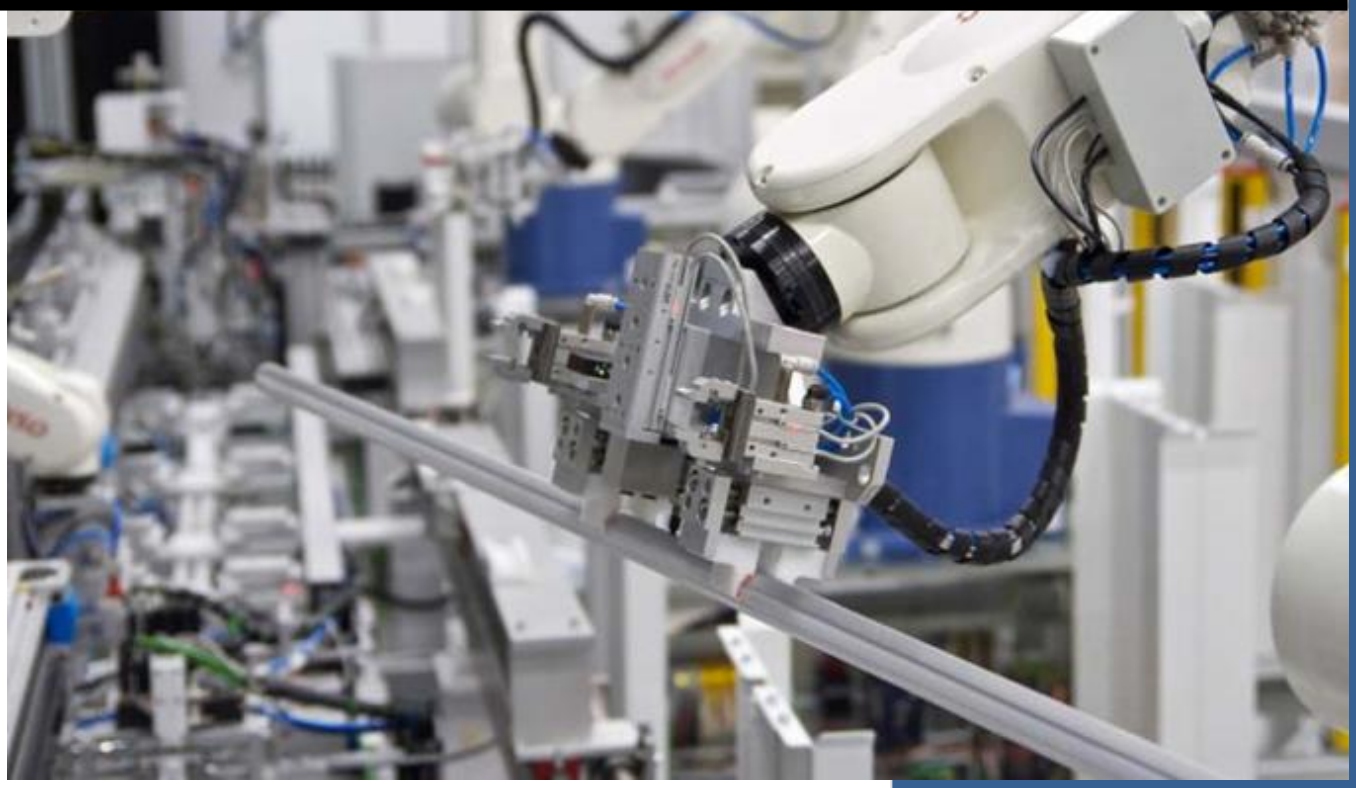
Transitioning towards a circular manufacturing industry: A mapping analysis based on the mission-oriented innovation system framework



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Contents

Management summary

The manufacturing industry is one of the sectors on which the Dutch policy development regarding circular economy is focussing. In order to obtain more insight in the functioning of the sectors innovation system in its transition towards more circularity, the concept of Mission-oriented Innovation Systems (MIS) was used as the basis for an evaluation framework.
Based on workshops and interviews with companies, an analysis was performed for OEMs, the recycling sector and several start-ups in the B2C market.

The assessment led to the observation that the creation of directionality, creation of legitimacy and coordination of activities are the largest barriers that need to be overcome in order to achieve the mission of creating a more circular economy. Furthermore, it became clear that many innovations that may be qualified as circular were the unintended outcomes of innovations of a different nature: serendipity plays an important role here, besides the disruptive consequences of digitization.

The system functions of the innovation system led to the conclusion that demand-pull policies are likely to be more effective than supply-driven routes. Market formation is an important aspect there. The government may play a stronger stimulating role in acting as launching customer or, otherwise, by clearly setting the desired direction through policies working on market-based instruments.

This analysis of the functioning of the innovation system of OEMs in the high-tech equipment sector is agrees well with the observations from almost 70 interviews with companies in this sector that were carried out in parallel projects (CESI) since 2018. Also in these interviews circularity was found to be a by-product of digital innovations. Moreover, the lack of market formation and government stimuli was often mentioned as well.

The current portfolio of the Implementation Program Circular Manufacturing Industry (UPCM) was assessed in the light of the findings of the workshops and interviews. The portfolio of projects were both of a demand-driven and supply-driven nature.

The framework of the Mission-oriented Innovation System proved to relate well to findings in the field and proved useful to investigate the balance in the portfolio of implementation programs like the UPCM.

1 Introduction

1.1 Goal

The Netherlands has started its transition to a circular economy; one characterized by more efficient resource usage and less dependency on the influx of virgin resources[1]. On a national level the goal is to be fully circular by the year 2050[2]. To provide guidance for the envisaged transition, the Dutch government, scientists and industry have jointly sketched various sector-specific transition pathways that businesses and governmental agencies can use for their circular innovation strategies. One of those sectors is the manufacturing industry, including actors using physical, mechanical or chemical methods to process goods or materials into new products.

The specific action points and milestones marking the transition paths for the manufacturing industry are outlined in the “Transitieagenda Circulaire Maakindustrie”[3]. Additionally, the Dutch government and engaged sector actors collaboratively created the “Uitvoeringsprogramma Circulaire Maakindustrie” (UPCM)[4]. The UPCM aims to give shape to the transition to a circular manufacturing industry as outlined in the Transitieagenda, through constructing roadmaps for guiding decision-making and by performing a coordinating role in e.g. knowledge-sharing activities.

Recently, the Dutch ministry of Economic Affairs and Climate Policy (EZK) expressed its demand for insight in the mission-oriented transition dynamics currently at play in the manufacturing sector. A detailed and up-to-date understanding of how the actions listed in the Transitieagenda and undertaken by the UPCM resonate in the sector, could be of significant relevance to accelerate the transition to a circular manufacturing industry. Therefore, this document presents the outcome of a series of workshops hosted by TNO and the University of Utrecht, combined with a set of interviews with the objective to map the current transition dynamics in the mission for a circular economy in the manufacturing industry. By getting relevant stakeholders to exchange their views on the current state of affairs, intervention points for accelerating the transition to circularity were identified. These (type) of stakeholders will be further introduced in section 3.

1.2 Evaluation framework

The concept of *Mission-oriented Innovation Systems* (MIS) [5,6] was used as the basis for an evaluation framework to map the different processes at play in the current innovation system. Considering an ‘innovation system’ of interacting actors and structures is relevant here, as achieving the mission for a fully circular economy

[1] https://www.rijksoverheid.nl/onderwerpen/circulaire-economie/nederland-circulair-in-2050
[2] Ministry of EZK (26-04-2019). Missies voor het topsectoren- en innovatiebeleid.
[3] https://www.rijksoverheid.nl/documenten/rapporten/2018/01/15/bijlage-6-transitieagenda-maakindustrie
[4] https://circulairemaakindustrie.nl/app/uploads/2020/02/Werkwijze-UPCM-externe-versie-20200130.pdf
[5] Hekkert, M. P., Suurs, R. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological forecasting and social change*, *74*(4), 413-432.
[6] Hekkert, M. P., Janssen, M. J., Wesseling, J. H., & Negro, S. O. (2020). Mission-oriented innovation systems. *Environmental Innovation and Societal Transitions*, *34*, 76-79.

requires collective action; it cannot be reached by a single actor alone. Actions are required by industry as well as government, scientists, NGOs and consumer organisations. Particular about a mission is that actors might unite their efforts along different possible solution paths, of a complementary or competing nature. The development and interaction of those paths is an important part of the innovation and deployment dynamics taking place in a mission-oriented innovation system. The Mission-oriented Innovation Systems framework, based on this innovation system notion, states which key processes need to be taken care of collectively, in order to achieve this mission. These processes are described in section 2.

