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INSPIRE
Deliverable D 3.2
Innovative business models
V 1.5

D 3.2 – Innovative business models

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Executive Summary

The focus of the INSPIRE project is the development of innovative business models for flexible, sustainable, and demand-driven manufacturing and processing. As part of the project, this document focuses on the proposal of novel and innovative business solutions to provide new opportunities for more flexible and sustainable business networks in the European process industry.

The business solutions are structured along five business model (BM) archetypes:

(1) Mass customization.
(2) Decentralised or modular production.
(3) Servitisation.
(4) Reuse and sustainability.
(5) Emerging Energy Carriers.

The methodology used regarding the development of the novel business models has two phases: (1) first phase initially checks whether the proposed business model archetype is "technically feasible" for a particular company and if feasible "how good" it is in terms of improving key performance indices for a particular company. In doing so, a list of requirements and critical factors that are relevant to the "technical feasibility" and the "additional value generated/fitness" is developed for each proposed BM archetype. The identification of such requirements and factors is based on both desk research and the feedback received from our industry partners through previous workshop and interviews, which will be further validated for Deliverable D3.3. Each factor is associated with particular objectives related with the three sustainability pillars: economic, social, and environmental. The first phase also outlines the methodology to measure the "scores" that a particular firm has for certain factors, which would yield the overall "fitness" of this business model. This model will be presented in detail in Deliverable D4.2. (2) In the second phase, challenges impeding the successful deployment of the BMs are defined as well as linked to the factors from the first phase. In order to help firms to deploy such models successfully, specific and concrete "solutions" are provided. The ultimate goal is to provide a decision support tool to help managers take some actions based on the solutions we provide in order to make sure that the scores a particular firm would have for the factors increase making the proposed business model more attractive. An overview of the methodology is depicted in Figure 1.

The set of challenges and business solutions we present here definitely is not exhaustive as there may be other specific solutions for different value chains. Our intention in this research

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is to create a general guideline for companies introducing new business models, instead of defining a specific business model case.

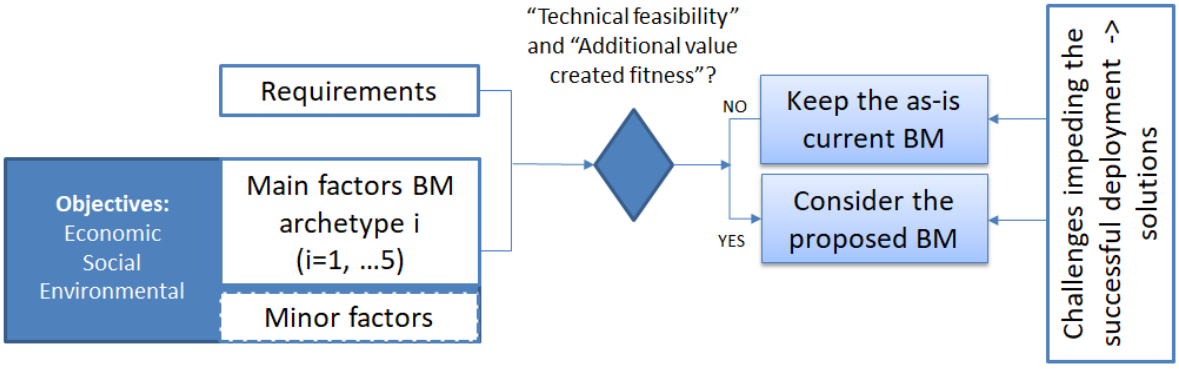

Figure 1. Methodology used in the deliverable for the definition of business solutions in each business model (BM) archetype

Table 1 presents a summary of the factors listed for the five BM archetypes (please refer to the particular BM archetype in Chapter 2 for details). The factors that are common to all archetypes are related to cost and flexibility. The other factors are focused on the customer, capabilities, risk, sustainability and corporate identity.

