Scale up:	Green bonds could most likely be used by other large dairy companies, as well as others in the food sector and beyond. As Green Bonds & Schuldscheine are often issued to raise tens/hundreds of millions of euros, they require a significant asset base, and are therefore likely to be unsuitable for decarbonising upstream activities in the agricultural value chain, where the asset base is more dispersed.
Relevance of Case Study for Transformation of the Sector:	Due to being one of the largest dairy companies in the world, FrieslandCampina's actions can make a real impact on the sector's emissions, as well as providing a lead that others may follow. Innovation (within for example the Multi-Level Perspective literature) is often associated with niche actors, it is therefore interesting to see what a large incumbent is doing and whether/how they have the potential to transform the sector. From the case study research we can conclude that while the intervention led to changes in technological processes, it did not alter the fundamental high-carbon aspects of the value chain, particularly farm-based methane and nitrous oxide emissions.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	This is one of two proposed case studies that considers the intersection between finance and one of the REINVENT sectors. It thus provides detailed insights into how financial innovations can contribute to decarbonisation of a particular value chain, in this case dairy. Furthermore, within the pool of meat/dairy case studies it complements the other cases by focusing on carbon reduction of existing dairy products and processes, rather than focusing on substitution of meat/dairy products.
Linkages to other	☒ WP 2 (Database) ☒ WP 4 (Scenarios)

Work Packages:	*Comments:* Part of the fieldwork has been conducted in collaboration with a member of WP4, who will follow up with FrieslandCampina to gain more insights in their impact analyses, which can then potentially feed into WP4 models. The case was also included in the WP2 database.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	Case study now completed. No access to investors in the Schuldschein was gained. Nonetheless, through interviews with a variety of other stakeholders as well as attendance at events, and review of the literature a good picture was obtained regarding the transformative impact of the case.

Intervention:	**Green Protein Alliance GPA**
Responsible Project Partner(s):	UU M. Tziva, S. Negro
Sector:	☐ Steel ☐ Plastics ☒ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☐ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☐ Technical ☒ Social ☒ Political ☐ Economic
Location of Initiating Intervention:	Netherlands
Short Description of Intervention and (if possible) Initiative:	The Green Protein Alliance (GPA) is an initiative of the Dutch plant-based protein producers' association Planeet, the Netherlands Enterprise Agency (RVO) and the private consultancy company New Foresight. It is a multi-stakeholder partnership, which consists of firms from the complete supply chain of plant-protein products, and partners including the ministry of economics and the Dutch Nutrition Center. It aims to change the protein consumption balance in the Netherlands to 50:50 protein in 2025 (plant:animal) by providing a space for sector organization activities such as setting sector-wide product standards, inspiring product development partnerships and implementing consumer awareness campaigns.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	The interesting element of the case lies in how plant-based product processing firms managed to commit governmental and independent organizations as well as firms up-stream in the supply chain, in promoting the diffusion of their products as a sustainability solution.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: meat and dairy products Relative Carbon Significance: ☐ Low ☒ Medium ☐ High *Short Explanation:* Several studies associate plant-based protein products with lower GHG emissions, relative to meat and dairy products.
Absolute Carbon Significance within Sector:	☐ Low ☒ Medium ☐ High *Short Explanation:* The GPA estimates that the goal, 50:50 (plant:animal) protein consumption, if achieved, will lead to the reduction of CO_2 emissions by 5200 kton.

Maturity of Case Study:	The GPA was founded in 2016 and has already released its first impact report. Members of the GPA have developed and implemented relevant programs.
Potential for Scale up:	The GPA has already managed to attract as members important stakeholders for the agri-food sector, including the Dutch Ministry of Economics and Nutrition Center as well as incumbent firms such as Unilever.
Relevance of Case Study for Transformation of the Sector:	The deep decarbonization of the agri-food sector requires reducing consumption of livestock products. The diffusion of a wider range of plant-based protein products could contribute to a dietary shift and disrupt meat and dairy consumption. This case contributes to understanding the opportunities and challenges for the wider diffusion of plant-based protein products in EU countries.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within Reivent Project and overall Pool of Case Studies:	Apart from the development of technological innovations, the REINVENT project aims to understand how innovations are being realized. This case provides an example of how relevant stakeholders aim to promote and widely diffuse low-carbon innovations in order to reduce the consumption of emission intensive products.
Linkages to other Work Packages:	☒ WP 2 (Database) ☐ WP 4 (Scenarios) *Comments:* The GPA is part of WP2 (database and biography).
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	Already completed – conducted more than 10 interviews with stakeholders directly involved in the development of the case and its implementation.