Together the key processes cover the momentum and the alignment of the innovation strategies actors in a MIS are pursuing. As a mission-oriented innovation system emerges around problems rather than solutions, the actors playing a role in developing and diffusing innovative solutions, and the solution to the problem they pursue, can fluctuate over the duration of the mission[5]. As a result, the actors operating in a MIS are jointly searching and, as the innovation systems is maturing, deciding the most optimal innovation trajectory. For instance, in the case of circularity, we observe actors experimenting with and implementing strategies that increase the lifetime of products, components and materials leading to more intense and longer use of assets. These strategies include servitization (though e.g. product-as-a-service business models), engaging in repair and maintenance, enhanced product reuse, refurbishment, and material recycling. The route towards servitization and product-as-a-service model does not by nature lead to more circularity and less environmental impact, but they incentivise optimal reverse logistics and a redesign for total-cost-of-ownership (TCO) considerations which in turn could yield environmental benefits. Material recycling, in which waste streams are processed to capture the originally used materials, is considered a low-end strategy, leading to less value retention than strategies that maintain the entire complexity and functionality of products.

In this analysis, multiple actor groups from the manufacturing industry were included. These actors pursue different strategies that may contribute to a more circular economy. They are therefore expected to encounter different barriers in their trajectory. Due to this reason, this report is divided into two sections corresponding with strategies pursued by OEMs in the manufacturing industry and with strategies for companies in the recycling sector. All findings in this report are based on the input given by the participants in the workshops and interviews. Other actors from the sector not represented in the workshops, might hold different opinions.

2 Mission-oriented Innovation Systems

This report structures its analysis on the Mission-oriented Innovation System (MIS). As described by Hekkert et al. (2020), a MIS is defined as "*the network of agents and set of institutions that contribute to the development and diffusion of innovative solutions with the aim to define, pursue and complete a societal mission"* (page 2). This definition stresses the strong influence of institutional structures, in the form of rules and regulations, on actor's needs, abilities and opportunities. Actors like the European Commission, the Dutch ministries can thus exert influence on the dynamics in the mission-oriented innovation system through e.g. (environmental) regulations and collective agreements like the UPCM. For the scope of this analysis, in which we examine a transition sparked by the mission of reaching a 100% circular economy by 2050, the MIS is therefore very well suited as a theoretical framework.

As stated earlier, a MIS emerges around problems. Actors from either private or public domains can be engaged to experiment, develop or coordinate social and technological innovations promoting or contributing to the collectively shared goal framed as the mission. What aspects of the problem are prioritised and how the problem is translated into the mission may affect the type and number of actors involved. Actors could be engaged in the innovation system for varying reasons, like firms interested in the expected economic gains from suitable solutions, NGOs aligned with the normative values of the mission, or due to their institutional roles (like financial institutions providing capital or universities educating students).

Which solution(s), or what type of solution(s) will be used to address the problem could remain (partly) unclear in the trajectory of the MIS. Missions typically require an integration of several technological and socio-economic innovations. The interplay and coordination of these different strategies and experimental efforts is of essence in order for the MIS to take form, evolve and eventually accelerate. A MIS can thus be described as an innovation system in which policy makers, businesses, knowledge institutes and other actors aim to coordinate innovation activities, with the objective of developing a coherent set of technological, institutional and behavioural solutions tackling the problem addressed by the proposed mission [6].

To what extend the innovation system is functioning well is determined using a selection of key parameters, the system functions. Table 1 presents these system functions and briefly introduces their relevance and contribution to the Mission-oriented Innovation System[7,8]. These functions do not stand alone but interact in either positive or negative feedback loops, the so-called Innovation Motors[9]. By mapping these interactions and relations we can identify intervention points to break out of current cycles. Understanding the nature of these intervention points enables

[7] Hekkert, Negro, Heimeriks & Harmsen (2011). Technological Innovation System Analysis – A manual for analysts. Utrecht University.
[8] Elzinga, Negro, Janssen, Wesseling & Hekkert, 2020. Het Missie-gedreven Innovatiesysteem: Uitbreiding 'Technologisch Innovatie Systeem'-raamwerk ter monitoring van de Circulaire Economie. DOI: 10.5281/zenodo.4005752
[9] Suurs, R. A. (2009). *Motors of sustainable innovation: Towards a theory on the dynamics of technological innovation systems.* Utrecht University.

actors to try and redesign the current ecosystem, creating a chain reaction tackling the proposed barriers hampering the transition.

Table 1: System functions

	Function	Description
F1	**Entrepreneurial Experimentation**	Entrepreneurs are key players that turn the potential of (new) ideas into business opportunities. It is of essence that entrepreneurs' experiment with circular economy concepts in order to find out what works and what does not work and what business propositions do well in the market.
F2	**Knowledge Development**	Knowledge is needed in order to innovate. Therefore, activities that result in the creation of knowledge are fundamental in the innovation process. The function of knowledge development concerns academic research, R&D, experience-based learning and likewise activities increasing the sectors' understanding of new and circular technologies, products, services, markets regulations and consumer behaviour. To assess whether the creation of knowledge is either accelerating or hampering the transition to a circular economy, we reflect on the amount of knowledge creating activities, the level of knowledge present within the sector and potential gaps in the sectors understanding of circular economy principles and implications.
F3	**Knowledge Exchange**	In order to scale up, knowledge needs to flow. Joint projects like conferences, workshops and alliances within both sectors and supply-chain actors stimulate the exchange of knowledge. When knowledge and experiences are shared, this will boost the uptake, implementation and success rate of innovative circular principles. It is important not only for the exchange of R&D-specific or commercial knowledge (and skills) between companies, but also for the exchange of knowledge between government and the market. To assess whether knowledge sharing is a barrier in the transition to a circular economy, we examine if relevant actors manage to find each other and share knowledge and experiences that might drive the large-scale implementation of closing the loop principles.
F4	**Creation of Directionality**	How to solve a problem when the problem itself is unclear, let alone the solution to the problem? A clear vision, regarding both the shared problem to be solved and the solutions able to address it, and positive expectations about the potential of moving in a certain direction is the main aspect in this function. This key process summarises all the activities and events that convince actors to enter a certain development path, or to further invest in it. These expectations may be based on strategic outlooks, road maps, policy visions, changes in customer attitudes, and front runner strategies. Within this function we assess if there is a strong and shared problem perception that drives CE innovation and whether there are strong and shared visions related to which transition pathway to follow. Are these visions and expectations strong enough to break out of existing innovation pathways?
F5	**Market Formation**	Novel innovations in the form of products or services, need to compete with existing products currently dominating the market. These existing products already went through their learning curves and enjoy massive advantages due to perfect alignment of technological characteristics, consumer expectations and regulatory rules. The creation of temporarily protected niche markets is necessary for innovative ideas and solutions to further develop and to gain market share. Such niches can be found in specific market segments, sometimes created through supportive policies like environmental standards and by government procurement policies. Also, industry leaders can aim to create new markets through marketing and educating customers. Within this function we assess whether there is a market for innovative circular propositions and whether innovation system actors are sufficiently active to create such a market.
F6	**Resource Mobilisation**	Financial and human resources need to be allocated to the emerging trajectories in order to scale. Without these necessary resources, emerging development paths cannot take off. New (technological) solutions are in need of complementary assets, such as complementary products, services and network infrastructure which are yet to be developed. This cannot be scaled up without involving the people with the right knowledge, skill and financial funding. Within this function we assess whether innovators are able to attract sufficient financial and human capital required for implementing circular economy principles.
F7	**Creation of Legitimacy / Counteract Resistance**	In transitions based on innovation-based growth, many parties are reluctant or hesitant to change because of the perceived risks, perceived stranded assets, jeopardisation of vested interests and sometimes even simple ignorance. These conservative emotions are caused by the lock-in of existing practices. It is therefore important that actors that support the new transition pathways try to overcome this resistance to change. Therefore, this function assesses the amount of attention for actions and strategies that create legitimacy for the transition to a circular economy. Focus-points are the removal of legislative barriers and shaping attitudes of both firms and other stakeholders.
F8	**Coordination**	There is not a single pathway to reach the (circular economy) mission. Some pathways may be competing while other pathways may strengthen each other. To deal with the diversity in solutions, coordination is necessary. Through coordination, activities between different actors in the innovation system become aligned and thereby lead to acceleration. This function addresses efforts from governmental and private organisations to steer and align the various actions taken to accelerate the transition.