Factors	Mass Customization	Decentralized & Modular	Servitization	Reuse	Emerging Energy Carriers
Customer	Customer Centricity	Quality	Service Scope Definition	Market Attractiveness	
	Timely availability of material and components (lead time)	Lead time of innovation	Capabilities to deliver a *better* service		
	Market Demand	Production closer to customers			
Cost	Transportation Cost	Cost per unit of product	Profit Ratio	Profitability	Availability of electricity at low prices (from Chemical)
	Timely availability of material and components	Taking advantage of lower investment costs		Resource Consumption	Cost of flexibility (from Electricity)
		Lead time of innovation			Shortage of electricity in the market (from Chemical)

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Capabilities	Production Technologies		Capabilities to deliver a better service	Maturity of and trust in RR&S technologies	Possibilities for flexible production of energy carriers (from Chemical)
	Timely availability of material and components		Overall degree of resistance to change (agility)	Capability to organise waste collection	
	Existence of networks and collaboration				
Flexibility	Flexibility (product)	Flexibility	feedstock/capacity / location/ innovation	Feedstock /location	Need for flexibility in the grid (from Electricity)
Risk			Level of risks		
			Profit Uncertainty Ratio		
Sustainability			System sustainability improvement	Resource Consumption	
				Capability to organise waste collection	
Corporate Identity	Customer Centricity			Maturity of and trust in RR&S technologies	
				Strategic Alignment	

Table 1. Summary of the list of factors

Table 2 presents a summary of the solutions proposed for the challenges identified in the introduction of new BMs. It can be seen that most of the challenges could arise from misalignment between the product/service provider and the user, lack of a clear and well-defined scope, not clear obligations, the expectations are not properly set, the potential risks are not identified, or existing miscommunication or mistrust among the different parties. Therefore, is necessary that the parties can establish a deep trust and not a shallow confidence for a successful implementation of the different BMs for each archetype.

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Solutions	Decentralized & Modular	Emerging Energy Carriers	Mass Customization	Servitization	Reuse
Scaling	Develop franchising or production hubs	Utilize low hanging fruit	Collaborate with Fab Labs	Start with a simpler/smaller offer to start identify and build up the scope: From CPFR to VMI, following VMI plus an application, following VMI plus an application plus take-back and resell.	An existing recycling company takes on new technological solutions and build a new business model.
	micro factory retail concept	Start with pilots for energy carriers with most economic potential	Create start-ups	Start with Product-Oriented and then move to User-Oriented and Result-Oriented.	A completely new recycling company is set up to manage the new R&R opportunities.
			High customization levels through local sourcing and distribution	Have facilitators as neutral third parties to promote	
Financing	Improving the business case to achieve financing	Validate business models and cases by setting up pilots	Corroborate investment cost	Perform cost-to-serve analysis	
	Collective financing				

Table 2. Solutions for challenges that affect the introduction of new BMs

The reader can find the detailed descriptions of such solutions and ways to introduce the new business models in Chapter 2. In addition, some examples from different industries are also provided to show the impact of such "solutions" and to concretize "how" these could be implemented in the process industry in Europe.

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Chapter 1.

Introduction

This document presents a study performed by ITIA, PNO, TNO, and ZLC on behalf of the European Commission for WP3, Task 3.3 of the GA Nr. 723748- INSPIRE under H2020-IND-CE-2016-17/H2020-SPIRE-2016.

The objective of this document is to propose novel and innovative business solutions that would help remove barriers and provide new opportunities for more flexible and sustainable business networks in European process industry.

Traditionally the production industries have been dominated by the economy of scale paradigm. This has led to manifestation of large supply chains that are typically reinforcing the economies of scale-in-production for newer generations of production capacity. However, a substantial need for flexibility (or agility) is becoming obvious for many firms. We see increasing volatility in demand (e.g. due to emerging economies and urbanisation); extreme volatility in prices for feedstock and energy (e.g. due-gas, fracking and land-use competition for bio-based drop-in chemicals); shorter product life cycles driven by innovation and a continuous need to secure cash flows; increased digital connectivity that increases the speed of awareness and diffusion of innovations; and a detrimental pressure to reduce environmental footprint (COP21).

Such largely unpredictable trends call for a new paradigm in setting up or redesigning existing supply chains. Economy of scale of the production plant (pushing risk to longer logistics chains and stocks) is challenged by economical, personalised, production, distribution, use and reuse – under uncertain maybe even unknown scenarios. Optimization/Efficiency is in a way traded-off with the capabilities to mitigate risks, in order to respond to emerging changes and preparing for multiple scenarios. And this capability expands beyond the boundaries of a single organisation.