Innovation:	**Making plant-milk from Oats – patented enzyme process.**
Intervention:	**Oatly relables itself as a "lifestyle brand" and starts competing with dairy for the same market-share.**
Responsible Project Partner(s):	Lund University – SVET (Political Science) Ludwig Bengtsson Sonesson, Mark Cooper, Johannes Stripple
Sector:	☐ Steel ☐ Plastics ☒ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☒ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	Sweden
Short Description of Intervention and (if possible) Initiative:	Oatly, originally producers of oat milk aimed at the lactose intolerant and/or vegan market based on research at Lund University in the 1980s, made a decisive shift in 2013/14 to target the whole market for "milk" drinks and derivatives. This led to a rapid expansion of both sales and product portfolio as well as a much publicized dispute with the Swedish dairy lobby in what newspapers referred to as "the milk wars". The ensuing court case centred on Oatly's use of phrases such as "No Soy. No Milk. No Badness" in their advertising, indicating that dairy milk is inferior to oat milk due to its effect on animals and the environment. Although Oatly lost the case, it has boosted their development; they have now expanded beyond Sweden to an international market. The initiative has also spawned a counter-culture of activists and advocates who title themselves the "post-dairy generation". The key technological innovation is an enzyme, which breaks down the oats to produce a liquid substance.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	Several interesting angles; for instance, it was originally part-owned by a Swedish dairy company only to develop into their biggest competitor. The initiative has managed to gain ground against a very powerful cultural symbol like milk through effective narratives and social mobilization. It's also very intriguing that the core technical innovation has not changed since the 1980s, yet only in 2014 the company really managed to put itself on the map. It shows that while the technical process is a pre-requisite for an innovation to scale, there is also a need for a compelling transition story. It is also an interesting case because they have a very bold narrative of a "post-dairy society" and a decarbonised sector.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Milk Relative Carbon Significance: Milk 60% less CO_2-emissions (Röös 2015, p. 30) 80% less GHG (Florén et al 2013 x Confidential) ☐ Low ☐ Medium ☒ High

	Short Explanation: An independent LCA compared Oatly to conventional milk in 2015, showing a 60% decrease in CO_2-equivalent. The number used by Oatly in all their marketing is from a 2013 paper that we have yet to get access to; it seems to be an internally commissioned LCA where the details are confidential, presumably in order to protect their IP.
Absolute Carbon Significance within Sector:	☐Low ☒Medium ☐High *Short Explanation:* Dairy products are a significant share of CO_2e within the livestock sector. The carbon significance of Oatly (and similar products) within the sector depends on the rate and extent that consumers replace dairy products with plant-based products. In addition to oat drink, Oatly's product range also includes alternatives for yoghurt, cream, protein drinks, cream cheese, and ice cream; but not cheese. Given the relative carbon significance to the reference products a moderate level of adoption (25% or more) would yield significant reductions.
Maturity of Case Study:	The Oatly Oatmilk has been on the market for a long time, sold under different names since 1995 and since 2001 in grocery stores in Sweden, Finland and the UK. They have since expanded to numerous countries in the EU and have entered the US market.
Potential for Scale up:	As dairy products are consumed worldwide, the potential to scale is quite large. Barriers include: 1) a higher price, which could result in it being limited to higher income brackets short term; and 2) established consumer tastes and preferences, the durability of which is difficult to assess. Long term, scale benefits, possible removal of dairy subsidies, and shifting consumer preferences may result in a more competitive price and widespread expansion.
Relevance of Case Study for Transformation of the Sector:	High relevance. As much of the emissions from dairy are from the ruminants themselves, achieving significant CO_2e reduction within existing diary production will be difficult. While there is ongoing research seeking to reduce CO_2e from cows, the transition to oats or other plants as the basis for milk consumption offers a more immediate and deeper transition than livestock-production oriented interventions. Given the limits of existing technological interventions in livestock production, the decarbonisation of the dairy sector would seem to make a transition to plant-based milk inevitable.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within REINVENT Project and overall Pool of Case Studies:	Oatly gives the project insight into the dairy industry, which might very well be one of the most inertia-driven sectors in the project. To understand Oatly's development is to understand how powerful cultural artefacts and systems can be leveraged to promote sustainable transitions. Within WP3, Oatly is the only explicitly dairy-connected case study. It covers both production and consumption and has potential for interesting insight into financial flows due to its recent raised capital from a quasi-state owned Chinese fund.
Linkages to other	☒ WP 2 (Database) ☐ WP 4 (Scenarios)