3 The innovation system for OEMs in the manufacturing industry

This section of the report addresses the innovation system for original equipment manufacturers (OEMs) operating in the transition to a circular economy by pursuing the high-end circular strategies. These actors are characterized by exploiting business models in which companies are responsible for their own design strategies and serve, mostly, B2B markets. Examples of the latter are business model innovations that lead to closing material loops, servitization and product reuse, repair, maintenance and refurbishment. The innovation system related to recycling of materials embedded in goods is dealt with in Chapter 5. The dynamics in that system and the role of legislation is distinctly different from the situation dealt with in this chapter.

The following analysis focusses on the firm's perspective of the transition dynamics. Therefore, the data gathered from other non-business actors is not presented in the given scores but is included when discussing system dynamics (section 4). During the workshop, the capital good supplying companies (N=8) were represented by multiple persons elaborating on the firm's perspective on the transition.

The quantitative scores for the function were obtained using questionnaires that the workshop participants completed in preparation to the workshop for the Capital Equipment Coalition. During the workshop, participants were able to verify or adjusted their given scores based on new insights or opinions stressed or gained during the workshops. Also, many participants did not fill in the questionnaire. Their opinion is also included in the qualitative part. An overview of the scores obtained from the workshops for Capital Good Suppliers firms is presented in table 2. Table 1 clearly shows that, according to the workshop participants, the creation of directionality (F4), creation of legitimacy (F7) and coordination of activities (F8) are the largest barriers that need to be overcome in order to achieve the mission of creating a more circular economy. The scores are presented as barriers. A score of 5 means a very high barrier and therefore low fulfilment of the system function; a score of 1 means a very low barrier; this implies either a well fulfilment of the system function or low importance of the system function. These scores, like all findings in this report, are based on the input given by the participants in the workshops and interviews. As stated in section 1, other actors form the sector not represented in the workshops might hold different believes.

Table 2: Scores of CE innovation system functions for High R-strategies for capital good suppliers *(1 = low barrier, 5 = high barrier).*

	Innovation System Function	Score
F1	Entrepreneurial Experimentation	2.2
F2	Knowledge Development	3.0
F3	Knowledge Exchange	3.3
F4	Creation of Directionality	4.8
F5	Market Formation	3.8
F6	Resource Mobilisation	3.1
F7	Creation of Legitimacy / Counteract Resistance	4.7
F8	Coordination	4.5

Below, each system function is elaborated upon in more detail. Reasons for the assigned scores by the workshop participants are presented per system function. Subsequently, the interplay between the functions (Innovation Motor) is discussed to display the current feedback loops in the sector. In doing so, intervention points will be identified to accelerate the transition to a more circular economy.

3.1 F1 Entrepreneurial Experimentation

The capital good suppliers who participated in the workshop do not regard *entrepreneurial experimentation* as a major barrier, nonetheless there are indications that not that many experiments are taking place. Some market leaders are setting up pilots demonstrating the value of a circular supply chain. At the moment CE is not an innovation priority. Large organisations in the sector, do undertake initiatives. However, technologies which could enable a circular economy were generally intended for other projects with alternative scopes and goals. Circular economy is often an incidental outcome of higher priority business strategies. Therefore, the full circular potential of technologies is rarely fully explored. Resources needed for circular pilots are spent in competing projects, by which circular propositions do not receive the amount of time and resources needed to scale and mature. This emanates the absence of showcases and successful examples which could inspire other actors in the sector. Overall, the combination of missing urgency and the lack of widely known examples highlights the fact that CE is not a top priority in the sector. As stated by the workshop participants: “Entrepreneurship is in our DNA, but CE just isn’t”

Even though not many experiments take place or are communicated clearly, the incumbent firms indicate that this can change rapidly when a more supportive environment for CE starts to emerge. To quote: “We want to innovate, but the ecosystem is not supportive at all”. This supportive environment is described in the other system functions.

Moreover, the participants do experiment with circular proposition in a variety of manners, but not all communicate their efforts. The current market does not favour, or even accept, solutions and products which make a first attempt to be circular but not yet fully are. Herewith, there is a lack of experimentation with “intermediate” solutions which could be used as steppingstones in order to achieve 100% circular solutions. Operating in this interplay, especially the capital good suppliers show

hesitance to openly discuss circular products and solutions as they fear mostly negative response from the market.

3.2 F2 Knowledge Development

The capital good suppliers indicate knowledge regarding technological solutions facilitating the principles of a circular economy is abundantly available within the sector. They also raise the point that knowledge created mostly addresses strategic and technological challenges. Due to the newness of the circularity concepts, knowledge creation activities focus on the first steps in a transition cycle; upcoming solutions or technologies and the corresponding strategy. Capital good supply-chain actors indicate to be well informed on the needs in current markets but do signal a lack in understanding on how to implement these new solutions, adapting the financial organisation supporting these solutions and the behaviour of consumers active in these new markets.

Even though capital good suppliers seem to have sufficient knowledge regarding the circular economy, they point out circular outcomes from knowledge development activities are often unintended outcomes. They indicate that serendipity is an important factor in CE knowledge creation. Digitization is an often-proposed example for this argument. Firms stressed the value of data regarding product location, performance and ownership for various reasons. However, this type of real-life data could also enable much-needed circular servitization business models. So, the input for a circular proposition is mostly a by-product of a project with a different focus.

3.3 F3 Knowledge Exchange

Knowledge exchange is seen as a barrier in the transition to a circular economy. The current system is unable to adequately disperse the large quantity of knowledge present in the sector.

Although the circular knowledge seems easy to codify, capital good suppliers pointed out a knowledge gap between policy makers, politicians and businesses. All parties operate within their own spectrum of activities, with related knowledge, resulting in a fragmented landscape. The knowledge flow between the sector and knowledge institutes is deemed well-coordinated by the participants. However, the communication and knowledge sharing between these other parties is considered insufficient and hampers the ability to collaborate and take collaborative action.

A second point is either the inability or unwillingness to share knowledge. Within consortia, actors show eagerness to collaborate and share knowledge with supply-chain actors, arguing this would facilitate supply-chain wide improvement and efficiency. Unfortunately, these companies noted that they are often not successful in facilitating supply-chain wide initiatives. Effective communication and collaboration among firms often only seems possible with adjacent supply-chain actors, as long and complex supply-chains make supply-chain wide collaborations very challenging.

When it comes to interactions outside the companies' own supply-chain, it is not inability but reluctance that is hampering knowledge sharing. Although circular

economy rarely enjoys the role of the main priority in the eyes of capital good suppling firms, the competitive advantage of servitization and circular value propositions is increasingly recognised. Especially among capital good suppliers, sharing company specific and valuable knowledge is often labelled as an ill-advised business practice. Therefore, companies mostly act reserved when asked to share knowledge with actors outside their ecosystem.

3.4 F4 Creation of Directionality

Directionality was scored as one of biggest barriers in the transition to a circular economy. Contradicting claims regarding both problems and solutions point at a somewhat confused and chaotic ecosystem. Businesses in the manufacturing industry do experiment, but these experiments do not add up due to poor alignment with other initiatives in the sector. On top of this, various pathways have emerged to address the same circular challenges.

Companies hold the believe that the causes underlying the lack of directionality are the conflicting messages from policymakers and academia. Research results displayed by academic research are often-times not consistent with each other. Academic institutions are a great source of input but often communicate conflicting messages. Due to the high level of legitimacy of these knowledge institutions, business action in a contradicting direction can easily be offset. Policy is no exception to this conflicting message. The sector does feel encouraged by the government to experiment and innovate with circular principles, but unfortunately indicates this support fades away when the conversation progresses towards upscaling and circularity. As much as new policies ask for circularity, old policies stimulate the principles of a linear economy. An example of the latter are the numerous plans constituted by the government to facilitate the CE. To quote a workshop participant: “these plans are great and beautiful, but they rarely guide everyday decision-making. It’s time to start putting our money where our mouth is.”