INSPIRE provides industry with options for agility. Appreciation of agility requires a mind-set in which scenario thinking, strategic options and a holistic supply chain perspective are resident. Essentially collectively preparing for different scenarios is a matter of acknowledging the risk of having to change and the risk distribution over actors in the supply chain: to organise the option to gradually increase capacity or relocate capacity; to organise

the option to tailor new products; to organise the option to replace production technology for better ones without disturbing the chain; to organise the option to reuse materials and energy; to organise the option to absorb large quantities of renewable energy when it's available.

The business solutions that we propose are to work on two levels. The first is to serve as a blueprint for changing a specific supply chain of a product for the better. One could call this 'micro-economical'. The second level is that the blueprint itself needs to be applied to many cases (supply chains) in order to be substantially effective. One could call this 'macro-economic'. The latter level implies that the proposed blueprints need to become diffused over many sectors. In that sense the innovative business models can be considered innovations in themselves.

In general, three phases of development in innovations can be distinguished (see Figure 2.): (i) innovation; (ii) adaptation and (iii) stabilization phase. The phases are defined by Ortt and Schoormans (2004) as:

i. *Innovation phase:* from invention of a technology up to the first market introduction. In this phase, research is needed to prepare for the first market introduction. For INSPIRE this is translated as: to learn from the business model archetypes that are rooted in real-life applications and developments.
ii. *Adaptation phase:* from first market introduction up to the moment that diffusion of the product takes off. This phase comprises of finding the best product-market combination, creating critical mass and establishing or creating product standards. For INSPIRE this is translated as: to reconfigure and adapt the business model archetypes to the requirements of new cases and supply chains.
iii. *Stabilization phase:* from the moment that diffusion takes off up to substitution of the technology. In this phase, the technology is scaled up. For INSPIRE this is translated as: developing an ecosystem of actors that is able to sustain large scale deployment and instantiation of the archetypes.

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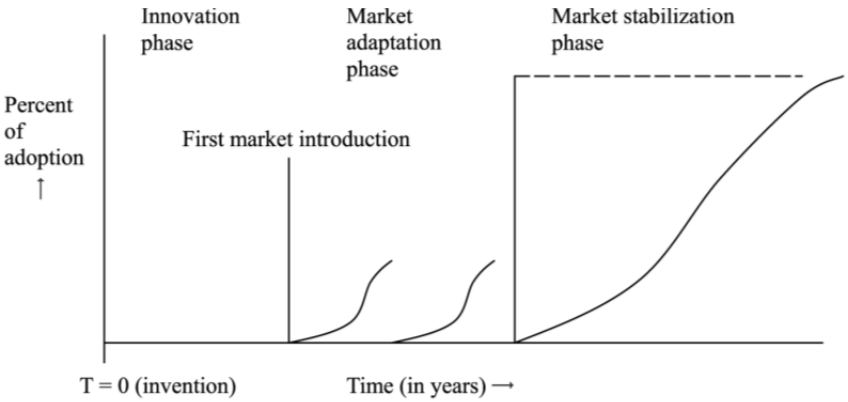

Figure 2. Three phases of the discussion process in innovation
Source: Ortt and Schoormans (2004)

During these phases, different market mechanisms apply and different business models are needed. This is illustrated by Figure 3, when time passes and the adoption rate and/or firm value changes the business model also changes.