Work Packages:	*Comments:* Was in the WP2 decarbonisation database (D2.1). There will also be an innovation biography on Oatly (D2.7). Case study research will endeavor to obtain data useful for WP4 scenarios on the meat/dairy sector.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	As Oatly's head office is in Malmö, 16 km away from Lund University, access to interviews has been easy. Visits to their production facitility will also be conducted.

Innovation:	**Cultured Meat**
Intervention:	**Memphis Meats/Mosa Meats**
Responsible Project Partner(s):	Lund, Mark Cooper; Utrecht, Richard Lane
Sector:	☐ Steel ☐ Plastics ☒ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☐ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☒ Social ☐ Political ☐ Economic
Location of Initiating Intervention:	US/Netherlands
Short Description of Intervention and (if possible) Initiative:	Cultured meat is an example of the new field of cellular agriculture of which there are two general types: (1) Tissue engineering, e.g. the production of cultured meat and leather which takes cells or cell lines from living animals and cultures these in vivo in order to produce maximum useable tissue output from minimal tissue input; (2) fermentation based agriculture e.g. the biofabrication of familiar animal products such as gelatine, egg white, collagen using non-animal inputs, typically genetically modified bacteria, algae or yeast. The first patent was filed in 1999 followed by experiments funded by NASA and by the Tissue Culture and Art Project resulting in sniff and taste tests to assess palatability in the early 2000s. 2005 and 2010 saw Dutch Ministries subsidise collaboration between the Universities of Utrecht, Amsterdam, Technical University Eindhoven and Wageningen. 2013 saw Maastricht University's Mark Post present the first lab meat burger and go on to found Mosa Meats in 2015 with Peter Verstrate (previously with Dutch sausage producer Stegeman). Early investment of €300k was provided by Google co-founder Sergey Brin. Memphis Meats was founded in 2015 by Uma Valeti, Nicholas Genovese, Will Clem and raised over $22 million in a Series A funding round with investment from Agrifood companies such as Cargill and Tyson. Several third sector organisations are supporting the development of cultured meat through awareness raising/networking: The Modern Agriculture Foundation (2014, Israel), The Good Food Institute (2016, US), Next Nature Network (2014, NL).
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	Cultured meat has the ability to address several environmental and social issues: the reduction of direct non-CO_2 greenhouse gas emissions; the reduction of land use and land use change which could reduce indirect CO_2 emissions and maintain biodiversity; reduction of both water use and freshwater pollution due to agricultural runoff and eutrophication; reduced biological risk and health concerns from the production of meat, in part through a reduced use of agricultural antibiotics; addressing animal welfare concerns through the use of fewer animals, and the maintenance of livestock diversity; and reduced food waste.