Up till now, there have not been many inspiring and tone setting pilots - light houses - illustrating the value of new solutions to the problems a circular economy aims to address due to a lack of vision. The doubt in prioritisation of the circular principles and problems results in a lack of vision driving the businesses. The wide diversity of circular strategies proposed to enable the circular economy results in unguided efforts. Capital good suppliers suggest a limitation of the possible R-strategies to pursue, by regulations or financial incentives, would unify the efforts taken to address the problem.

3.5 F5 Market formation

Market formation for refurbished, remanufactured or re-used goods strongly hampers the transition to a more circular economy. Apart from a few situations in which companies were able to meet customers’ articulated needs by providing such circular propositions, the market for this category of circular products is currently underdeveloped.

Capital good suppliers state it remains difficult to maintain on the one hand their premium quality reputations, while on the other hand finding markets for repurposed products. Especially when products cannot be brought up to quality after they have

been recollected, as closing the loop means both finding new uses (for parts and materials retrieved from recollected products) as well as new customers. An additional complication for this double challenge is that margins in markets for repurposed parts and materials are likely to be substantially lower, thereby asking a business approach significantly different from how the actors in the sector usually operate.

Looking at the demand for circular solutions, it appears difficult to translate the socio-economic benefits into financial value. Businesses struggle translating non-financial value to customers and investors and find it difficult to change the behavioural patterns and beliefs of these parties. Parties seem to misinterpret circular value propositions in both B2B and B2C markets and do not understand the benefits delivered over the entire lifecycle. Customers are expected to only base their buying behaviour on financial incentives. Under current circumstances circular propositions turn out to be generally more expensive and are therefore not favoured by the market. So, the current business models are often unable to create and capture value from the circular propositions which surpass merely financial value.

Moreover, current policy structures are unable to create the protected niche markets needed to develop innovative circular business models. An example given by a workshop participant: “bringing refurbished products to market has no use as businesses cannot deduct VAT from refurbished purchases”. Even though governmental agencies have proven to be the largest customer of circular products for a selection of the workshop participants, others state more effort of these type of actors will be needed to create competitive advantage for circular solutions in future markets. Currently, circular products (and services) are too easily outcompeted by their linear competitors, due to guidelines, regulations and investment strategies being aligned to the linear model making those products cheaper and better accessible.

Another contributing factor is the increasing competition capital good suppliers experience from Asian markets. As non-EU countries exert less strict regulation schemes for product quality, pricing can be kept significantly lower, creating an unequal playing field.

As stated above, capital good suppliers would need to redesign their business approach in order to most effectively use the low margins of circular propositions. Again, this is predominantly the case when refurbished goods are the core of the circular proposition.

3.6 F6 Mobilisation of resource

Resource mobilisation was scored as a moderate barrier in the transition to a circular economy. Resource problems do not occur in the first few stages of new product development, but start being of influence in the later stages when pilots need to be set up and scaled up. Even though there are new and emerging models, they often do not reach maturity. At those points in time, actors indicate to have a lack of human assets available to successfully bear the challenges and the financial capital to make the needed investments.

When discussing lager projects from the capital good suppliers' banks, investors and other financial institution mostly operate conservatively, due to the risk aversion embedded in the incentives they respond to. As credit and loan provision is not associated with benefitting from an investment 'upside', capital-intensive innovative trajectories do not receive the financial support they need. Therefore, larger circular innovation trajectories often come to a stance when entering the piloting and scaling phase, which are highly capital-intensive phases.

Next to financial institutions withholding support, capital good suppling companies themselves seem unwilling to invest large amounts of their own human and financial capital in circular initiatives as well. They state resources are not scarce but are spent on alternative projects. Again, circular economy is not perceived or dealt with as a priority, therewith lacking the needed resources for the more capital-intensive phases. Companies noted external funding was either from private parties or a combination of public and private sources, but never originated from public systems alone.

Although financial capital might not be limited in scarcity but in focus for capital good suppliers, *human capital* is found to be a scarce asset for capital good suppliers. Companies claim to experience fierce competition for the current talent in the market. Businesses state to have an abundance of knowledge regarding circular economy but cannot find or allocate the right people with the needed skills to implement or process this knowledge. To quote a workshop participant: "To find someone who understands the circular propositions and knows how to successfully bring them to market, while being able to navigate in the current regulatory landscape, is very challenging". That being said, it is also recognised that circular thinking is added to educational curricula. The latter might imply that by the time circular practices are taking off at a larger scale, also more suitable skilled employees able to combine these requested skills are available on the labour market.

3.7 F7 Creation of legitimacy

The *creation of legitimacy* is perceived as one of the biggest barriers for successful implementation of circular practices. Generally, service models and circular alternatives are not easily accepted by the market as the more complex nature of these business models have a stifling effect.

An important contributor to this pattern is the inability of current markets to perceive long-term benefits. Regularly, circular alternatives show lower lifecycle costs, but higher upfront investments. Customers are unaware of or cannot fully comprehend these long-term benefits. This mechanism seems to cause tension in the customers decision-making process resulting in a preference for the linear products.

Moreover, refurbished, remanufactured or re-used products often suffer from an inferior image in comparison to new products. Customers might question the quality of refurbished and repaired products and therefore avoid those products. Marketing and sales designed to convince customers on both the long-term benefits and the comparable quality standards of circular products could resolve this resistance. Examples of the latter warranty schemes or stressing total-cost-of-ownership (TCO) considerations. Apart from the small efforts of governmental

agencies in marketing projects, market actors have remained hesitant. The previously described fear of negative market response on circular products (F1), also results in the perceived lack of marketing efforts, leaving the customer unaware of circular possibilities and associated benefits.

Workshop participants did notice an increase in the frequency they are being asked to participate in governmental agenda setting discussions. Even though circular economy is receiving increasing attention at the European level and is appearing on the political agenda, this has not yet resulted in success stories and inspiring projects in the market. The workshop participants state “markets are shaped by examples, but there is currently nothing to show for”.

3.8 F8 Coordination

Coordination was scored as one of the biggest barriers in the transition to a circular economy. As there is no uniform consent on the most optimal development path, different actors in the ecosystem take up a leading role in the transition. Different parties propose alternative paths or roadmaps to a circular economy which creates misalignment and often confusion. Companies are very capable of creating good governance mechanisms within the firm boundaries, but this is much harder to do at the level of the innovation system as a whole. So far, no new sector organisations have emerged that take up this coordination role. There is a lack of public private initiatives to align activities and create a common denominator for change.

Furthermore, the workshop participants indicate a lack of leadership from governmental institutions. Directing and risk-taking actions, in line with the clear ambition of the government, have yet to be implemented. The lack of a central party pushing forward the transition, creates space for numerous initiative takers. However, these initiatives each have their own goals and methods, resulting in contradicting and confusing leadership. An example of how the government could set the standard in circular entrepreneurship, is public procurement (of innovative and/or sustainable propositions). Clearly displaying circular requirements can set industry standards, setting the desired example the industry is looking for.

An indirect form of *coordination* is leading by example. As stated above (F4), strong CE lighthouse projects that show the direction are not yet in place. While for the example of servitization, many people are familiar with hallmark cases like Rolls-Royces ‘Power by the hour’. Such examples seem to be missing for the case of circular economy practices.

4 The Innovation Motor for OEMs in the capital goods segment

4.1 Current state of the Innovation System dynamics

In this section the interplay between the different listed functions and associated barriers is discussed. As can be seen above, the current ecosystem or innovation system holds several barriers hampering the transition to a circular economy. Both entrepreneurs and the market have as of yet not shown high interest in circular propositions (Note: some innovations in the manufacturing industry that have a circular character are not identified as being circular). With a lack of both supply and demand, the sector is stuck in a catch-22 situation. There is little demand since appealing showcases are not available (or recognized as such) and therefore not many firms prioritise R&D efforts in this direction. The government is pushing hard for CE but does not follow up with a clear institutional framework that creates the right incentives for all actors in the supply chain to undertake action. The transition to CE seems to be less of a technological problem but a problem related to legitimacy of the added value of circularity in this sector. This is then translated into relatively poor directionality, market formation and coordination.