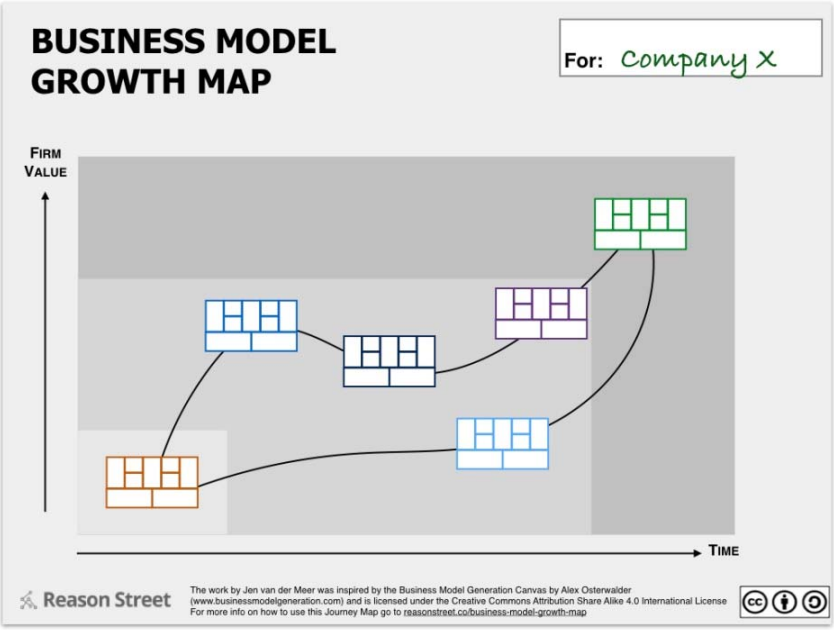

Figure 3. Business model growth map
Source: Taken from Reasonstreet[1]

[1] https://reasonstreet.co/2017/03/19/business-model-growth-map/

In this report, we will focus on business model aspects that are applicable to the different diffusion phases, but more importantly we try to derive implications for the different roles in the ecosystem for a larger scale deployment, instead of application in a single case. Please note that a new business model archetype, called the "Emerging Energy Carriers", is also considered in this deliverable in addition to the four main business model archetypes defined in the D1.2 from INSPIRE project ((i) Mass customization; (ii) Decentralised or modular production; (iii) Servitisation; and (iv) Reuse and sustainability).

We added energy carriers because majority of process industry operations are energy intensive (e.g., steel, cement) and energy costs represent a significant portion of total operational costs (e.g., 40% for steel[2]). Therefore, we believe that new business models to generate and store energy is of utmost importance and in order to ensure sustainable growth, this business model archetype is also necessary for the European process industry to consider. Consequently, we added the emerging energy carriers" to the portfolio of BM archetypes to be analyzed in the INSPIRE project

Chapter 2 discusses how the new business models could be created to ensure the development of flexible and sustainable networks. In doing so, we follow a two-phase approach. First, we list and describe factors/parameters that are critical in defining the "technical feasibility" and the "additional value created/fitness" of the proposed business model archetype. Distinguishing the factors in such a way helps companies assess the feasibility of the business model archetype before performing a detailed and expensive (cost and time) analysis of "how good" it would be for the value chain. We provide the methodology to assess the current situation for any particular business case (i.e., the scoring mechanism defined in Chapter 2 separately for each business model) that managers can use before making the decision to employ those business models (i.e., a binary decision whether to keep the as-is/current business model or the business model proposed, although we do not rule out a hybrid approach where both models are used by the same stakeholders). In addition, each factor is associated with particular objectives (economic/social/environmental) taking into account different goals different stakeholders might have and they may shift over time. In the second phase, challenges impeding the successful deployment of the business model and harming the potential positive impact for the value chain are presented, linked to the factors defined in the first phase. For each challenge business model archetype, we do present "responses" (i.e. potential solutions) and therefore offer more specific/concrete business models, guiding decision makers as to what actions can be taken to overcome these challenges and make the business models "work" in the process industry in Europe. These responses help alleviate the

[2] https://ec.europa.eu/growth/sectors/raw-materials/industries/metals/steel_en

problems that might surface due to changes in relationships, activities, responsibilities, and network structures in the value chains due to proposed business models.

The list of factors/parameters, the relative importance of each factor (i.e., the weight assigned to each factor) in determining the potential of the business model in the development of flexible/sustainable networks, related challenges leading to low scores and the proposed solutions (i.e., responses) will be first validated and then calibrated later in D3.3, based on the input from interviews/surveys with the expert groups formed in the INSPIRE project. This will feed the quantitative tool that we will develop in WP4. That will help managers make decisions to go for investments in deploying such business models, based on the methodology to calculate the "fitness index" for a particular value chain under different scenarios that the INSPIRE project will present in WP4. The ultimate goal is to develop and present novel tactics/ strategies/ mechanisms/ tools to be added to the different business model archetypes that would enable value chain stakeholders successfully implement those business models.

The description of the factors that are critical in the assessment of the feasibility and potential of the five business model archetypes, and the challenges are based on both desk research and the feedback received from our industry partners through workshops and interviews. We conclude with general insights in Chapter 3.

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Chapter 2.

Business models development

2.1. Introduction

This section presents and discuss the decision factors that need to be considered by relevant stakeholders before making the decision to employ some of the following business model archetypes:

(i) Mass customization.
(ii) Decentralised or modular production.
(iii) Servitisation.
(iv) Reuse and sustainability.
(v) Emerging Energy Carriers.