	The innovation also presents the possibility for disrupting the control of global meat production by large corporate actors through local production and diversity (think craft beer, but for meat) oriented around a circular economy model. However, current funding and organisation is structured around a Tech-sector startup model with increasing large corporate penetration and power.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Meat production Relative Carbon Significance: ☐Low ☒Medium ☐High *Short Explanation:* Assessing the potential carbon significance of cultured meat is not straightforward. Cultured meat could reduce non-CO_2 greenhouse gas emissions and reduce land use. Energy use in comparison to meat production is unclear. Tuomisto (2011) found cultured meat could produce 78-96% reduction in greenhouse gas emissions, 99% less land use, 82-96% less water use, but only 7-45% less energy use (higher than poultry). Mattock et al. (2015) & Smetana et al. (2015) found cultured meat could have a lower environmental impact than beef, but higher impact than pork, chicken and plant-based proteins.
Absolute Carbon Significance within Sector:	☐Low ☐Medium ☒High *Short Explanation:* Cultured meat is intended to offer a means to producing significant volumes of animal-based protein for human consumption without the substantial environmental and animal welfare issues associated with livestock production. Livestock production is estimated to directly contribute 9-18% of annual CO_2e emissions, 37% of methane emissions (Gaydhane et al 2018), and is a significant contributor to LULUCF emissions due to deforestation arising from the encroachment of livestock grazing. Grazing land and cropland dedicated to the production of feed represent almost 80% of all agricultural land (FAO). Demand for animal protein is projected to increase by 73% by 2050 (FAO). Replacing conventional livestock production with cultured meat therefore has a potentially high impact for significantly reducing GHGs from meat/dairy production.
Maturity of Case Study:	Cultured meat does not yet exist at market scale. In 2013, Maastricht University's Mark Post presented the first ever lab grown burger (costing £220,000). In 2017 Memphis Meats presented cultured chicken and duck (at around £15,000 per meal). Both Memphis Meats and Mosa Meats (the start-up formed by Mark Post) have a target market launch of 2020-21. Social attitudes are considered crucial to the public acceptance of cultured meat as a substitute protein source to livestock agriculture. In December 2013 the EC agreed to add cultured meat as a new technology to the process for novel food regulation. The case study will also examine recent plant-based meat-replacement products (e.g. Impossible Burger, Beyond Burger) as currently existing products that seek to imitate the taste and texture of meat.
Potential for Scale up:	Currently only a handful of start-ups are known to be working on cultured meat: Memphis Meats (US); Mosa Meats (NL); Just Inc. (US - claimed to be bringing a cultured meat product to market in 2018); SuperMeat, Future Meat Technologies & Meat the Future (All Israel); Modern Meadow (US - demon-

	strated dehydrated 'steak chips' in 2015); Finless Foods (US - cultured fish). However, the Israeli companies are expected to benefit from a recent $300 million trade deal with China, while large Agrifood producers such as Tyson are leading recent funding efforts in Future Meat Technologies and Memphis Meats. At present there exist significant economic and technological limits to scaling up this innovation, but some advocates of cultured meat have expressed the possibility of eventually replacing almost all livestock production with cultured meat.
Relevance of Case Study for Transformation of the Sector:	If successfully commercialised, cultured meat could substitute for a significant volume of meat currently produced through traditional methods. Cultured meat holds the potential for a wholesale transformation and disruption of livestock agriculture, and agricultural land use more generally. However, given the anticipated growth in demand for meat, it is also possible that cultured meat would only supply this additional demand, leaving livestock agriculture relatively unchanged.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within REINVENT Project and overall Pool of Case Studies:	A cultured meat study is relevant for three reasons: (1) Its potential to address numerous environmental and social issues through a single process shift; (2) Its importance as a background assumption in some of the modelling work informing WP 4 of the REINVENT project and its use in broader modelling work informing goal setting, carbon budgets and decarbonisation pathways; (3) the considerable funding and emphasis it is currently receiving as a potentially 'disruptive' technology make it a strategically important case to empirically address.
Linkages to other Work Packages:	☐ WP 2 (Database) ☒ WP 4 (Scenarios) *Comments:* This case study research will seek to obtain data and contribute information that would enable the incorporation of cultured meat within WP 4 scenarios.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	Access to a considerable academic literature concerning the development of cultured meat processes, technical innovations and applications, ethical and consumer concerns, social, political and legal constraints indicate the feasibility of this case study. A variety of grey literature sources, additional corporate actors and third sector organisations have been identified. However, interview access and further data may be difficult to obtain however given the commercial sensitivity of the process and lack of publicly available information. Several important industry workshops/conferences have been identified that would enable access to key interviewees (Future Food Tech events in 2018; the Good Food Conference 2018).