Though technological developments have initiated interesting examples of circular innovations, still many of the identified barriers are present. As such the transition to CE can be considered to still be in a nascent phase. In order to develop a strong market, it is important to build up the complete innovation ecosystem. When this is in place, often market growth follows. The innovation system is built-up by interacting system functions. This is called a System Building Motor[10] (figure 1). The interplay in functions as described within this motor starts with entrepreneurs and other actors undertaking and experimenting with innovative projects, creating strong directionality and legitimacy for this process of change. Most often this is done through pilots and showcases demonstrating new value proposition in the market (F1), communicating about these project (F4) and lobbying for necessary changes in institutional structures (the rules of the game) (F7), resources to finance innovation, and opening of markets (F5). In order to support innovation, knowledge development and exchange also play an important role (F2, F3). This whole process is accelerated when coordination and self-organisation takes place.

The above described interplay as seen in the System Building Motor does not reflect the current state of the transition as observed in the manufacturing industry. Figure 2 illustrates the presumed interplay of the system functions, based on the results obtained in the series of workshops. Both suppliers and customers are not fully convinced of the additional value of circularity. Short term economic considerations are considered more important than the longer-term gains that circular business models may deliver. There is little demand since appealing show cases are hardly available (or communicated as such) and therefore there is little incentive for firms to spend time and effort in market creating activities [-+F1→-F5, -F5→-F1]. At the same time, the government is pushing for circular initiatives, but the mixed signals in the form of the current policies and regulations that do not

[10] Suurs, R. A. (2009). *Motors of sustainable innovation: Towards a theory on the dynamics of technological innovation systems.* Utrecht University.

stimulate refurbishment nor the broad implementation of new servitization related business models have a negative effect on the entrepreneur [+-F4→-F1]. At the same time, the confusion regarding the problem at hand and the solutions to tackle the problem have a downgrading effect on the legitimacy of the circular cause [-F4→-F7]. Jointly with the inferior perception customers hold to re-used or refurbished products and the cost aspects of 'circular' services [-F5→-F7], this results in resistance hampering the entrepreneur [-F7→-F1]. Lastly, circularity requires engagement and cooperation of the entire supply-chain. Supply-chain actors, however, claim such coordinated activities are not yet possible in the current long, complex, uncooperative and fragmented supply-chain [-F8→-F1]. Moreover, entrepreneurs do not generally perceive the need for collaborations and coordination as they do not aim to deliberately experiment beyond simple business cases [F1→F8].

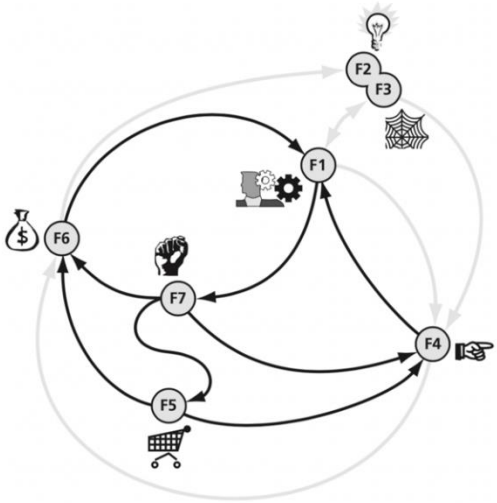

Figure 1: System Building Motor by Suurs (2009)

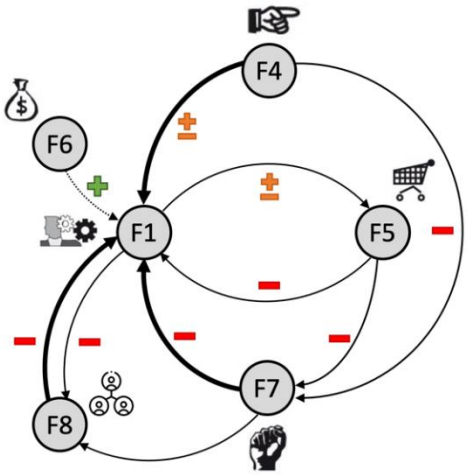

Figure 2: Presumed Innovation System dynamics based on the results obtained in the series of workshops. The bold arrows indicate the interactions most hampering the transition according to the workshop participants.

4.2 Leverage points to change Innovation System dynamics

Two types of leverage points were identified that may break the current cycle and change the Innovation System dynamics: demand driven and supply driven.

The first leverage point can be described as a demand driven leverage point (Figure 3). Capital Good Suppliers and other entrepreneurs would be strongly incentivised to experiment with circular propositions, like circular business models, when there is more clarity on which circular business models will become appealing in the future [+F4→+F1]. Therefore, the direction of change needs to become much clearer. Additionally, if the demand for these circular innovations would increase, the entrepreneur's incentive to innovate would spike [+F5→+F1]. Since it is hard for firms to create market growth in the current situation, government intervention aimed at market formation is legitimate [+F4→+F5]. In that case, CE will also receive higher prioritisation on the agenda by R&D and marketing departments.

Improved directionality and market formation will increase legitimacy [+F4→+F7, +F5→+F7] which in turn will also influence entrepreneurial action [+F7→+F1]. When entrepreneurial experimentation leads to interesting business models diffuse into the market, market formation itself will increase as well. As a result, these positive feedback loops may change the system dynamic and system change will accelerate.

The second leverage point can be described as supply driven. Two alternative supply-driven leverage points are identified.
The first variant starts with stimulating entrepreneurial experimentation through R&D policy that could result in a breakout of current patterns [F6→F1] (figure 4). Stimulating entrepreneurs through available public resources allows for the experimentation with and development of new business models. Businesses will start communicating and displaying their circular efforts and thereby provide directionality [+F1→+F4]. These tone setting projects will positively influence other entrepreneurs to start experimenting with similar propositions as well. When these experiments are tested in the market, the market itself will reform too towards circularity[+F1→+F5]. This market formation is likely to further incentivise other entrepreneurs to set up more experiments [+F5→+F1].

An alternative supply-driven leverage point also starts by allocating more resources to entrepreneurs in order to start experimenting. In this case, entrepreneurs do not want or are hesitant to clearly display their circular efforts due to the fear of negative (market) attention. Alternatively, the sector harmonises their individual actions to collectively choose the most preferable innovation pathways [+F1→+F8] (figure 5). This may be accelerated by a formal organisation that takes up this role which might evolve into advocacy coalitions performing lobby-oriented activities [+F8→+F7]. This coordinated lobby can aim to counter the current resistance in the market (as was clearly recognized in the cases where refurbished or remanufactured products were part of the circular business model) by reforming customers perspective and create directionality in the form of roadmaps to articulate coherent visions on the CE [+F7→+F4]. As described under the first leverage point, the availability of these clear visions on promising pathways may install the directionality needed to create markets, spark entrepreneurship and therewith redesign the innovation system for circularity.
Both supply-driven leverage points would profit strongly from a broader recognition of the already existing ‘circular’ experimentation and implementation of circular initiatives in the manufacturing sector. Such recognition would lead to a broader stimulus in the sector to communicate about their sustainable development direction.

Given the current state of affairs, demand-pull policies (see Fig 3) are likely to be more effective than these supply-driven routes (See Fig 4 and 5)[10]. Market formation is an important aspect there. Government may play a strongly stimulating role here in acting as launching customer or otherwise stimulating clearly the desired direction of policies by working on market-based instruments.

[10] Costantini, V., Crespi, F., Martini, C., & Pennacchio, L. (2015). Demand-pull and technology-push public support for eco-innovation: The case of the biofuels sector. *Research Policy*, *44*(3), 577-595.

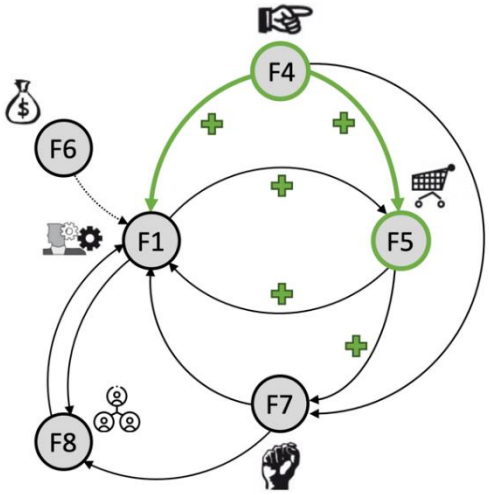

Figure 3: Demand-driven leverage point. A clear vision and directionality would result in the formation of new markets through governmental intervention.