Furthermore, based on the challenges and opportunities identified in deliverable D3.1 of the INSPIRE project and the feedback from our industry partners through workshops[3] and interviews, we present novel tactics[4] to be added to the different business model archetypes to successfully implement those business models.

2.2. Mass customization business model

2.2.1. An introduction to the mass customization archetype

Mass customization consists of a combination of mass production (large batching production) with the elements of tailoring products in a way they meet each customer´s individual needs. The advantage of mass customization is the usage of mass production techniques (e.g. small number of platforms that underlie different product) to create individual products (Pine and Gilmore, 1997[5]).

[3] www.inspire-eu-project.eu/wp-content/uploads/2017/10/Deliverable-D-3.1-Report-on-Spatial-Flexibility.pdf
[4] We consider these tactics also as strategies, mechanisms or tools.
[5] https://hbr.org/1997/01/the-four-faces-of-mass-customization

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The Mass customization business model is the result of the evolution along the years of the production paradigm as it is shown in Table 3, where the most important production models are compared along the years taking into consideration some important dimensions for a business model definition. As it is possible to see, globalization and fluctuation demand of the market, including the identification of target groups at the beginning of the years 2000, brought to the identification of this new paradigm, where the production flow has been shift to design-sell-make-assemble. This shift is enabled both by digital technologies supporting different processes (configuration, design, collaboration in supply chain and with customers) as well as new reconfigurable production systems, which should overcome the flexibility.

Paradigm	**Craft production**	**Mass production**	**Flexible production**	**Mass customization**
Started	~1850	~1910	~1980	~2000
Society needs	Customized products	Low cost products	Variety of products	Customized product
Market	Very small volume per product	Demand > supply Steady demand	Supply > demand Smaller volume per product	Globalization Fluctuating demand Target groups
Production model	Pull *Sell-design-make-assemble*	Push *Design-make-assemble-sell*	Push-pull *Design-make-sell-assemble*	Pull *Design-sell-make-assemble*
Technology enablers	Electricity	Interchangeable parts	Computers	Digital technologies
Production Process enablers	Machine tools	Moving assembly line	FMS (Flexible Machine Systems)	RMS (Reconfigurable Machine Systems)

Table 3. Production process changes
Source: adapted from Boer (2007)

Figure 4 shows a traditional mass production supply chain compared to the customized production model. The most important change is the removal of warehouses and physical retailers. Customers are involved in a more and more interactive approach and they benefit from the transport on demand.

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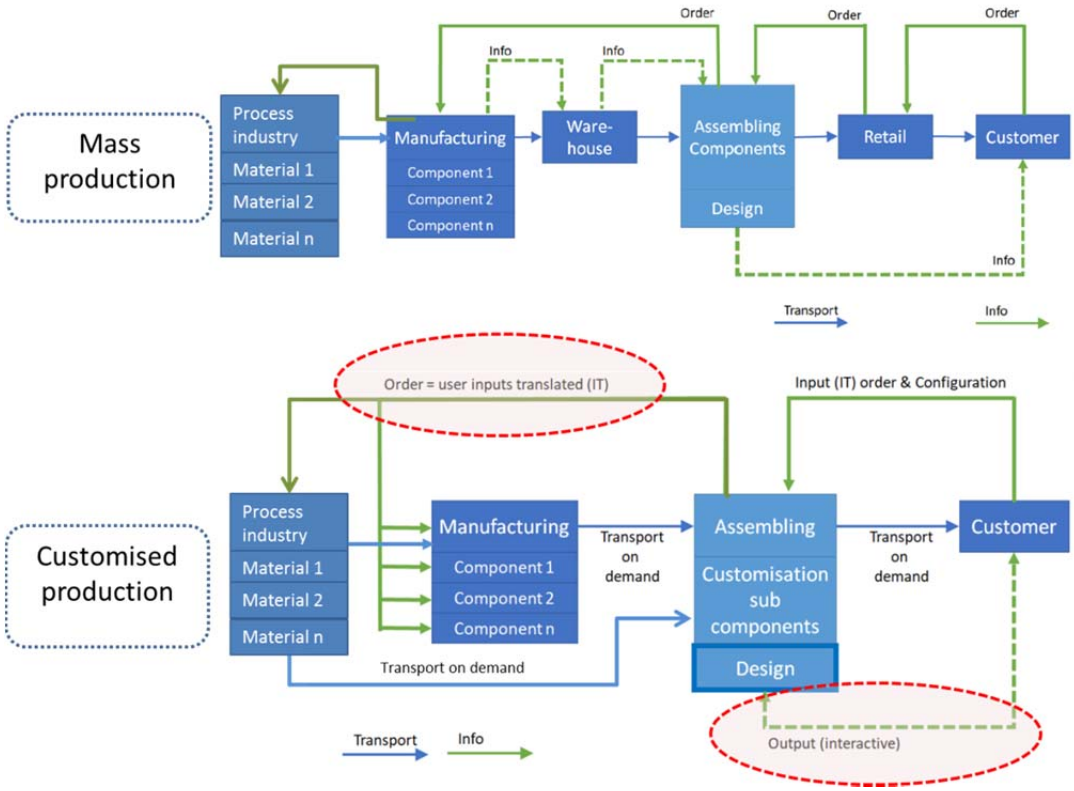