Innovation:	**Online Grocery platform**
Intervention:	**FarmDrop**
Responsible Project Partner(s):	Utrecht; Richard Lane
Sector:	☐ Steel ☐ Plastics ☒ Meat & Dairy ☐ Paper ☐ Cross-Sectoral
Value Chain Stage:	☒ Resource & Production ☒ Consumption & Waste ☐ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☒ Social ☐ Political ☒ Economic
Location of Initiating Intervention:	UK
Short Description of Intervention and (if possible) Initiative:	FarmDrop is an online Grocery platform founded in 2012 by ex-Morgan Stanley stockbroker Ben Pugh, along with Ben Patten (who had worked in the area of sustainable food for five years) and Kent Gowland (a university friend of Pugh's who designed and built the FarmDrop website). Pugh's avowed mission is to reconnect consumers and producers by restructuring the food supply chain. FarmDrop maintains that it removes intermediating supermarket retailers and wholesale entities, although a more accurate description would be that it replaces them with it's proprietary online platform. It aims to provide farmers and producers with a higher percentage of the retail price of the items they produce, approx 70-75% of shelf price, in comparison to at best 50% via supermarket retailers (according to FarmDrop). When launched in 2014, FarmDrop worked along a click-and-collect model with a distinct revenue split: 80%/10%/10% between those who produced the food (80 per cent), 'keepers' (10 per cent) who managed the online platform and encouraged membership, and FarmDrop (10 per cent). It has since moved to a more traditional online delivery service. Customers order online, producers then harvest the goods which are delivered to packing hubs. These goods are packaged into deliveries and droppers (delivery drivers) then deliver to customers within 19 hours of receiving the food from the farmers. FarmDrop currently serves three local areas in the UK: London, Bath and Bristol and employs 138 staff.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	Online local grocery platforms such as FarmDrop have the potential to address several environmental challenges: The reduction of direct non-CO_2 greenhouse gas emissions though the support for small-scale, organic producers less reliant upon cheap high carbon inputs; the reduction of CO_2 via the reduction of transportation emissions to local production and consumption and the use of an electric vehicle fleet (FarmDrop claims a maximum distance of 150 miles between customers and producers); the reduction of waste due to reduced transportation, minimal storage times, production impacts, and potential for reduction in post-consumer food waste due to change in relation to food production given transparency and commitment to animal

	welfare. Disintermediation and disruption of current control over the food value chain exerted by large retail organisations is the most interesting element of this innovation. However, issues around monopoly platform control (see e.g. Amazon, Uber, Google etc.) need careful evaluation.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Industrial food production and retail Relative Carbon Significance: ☒Low ☐Medium ☐High *Short Explanation (Max. 100 Words):* Relative carbon significance is related largely to a reduction in carbon emissions from two areas: ***Transportation emissions -*** Globally, transportation as a whole represents approx. only 11% of life-cycle GHG emissions for food production, so reductions here are limited. However mode of transportation is important, and the use and impact of an electric fleet by FarmDrop would need to be assessed; ***Reduced waste -*** Around 88 million tonnes of food are wasted annually in the EU, with associated costs estimated at 143 billion euros. 1/3 of all food waste occurs during the production, processing, wholesale and retail sectors amounts (FUSIONS, 2016).
Absolute Carbon Significance within Sector:	☐Low ☒Medium ☒High *Short Explanation:* Assessment of absolute carbon significance arguably revolve around broader, indirect impacts in two further areas: ***Disintermediation -*** The mission of FarmDrop is to disrupt current control of food production systems by large corporate retailers. Although not directly addressing corporate power more broadly within the system, FarmDrop presents at least the possibility to disrupt current high carbon industrial agriculture via the provision of prices for producers potentially adequate to support small-scale, organic, reduced input production; ***Transparency and consumer change -*** Could foster a transition to consumer relationship to food production resulting in lower carbon intensity diets and reduced post-consumer waste.
Maturity of Case Study:	Founded in 2012 with £750,000 raised through a crowdfunding platform and a further £500,000 backing from a number of technology entrepreneurs. FarmDrop has grown from operating only in London with 2 FarmDrops (collection hubs) in 2012, to operating in London, Bath and Bristol and by March 2017 had around 30,000 active users. FarmDrop raised £9m in series A funding in 2017, lead by Atomico (London-based VC fund started by Skype co-founder Niklas Zennstrom). FarmDrop maintains it is on track to achieve revenue of £10 million this year and 8-10 times that amount over the next three years.
Potential for Scale up:	FarmDrop itself has significant potential to scale up given its current funding levels and projected income. FarmDrop is part of a wave of organisations looking specifically to disintermediate the food production chain by replacing wholesaling and retailing organisations between producer and consumer with online platforms and click-and-collect or inline delivery services. Alternate organisations such as BigBarn (a UK based community interest company that provides both online marketplace and map of local producers) and the Open Food Network (which is an open source platform and store enabling producers to have significant autonomy, including on price setting) are similarly