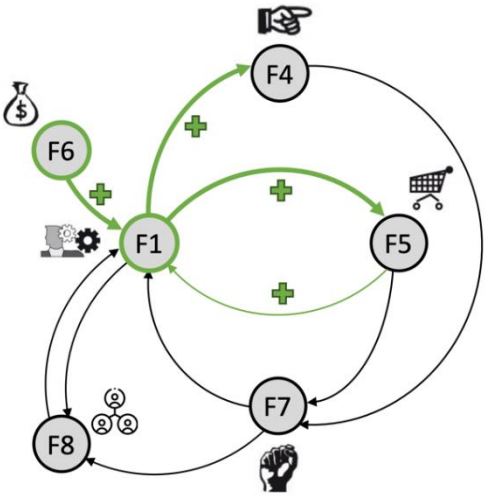

Figure 4: Supply-driven leverage point. Empowering the entrepreneur through resources will create showcases providing directionality to the innovation system.

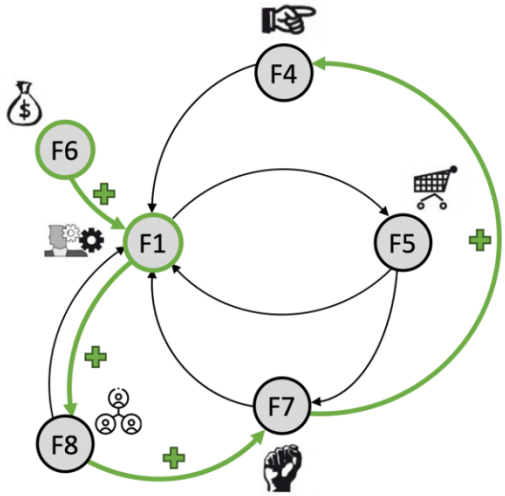

Figure 5: Supply-driven leverage point. Empowering the entrepreneur through resources would result in the formation of a coordinated lobby for circular propositions.

5 The innovation system for the recycling sector

Recycling is an essential part of a circular value chain, allowing for diminishing dependency on the influx of virgin material while reclaiming some of the original value of the wasted products.

The dynamics of this part of the materials value chain is distinctly different from the dynamics in the OEM segment. The current market is significantly formed by legislation related to waste management, and the recycling process is generally executed by non-OEMs that operate separately from OEMs. In order to understand the state of the innovation system functioning a series of interviews with Dutch recyclers and waste handlers was conducted. In preparation of the interviews, interviewees completed a similar questionnaire to the workshop participants in the previous section resulting in the quantitative scores for the Innovation system functions shown in table 3. During the interviews, participants were asked to reflect on these given scores. Table 3 shows that, according to the interviewees, resource mobilisation (F6) and the creation of legitimacy (F7) are the largest barriers that need to be overcome in order to achieve steps towards increased recycling. As stated previously, other actors from the sector not represented in the workshops might hold different beliefs.

Table 3: Scores of CE innovation system functions for recycling *(1 = low barrier, 5 = high barrier).*

	Innovation System Function	Score [11]
F1	Entrepreneurial Experimentation	2,9
F2	Knowledge Development	3,5
F3	Knowledge Exchange	3,3
F4	Creation of Directionality	2,8
F5	Market Formation	3,5
F6	Resource Mobilisation	3,9
F7	Creation of Legitimacy / Counteract Resistance	3,8
F8	Coordination	3,4

Below we discuss the identified innovation problems and their interplay with system functions.

Results

The Dutch recycling sector is well developed. A few large parties take up a central role by annually processing millions of tons of waste and providing infrastructure to redirect specific waste streams to smaller parties. Several smaller niche businesses handle specific waste streams. These actors worked on recycling for a long period of time. Therefore, a policy aiming for more circularity does align with those companies' business strategies, even though they were not inspired by the missions. Some companies formulated internal missions, which do overlap but are not based on the governmental mission for a circular economy (F4). The

[11] The scores are presented as urgent barriers; a score of 5 means a very high and pressing barrier and therefore insufficient fulfilment of the system function, a score of 1 means a very low barrier implying either a proper fulfilment of the system function or low importance of the system function.

interviewees did state these self-formulated missions do benefit from the legitimacy and directionality created by the missions set by the government and the efforts of initiatives like the UPCM.

The amounts of waste offered to waste handlers and recyclers has increased over the years due to legislations. The Dutch government has created disincentives in the form of a high levy on landfill and financial consequences for the disposal or incineration of waste[12]. In doing so, the business case for recyclers became more appealing resulting in larger quantities of waste provided to recyclers. Moreover, interviewees mention that interactions with government agencies have been established, in which challenges associated with specific waste stream can be discussed and supportive legislations enabling new business cases can be created. An example of the latter mentioned in the interviews was new and upcoming legislation in how to handle and process asbestos contaminated steal, enabling new business cases resulting in marketable secondary materials.

The products originating from the manufacturing industry mainly contain plastics, minerals and a range of metals (among which also so-called critical metals, characterized by a high economic value and a less than perfect supply security)[13]. The properties of metals make it excellent materials for recycling. With recycling rates close to 100 percent for some material streams, especially steal recyclers have developed adequate technologies to enable full material reuse. This high state of current technologies already meets the missions proposed to reach a circular economy, resulting in a low drive for entrepreneurial experimentation (F1).

However, products consisting of various types of plastics, metals and alloys are harder to recycle. Recycling actors indicated in the interviews that products from the manufacturing industry have an average recycling rate of over 80 percent. At the same time, actors state the remaining 20 percent cannot be achieved without better communication and cooperation between recyclers and producers (F2, F3, F8). To quote an interviewee: “we are literally screaming for collaborations with producers”. Products are currently not designed for recyclability and are fabricated in such ways that full material recovery is not economically viable or even physically possible. Material loss also occurs when recycling practices focus for example on the maximisation of gold extraction from wasted products and consequentially neglect other, less precious but still critical materials.

In order to boost design for recyclability, recyclers and producers would need to better align their interest. Though interests are not per se aligned[14], increased coordinated knowledge exchange might lead to initiatives in which these parties can jointly redesign products which meet consumers standards but can be fully dismantled and recycled after use. Producers have extensive knowledge on the required specifications of materials used in the production of their products, setting the quality standards recyclers have to meet in order to create a demand for secondary materials. This might improve the perception of actors on secondary materials, who currently regard circular or recycled materials to be an inferior product, as jointly created quality standards can assure the needed specifications of

[12] https://www.afvalcirculair.nl/onderwerpen/afvalregelgeving/afval-storten/bssa/
[13] Goosey, M. (2012). The materials of WEEE. In *Waste Electrical and Electronic Equipment (WEEE) Handbook* (pp. 123-144). Woodhead Publishing
[14] See: results of the AENEAS project GreenElec

recycled materials (F7). On the other hand, recyclers can inform and guide producers (in their search for alternative materials or production methods) by pointing out which alloys, material hybrids and other complex materials lead to recycling challenges and lead to further development of recycling technologies.

Next to increased sectoral collaboration and integration, interviewees stress that the market for recycled material could be boosted by legislations obliging producers to use certain amounts of secondary resources, as an alternative to virgin material in the production of new products. This again increases the need for collaboration throughout the supply-chain. As legislations regarding waste disposal strongly stimulated the supply of secondary materials, legislation increasing demand are still absent. An increased demand for secondary materials, resulting in development of the market (F5), can justify the capital-intense investments (F6) needed for innovations driving up the recycling rates in manufacturing industry.

6 The innovation system for B2C SME's

The previous chapters focussed mainly on larger and incumbent companies mostly active in the B2B (including the recycling) market. In the course of the project two start-up companies were interviewed that were actively pursuing new circular business models, also including B2C activities. These companies are initiating as-a-service business models in the consumer market. Although the number of participants in this segment is too small for an extensive analysis of the innovation system, the observations are worthwhile to report.

Results
It can be observed that the ecosystem, in which these SME's operate strongly differs from the system just described for the OEM's. Where the OEMs indicated that circularity was often a by-catch of innovations, these SME's indicated that circular propositions are at the core of their business and even the reason for their existence. In sharp contrast to the OEM's, they do communicate their circular efforts and position themselves in the market as such. In line with their circular ambitions, their more limited R&D budget is mostly deliberately allocated to the development or improvement of their circular products and services, leading to possible creation of new propositions which spark interest of capital good suppliers.

The participating start-ups have less capital-intensive trajectories than the OEMs. They indicate to receive adequate or even excessive financial support when strongly portraying the circular ambitions. Financial institutions seem very willing to invest resource in projects when framed by circular benefits and with high exposure. To quote a participant from the workshop: "it often feels like those institutions feel proud to invest in our projects". The clear marketing strategy was provided as an explanation for this observed interaction. On the contrary, they find it very challenging to source resources originating from public actors. "It is just way too complex, cumbersome and therefore time intensive". The given explanation for this is the current design of the guidelines for subsidiaries which are too much aligned with business-as-usual strategies, what might be more in favour of the incumbent actors.

On a different note, commonalities can be observed among these SME's and the OEM's. For example, the start-up companies agree with the OEMs that the lack of a uniform message regarding the benefits and hazards of innovative circular strategies of the research institutions does not lead to a feeling of direction in this field. Moreover, the absence of a clear directionality in the communication of prominent (governmental) organisations, for example in the ranging possible trajectories to persu circularity, results in uncertainty.

The circular start-ups agree with the larger OEMs that there is an abundance of technological knowledge. They however state to lack knowledge about consumer behaviour regarding circular propositions. This is in sharp contrast to the capital good suppliers who claim not to encounter such barriers. Moreover, as stated before, these start-ups do not regard circular knowledge creation as an incidental outcome, but actively pursue and engage in circular knowledge creating activities.

Like the OEM's, he participating start-ups do recognise the jeopardisation of competitive advantage associated with sharing knowledge but seem to take a more cooperative approach nonetheless. They indicated knowledge sharing events are essential in the formation of such collaborations, and that the topics with which they are dealing would deserve more attention at prominent conferences. Being president on conference agendas could spark collaboration among supply-chain actors.

The participating SME's experience similar barriers in the innovation ecosystem as OEMs. Self-evidently, the size of the operation diminishes the barriers related to financial support and the human resources aspect. But the need for a clearer direction of policies with a clearer goal and policy measures that fit these goals. The SME's indicate the margins in current markets often cannot be exploited sufficiently enough in order to be profitable, regardless of the adaptations their business models. Their circular methods mismatch with other actors in the sector, regulations in place or market preferences hamper these more disruptive innovation activities.

7 Alignment with the national program Circular Manufacturing Industry

7.1 The innovation system for OEMs in the light of CESI activities

In the period 2018-2020 almost 70 companies from the manufacturing industry have been interviewed in an attempt to discover to what extent current practices and innovations could already be regarded as a contribution to circularity and to what extent the digitization of the manufacturing industry had a decisive contribution in these innovations[15]. This set of interviews and subsequent activities (including environmental impact assessments of actual circular innovations) is known under the acronym CESI: Circular economy in the Smart Industry. Within this set of interviews there was a wide-spread in typology of companies: family owned versus public limited, SME versus very large multinationals, OEMs (Original Equipment Manufacturers) versus suppliers of components. Furthermore, the sectors to which these manufacturers supplied their goods varied as well, among others: horticulture, dairy farming, aerospace, semiconductor industry and maritime.

Regardless of this widespread typology, the general observation was that indeed digitization has an enormous role in the manufacturing processes and on the relationship with customers, enabling experimenting with and implementing business models based on deeper servitization of the customers. Examples include various forms of product-as-a-service systems enabled by sensor data and on-line monitoring of performance leading to potential preventive, predictive or condition-based monitoring. Such cases were found among companies who were aware of the framing of sustainability and circularity as well as among companies who did not use this framing as incentive. In any case, the commercial value and the business case of the innovation were the leading argument.

Given the number of observations from these interviews, it is relevant to use the reflections from these interviews in order to contribute to the findings from the workshop in which specific attention was given to the transition methodology of MIS. We will reflect on each of the MIS system functions.

F1 Entrepreneurial experimentation
It was observed (in paragraph 3.1) that circularity was often found to be “an incidental outcome of higher priority business strategies” and that innovation, adoption and scaleability was hampered by lack of widely known examples.

This is both the basic observation of the CESI program. The set of interviews showed that in principle the examples for circular activities and innovations are widely known but not always recognised and rewarded as such. Especially smaller companies (SMEs) do not have the luxury of hiring allocated personal, such as a CSR officer, as found in the companies in de Capital Equipment Coalition, who can support in identifying the circular and sustainable nature of existing innovations and

[15] These interviews were reported in several reports, focussing on companies in several provinces Gelderland, Noord-Brabant, Overijssel and Zuid-Holland. See amongst others: “Slim èn circulair : hoe de smart industry circulaire economie in de praktijk brengt -een verkenning onder Brabantse maakbedrijven”, Ton Bastein, Mario Willems (TNO) , TNO 2019 R11623, Oktober 2019

practices. Given such existing examples a wider audience and identifying them as ‘circular’ may help to overcome the barriers represented by this system function.

F2 Knowledge development:
In paragraph 3.2 it is again stated that “circular outcomes from knowledge development activities are often unintended outcomes”.

This again underscores the findings in the CESI context. Until now circularity is indeed often unintended. The question for further activities is whether intended outcomes will have greater impact, or whether making the link with circularity will help to boost uptake and upscaling.

F3 Knowledge exchange
The reported knowledge gap between business and policy makers in this field calls for a broadening of the communication about the already ongoing activities in the framework of CESI. It is partly hampered by the frequently used narrow definition of ‘circularity’ indicating only those activities that are literally framed as such and excluding activities that are deemed business-as-usual.

Furthermore, sharing data, knowledge and IP is self-evidently a difficult issue. An important topic in the ever-increasing importance of digitization and generating and exchanging data, is the inherent risk and in cases unwanted transparency of business operations that comes with it.

F4 Creation of directionality
It was stated during the workshops that the sector feels encouraged by the government to innovate with circular principles, though follow-up and upscaling is less favoured. Several interviewed partners in the CESI program have indeed acknowledged the fact that mainly in public procurement (e.g. health sector or airport management) the attention for circularity has spurred innovation in business models

F5 Market formation
Workshop participants see the lack of market incentives as a severe hampering factor in making use of refurbished goods. Though this observation is not broadly revealed in the CESI interviews (the refurbishment cases were all in commercial operation), the absence of market formation and the negative role for public procurement and financial institutions is broadly recognized. For instance, circular services cannot be easily implemented due to tendering procedures not focussing on TCO but on lowest price during tendering and not treating services and products similarly. Both municipalities and national procurement have an important role to play here.

F6 Resources
Workshop participants identify both financial but mostly human resources as hampering circular innovations. This is also revealed by CESI-interviews. Besides indeed financial barriers especially when business model changes need to be supported, companies experience barriers related to human resources. Both digitization and servitization require other competences. Scarce IT specialists need to be attracted and sales forces need to be adapted when selling services instead

of products. Furthermore, the design tools (CAD) and the design educations do not connect well with challenges that come with sustainability aspects of design.

F7 Legitimacy
The observed lack of actors in public procurement to take TCO arguments into account instead of lowest price has been mentioned before.

F8 Coordination
The CESI context shows that ‘leading by example’ is in principle possible, in case a broader perspective on circularity is chosen. The lack of leadership and direction that is mentioned among workshop participants is a natural consequence of the broad array of relevant strategies. A unique and clearly defined transition path is therefore by nature difficult to define.

It can be concluded that, broadly speaking, the workshop results with a limited number of participants representing mainly large OEMs of capital goods are in line with the observed barriers from the CESI-program. Given the much broader array of companies interviewed in that context, the similarity between observations regarding barriers and hampering innovation system functions is encouraging for the next step in this transition study: the assessment of the Innovation Motors of this system.