	growing.
Relevance of Case Study for Transformation of the Sector:	As part of a shift towards disintermediation in the food value chain, local production and consumption and potential role in shifting dietary patterns based on a changing relationship to food production and consumption, FarmDrop and other online grocery platforms have the potential to play a role in the significant restructuring of food production and the meat and dairy sector particularly. Undermining the structural power of large corporate retailers has the potential to shift food production from the current industrial agriculture model to smaller scale producers embedded in local communities and smaller geographical regions. Local food production is not straightforwardly decarbonising, as studies of the carbon footprint concept have shown. However, broader social, environmental and potentially economic impacts (reduction in power of retailers and large-scale producers; support for increased agricultural employment in small-scale agriculture) related to a shifting relationship to food production and consumption may have wide transformative impact.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within REINVENT Project and overall Pool of Case Studies:	A study of an online grocery platform such as FarmDrop is relevant for 3 reasons: (1) Its potential to address numerous environmental and social issues through its disintermediating role; (2) Its potential role in catalysing dietary shifts through the fostering of a different relationship of consumers to food production and the food value chain as a whole - this is then applicable to WP 4 scenario modelling; (3) the broader relation to the development of 'Platform capitalism' (Srnicek, 2016), and FarmDrop's potential role in the contemporary food economy and the possibility for the platform monopolisation of control over food production.
Linkages to other Work Packages:	☐ WP 2 (Database) ☒ WP 4 (Scenarios) *Comments:* Related to WP 4 scenarios around shifting consumption patterns
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	A FarmDrop case study sits at the intersection of several literatures concerning the environmental and social impacts of local food production, such as reduction of transportation emissions, emissions from waste, restructuring food producers and production along low carbon lines. Some grey literature in the general and business press has been identified. The relatively small scale of the innovation may limit the number of interviewees available. Access to and positive reception from FarmDrop's Founder and CEO Ben Pugh is likely to be essential.

Appendix 5 – Finance

Innovation:	**Quotas and targets for climate finance activity**
Intervention:	**European Investment Bank 25% target for climate finance**
Responsible Project Partner(s):	Lund University – SVET (Political Sciece) Mark Cooper, Johannes Stripple
Sector:	☐ Steel ☐ Plastics ☐ Meat & Dairy ☐ Paper ☒ Cross-Sectoral
Value Chain Stage:	☐ Resource & Production ☐ Consumption & Waste ☒ Finance
Type of Intervention (Technical / Social / Political / Economic):	☒ Technical ☐ Social ☐ Political ☒ Economic
Location of Initiating Intervention:	European Union, based in Luxembourg
Short Description of Intervention and (if possible) Initiative:	The European Investment Bank is a European Union organisation that acts as a non-profit lending institution. EU member states are the EIB's shareholders and set the bank's broad policy goals. The bank's capital-base is around €243 billion, with annual lending around €75 billion. Approximately 90% of EIB lending occurs within the EU, with the remaining 10% across more than 100 non-EU countries. As part of the bank's Climate Strategy (2015), the EIB set a target that 25% of the bank's activity would be directed to climate-relevant projects (including both mitigation and adaptation). The target was met within its first year. The aim of studying this intervention is to understand how investment banks – both public and private – might increase their engagement with climate change to supply capital that is otherwise lacking. This includes how the EIB established the boundaries of "climate finance" as an investment category, how the EIB identifies whether particular investments qualify as climate finance, what types of investments have been made 2015-2018, and how the goals of the EIB's climate strategy might evolve. The process of identifying the role of finance in REINVENT sectors as part of the WP2 innovation database demonstrated that there are few notable cases of "innovation for finance" or "financial innovations" in REINVENT sectors. The examination of this intervention therefore also aims to identify potential opportunities and difficulties for mobilizing investment in REINVENT sectors.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	Understanding how and where public banks like the EIB are positioned in relation to their peers and the wider investor landscape is important for understanding the role of finance in innovations in REINVENT sectors more generally. There is a history of public banks such as the EIB acting as trend-setters who establish new pathways for private investors to follow. Examining how finance at the EIB connects to actual GHG mitigation outcomes is important for understanding the new phenomenon of "climate finance" and the significance of finance for successful innovations.

Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Conventional investments and loans Relative Carbon Significance: Low ☒Low ☐Medium ☐High *Short Explanation:* Assessing the relative carbon significance of finance activities requires, at minimum, comparing mitigation achieved by projects specified as using "climate finance" funds versus conventional funds. As the EIB includes both mitigation and adaptation, it is not possible to identify the relative carbon significance of this intervention before having done the case study research. The relative significance has therefore been marked as "Low" until proven otherwise. The relative carbon significance could be very low (or non-existent) if climate finance investments yield no mitigation beyond what would have otherwise occurred. The relative carbon significance could also be high if the EIB's investments enable large volumes of mitigation that would not otherwise have been possible.
Absolute Carbon Significance within Sector:	☒Low ☐Medium ☐High *Short Explanation:* The Paris Agreement identified a lack of available finance for mitigation projects as a significant constraint for achieving a low-emissions economy. The EIB and public banks are often seen as trendsetters that motivate other actors to take similar action. If other actors were to adopt similar targets for mitigation-related investment, the gap in the availability of finance to support low carbon innovation could be closed. The significance of any one initiative within the finance sector to effect significant change or carbon reductions is low given the large number of actors within the sector and the diversity of types of actors (e.g. public, private) and the geographical diversity of finance and capital markets.
Maturity of Case Study:	The EIB Climate Strategy and climate finance quota are well established. The climate strategy was established in 2015. Subsequent to meeting the 25% quota, the EIB has set a higher target of 30% for investments within the developing world. The specific processes and dynamics behind the quota, however, are dynamic and will likely continue to change.
Potential for Scale up:	There is substantial potential for scaling up this innovation. Additional public and private investors could establish quotas and targets for climate finance and there is notable interest in this issue among private European investment banks (e.g. Nordea, Rabobank). There is also substantial potential for investors to scale up their commitment by increasing the ambitiousness of their quotas and targets.
Relevance of Case Study for Transformation of the Sector:	The EIB and public banks are often seen as trendsetters that motivate other actors to take similar action. The EIB's establishment and achievement of the 25% quota may inspire other investment banks to undertake similar goals. The sector, however, is characterised by a large number of actors and light government regulation. Voluntary change such as the adoption of quotas and targets will be uneven and – based on the experience of green and ethical investment funds – may remain peripheral to the sector generally.

Relevance of Case Study within REIN-VENT Project	
Strategic Relevance of Case Study within REINVENT Project and overall Pool of Case Studies:	This case is one of two cross-cutting cases on finance. This case focuses on the role of public banks and public governance of finance for investment in climate change innovations. It is currently unknown whether there are existing connections between this case and REINVENT sectors, but this will be examined during the research process.
Linkages to other Work Packages:	☒ WP 2 (Database) ☐ WP 4 (Scenarios) *Comments:* Is in the WP2 decarbonisation database (D2.1). Identifying what data might enable finance to be analysed within WP4 or WP5 is likely to prove difficult.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	The EIB headquarters is in Luxembourg. Initial contacts with staff at the EIB have been positive, but identifying and accessing the most relevant staff within the EIB may be difficult due to the organisation's size.