7.2 Alignment of projects in the Implementation Program for the Circular Manufacturing Industry (UPCM)to innovation system leverage points

The transition research primarily relates to the cluster of capital goods from the scope of the Implementation Program for the Circular Manufacturing Industry (UPCM). The additional comparison of the findings from the CESI program on the innovation functions justifies the robustness of the research for application to the UPCM.
Based on the desired transition management of the UPCM, it is particularly interesting to consider whether the programmatic approach and the underlying projects are sufficiently focused on stimulating the right innovation functions to actually accelerate the transition.

In section 4.2, an analysis was made of the possible levers to bring the transition to the next phase based on the concept of the innovation engines. Two types of levers have been identified there: demand-driven and supply-driven. The demand driven lever was mainly characterized by having a strong need for (top down) market creation, for instance through government intervention. The supply driven lever starts with enabling entrepreneurs (for instance through the availability of R&D funds) to experiment with technologies and business models and hence create directionality of the (re)search and ultimately market acceptance and market formation.

In the UPCM, attempts are made to achieve a system change through sectoral roadmaps, that contain both short and (medium) long-term activities which are coherent. To this end, so-called "decision horizons" are introduced with which the scale and complexity of the activities as well as the time period to realize them and coordinate them iteratively are mapped (see Figure 1).

Projects or trajectories cover multiple decision horizons. It is precisely from this interweaving and synchronicity that we learn about the right approach: in the short term we are working in a practical way and we connect people around themes, while we also work on knowledge development for the long(er) term.

The change strategies per decision horizon have been translated into action perspectives in the three different program pillars (Realisation, Acceleration, Broadening) to ensure a coherent working method.[16]

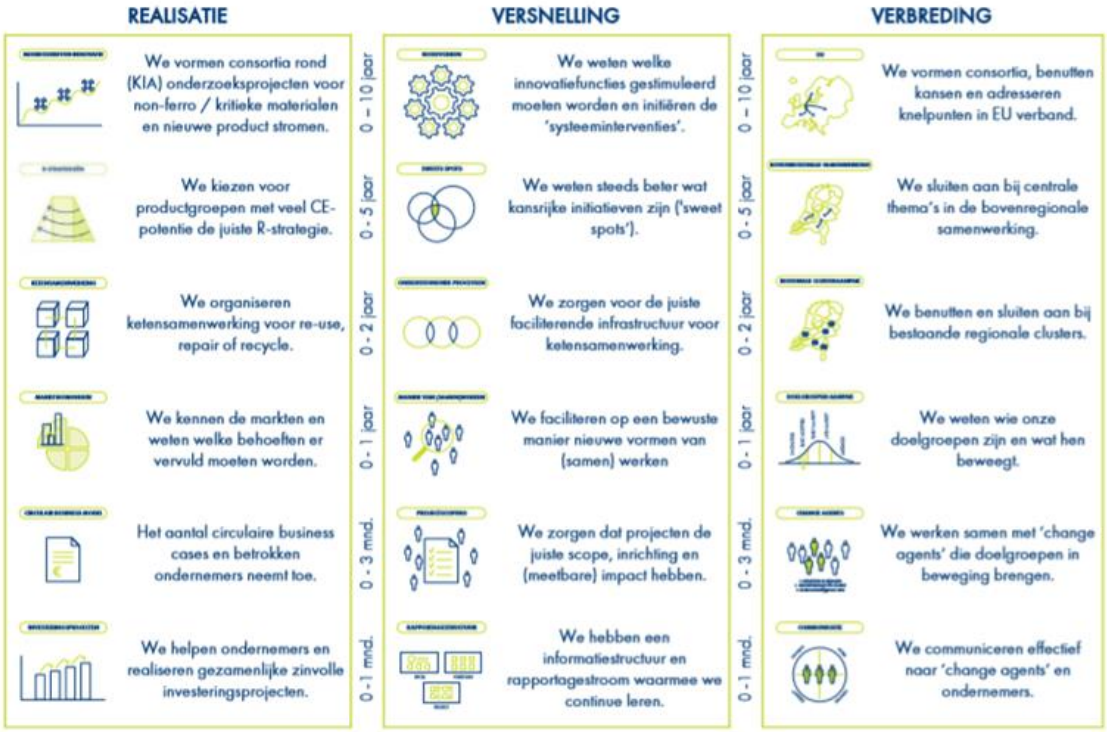

Figure 1 Roadmap structure of the UPCM

The action perspectives both on the long term decision horizons as well as on the short term decision horizons have characteristics of a supply-driven leverage point. Market formation -for instance by organising government intervention- in itself is not a focus of the activities of the UPCM.

7.2.1 Concrete projects 2021 – 2022 and innovation functions

To assess the role of projects in shaping the transition, we will assess the project portfolio that was formulated for 2021 against the transition system functions.

[16] https://circulairemaakindustrie.nl/app/uploads/2020/10/Werkwijze-UPCM-20201130s.pdf

The portfolio consisted of six concrete product-oriented projects (of which the project High Tech Equipment was not developed enough at the time of assessment) and three supportive, enabling projects.

We assessed these projects on the basis of the described interventions / system responses per lever, a + is scored if this intervention is specifically intended or identified within the project.

Table 1 Innovation system functions and the UPCM projects

	Circular wind parks	PV Systems	Heat as a service	Batteries	High Tech equipment	CESI	Material passports	Method residual value	Logistic tool
F1 Entrepreneurial Experimentation	-	+	+	+		+	-	-	-
F2 Knowledge Development	+	+	+	+		+	+	+	+
F3 Knowledge Exchange	+	+	+	+		+	+	+	+
F4 Creation of Directionality	+	-	+	-		+	+	+	-
F5 Market Formation	-	-	-	-		-	-	+	-
F6 Resource Mobilisation	Not applicable								
F7 Creation of Legitimacy / Counteract Resistance	-	-	+	-		-	-	-	-
F8 Coordination	+	+	+	+		+	+	+	+

Self-evidently, the UPCM in itself is set-up to organize coordination (with active participation of both companies and sectoral organisations and regional and national authorities), to develop knowledge and to organize exchange of knowledge to a broad group of stakeholders (witnessed amongst others by the active website CirculaireMaakindustrie.nl).
The same counts (at least for most projects) for Creation of Directionality: especially the projects with a rather wide range of participants and active stakeholders (such as CESI and Circular Wind parks) create a sense of understanding and direction for the underlying circular ambitions. The UPCM in itself engages in creating a wider and broader understanding of circularity in the manufacturing industry, thus also contributing to a creation of directionality.
The UPCM projects are not primarily geared towards (F5) Market Formation: market structuring by governments is not an element of the scope of the UPCM, nor are the marketing activities of large market structuring companies. When such activities would be supported more the UPCM could stimulate the uptake of innovation through a market-driven leverage besides the already strongly present supply driven leverage.

The energy transition of course leads to a clear direction to developments, as is clear for the Heat as a service project. Developments such as BENG (Bijna Energieneutrale gebouwen – Nearly Energy Neutral Buildings) and natural gas-free support these directions. Closer alignment with these policy directions within the UPCM project could accelerate alignment of stakeholders and the implementation of results.

The circular wind parks project has a different approach to want to steer towards system transition, for example via setting up tender criteria, thereby creating a clearer demand for (circular) wind parks.

As elaborated in the previous section, a clear picture of obstacles towards more circularity in the ‘smart’ manufacturing industry has been identified in the CESI project. Within the CESI project, the focus is now on broadening the lessons learnt from a first set of interviewed companies, thus creating a wider shared creation of directionality. Further deepening of this project, for instance around the use of big data, will lead to more entrepreneurial experimentation. This is a logical approach for this typical supply-driven acceleration.

The supportive projects dealing with implementing material passports and residual value determination are intended to contribute to a demand-driven acceleration by (co-) developing standards. A point of attention for the project dealing with material passports is the need to develop more explicit attention to the(impact on the) business case of its implementation for the manufacturing industry.

The logistics tool project has focused on knowledge access with the development of an assessment framework in line with the existing business model of a company. As a follow-up this project might look more closely into the way such projects might contribute to the levers of supply-driven acceleration.

Summarizing, it is clear that setting up the UPCM and setting up its project portfolio has the capability of stimulating an acceleration of circularity along a supply driven approach. The UPCM in principle is in the position to strengthen its impact on market driven acceleration (potentially a stronger driver for change as was discussed in chapter 4) by assessing barriers in that market formation and active communicating those barriers to authorities on regional, national and European level.