Innovation:	**Fossil Free Churches (FFC)**
Intervention:	**FFC Church of Scotland, Church of Sweden, Flemish Catholic Church**
Responsible Project Partner(s):	Durham University, Bregje van Veelen & Harriet Bulkeley
Sector:	☐ Steel ☐ Plastics ☐ Meat & Dairy ☐ Paper ☒ Cross-Sectoral
Value Chain Stage:	☐ Resource & Production ☐ Consumption & Waste ☒ Finance
Type of Intervention (Technical / Social / Political / Economic):	☐ Technical ☐ Social ☐ Political ☒ Economic
Location of Initiating Intervention:	Sweden/Scotland/Netherlands
Short Description of Intervention and (if possible) Initiative:	Churches have taken the lead in the movement for divestment: approximately 30% of organisations that have committed to divestment are faith-based organisations. In this cross-cutting finance case study we will look at churches in three countries (UK, Sweden, Belgium) that have committed to go 'fossil (fuel) free'. This means that all three have committed to divesting their investments (e.g. pensions) from fossil fuels. The Church of Sweden and the United Reformed Church in Scotland made this commitment in 2015, the Flemish Catholic Church in 2017. In this comparative case study we focus on the question of where the money that has been/will be divested, will be reinvested. In particular we are interested in finding out the extent to which the REINVENT sectors feature in the churches' reinvestment strategies, and thus the potential that institutional (re)investment has in funding decarbonisation of the REINVENT sectors.
Transformative Potential	
Most Interesting Elements/Features: of Intervention/Initiative:	It is interesting that churches are at the forefront of the divestment movement. Large churches such as the Church of Sweden hold significant investments through, for example, their pension funds, and a shift in their investment strategy can thus make a significant impact. Furthermore, the churches' actions – especially with regards to reinvestment – can thus give us insight into the extent to which the wider divestment movement will impact decarbonisation of the REINVENT sectors.
Relative Carbon Significance Compared to Reference Process/Product:	Reference Process/Product: Investment strategy from other churches / investment in funds that do not explicitly exclude fossil fuels Relative Carbon Significance: ☐ Low ☒ Medium ☐ High *Short Explanation:* No quantified data available, but the shift of millions – potentially billions - of euros of investment away from fossil fuels into 'green' sectors, can poten-

	tially fund the development of a significant number of new low-carbon innovations.
Absolute Carbon Significance within Sector:	☐Low ☒Medium ☐High *Short Explanation:* In the short-term the absolute impact is likely to be small. Initial indications are that most reinvestment is directed towards the primary energy sector (e.g. renewable energy). There are signs, however, that those in the divestment movement are beginning to focus on the broader concept of carbon economies, and in the medium-long term may also redirect their investments into companies that are not involved in the primary energy sector. The 'greenness' of reinvestment is however not 100% clear, with some reinvestment going towards companies that are the most green in their sector ('best in class') even when their emissions might be high compared to other sectors.
Maturity of Case Study:	Most churches have only fairly recently committed to divestment, and not all have developed a reinvestment strategy. Thus, impact of the innovation may not be readily available. The case should be able to provide insights, however, into decision-making processes, and how churches decide to divest & reinvest.
Potential for Scale up:	Significant. The movement for divestment is growing, with an increasing number of European universities and local governments also committing to divest from fossil fuels. The question where this money is reinvested is thus very timely.
Relevance of Case Study for Transformation of the Sector:	As faith-based organisations are at the forefront of the divestment movement, this case can potentially offer significant insights into the future directions that other institutional investors may be taking.
Relevance of Case Study within REINVENT Project	
Strategic Relevance of Case Study within REINVENT Project and overall Pool of Case Studies:	This is one of two cross-cutting finance case studies. It seeks to analyse the extent to which low-carbon investment is flowing into the REINVENT sectors. The answer may provide insights into the role of new actors, forms of agency, and materiality in achieving decarbonisation in the REINVENT sectors.
Linkages to other Work Packages:	☐ WP 2 (Database) ☒ WP 4 (Scenarios) *Comments:* We will seek to develop links with WP4 in order to understand how large-scale redirection of finance from fossil-based industries to fossil free industries impacts emissions scenarios.
Feasibility of Case Study (e.g. Access to Data, Interviewees etc.):	We are currently in the process of setting up fieldwork. We have recently attended an event which has helped foster connections within Scottish churches and others working on divestment by UK churches, and to date their responses have been positive. We will liaise with colleagues in Lund to contact the Church of Sweden, and overcome any language barriers. We will

	seek to contact the Flemish churches through the Belgian eco-churches initiative. Access to data on where churches (re)invest may be difficult to obtain, but we should be able to get insights into decision-making processes.