Figure 4. Transition from mass production to customized production supply chain

An increasing number of manufacturing industries and brands are adopting the business concept "Mass Customization (MC)" nowadays. This concept needs to find right fit to integrate the process industry and discrete manufacturing, taking into account the expectations of targeted customers.

Different segmentation dimensions can be taken into account in order to identify the target customers of an MC offer. Adopted elements are the same of traditional marketing approaches: age, sex, location, spending power, sector-specific categories. It is important to notice that the relevance of the segmentation elements is usually different in traditional and MC businesses (attitude toward customization is often correlated with products contexts of application, but also with the spending power). Table 4 shows some examples of MC application (Boer et al., 2013).

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Solution from pilot to large-scale application	The **mi adidas** customization initiative was structured in four sequential phases. Segmentation allowed to identify a promising market context where to test the pilot service (2001) on 300 customers from six European countries (geographical segmentation), all athletes (activity-related segmentation) interested in customizing soccer footwear (sector-specific element of segmentation). In phase 2 (late 2001), other segments were explored relaxing some of these constraints: not only athletes but any sportive customer, not only European, but also from U.S., not only soccer, but also running footwear. In phases III and IV, any kind of sport was addressed all over the world. In this case, segmentation has been thus used to approach MC gradually, starting with a test addressing the customer segment virtually more interested in product customization, then applying lessons learnt also to other segments. Usually MC initiatives start with the goal to answer to increasingly demanding customers, asking for more customized products or for a wider product portfolio.
Solution to answer to increasingly asking for more customized products or for a wider product portfolio.	**Andersen' Windows** is a U.S.-based manufacturer of windows for the home building industry. Until the mid 80s, Andersen was a mass producer of a variety of standard windows in large batches. Increasingly demanding customers forced the company to widen its product portfolio, including new product lines, new options, and a wide set of add-ins. Andersen was driven to move toward MC in order to be able to answer to changing needs of its current market segment.
Solution to grade the product with different solutions	**ChemStation** is a U.S.-based manufacturer of soap intended for industrial applications (e.g., car washes and cleaning factory floors) decided to mass customize a product that most of its competitors treat as a commodity. After analyzing each customer's needs, ChemStation custom-formulates the right mixture of soap, which goes into a standard ChemStation tank on the customer's premises. Through constant monitoring of its tanks, the company learns each customer's usage pattern and presciently delivers more soap before the customer has to ask. In this example, the co-design experience of the customer is really low: needs and expectations are gathered by the manufacturer merely analyzing its customer behavior and practices.
Solution Made-to-measure	**Bivolino** is a Belgian company producing customized shirts. Level of customization is based not only on aesthetic factors of the shirt but also on each single person measurement. The company has a smart and patented system to obtain with 4 measurements the best size for the person, or to produce made-to-measure. The company strengths are on the online configurator which is made available for shopping online as well as for other big brands willing to apply MC paradigm. The company has also a project to realize digital printing on the fabric according to the ideas collected from experts and designers and to propose this new fabric for its shirts.

Table 4. Some examples of MC application
Source: Boer et al. (2013)

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With mass customization, customers become part of the design process that enables them to get a product that meets their individual preferences. Customer interaction is in an operational scalable form and must be easy to perform and to be controlled by the company. With MC, products are not invented but configured (customized) to meet specific needs. The use of information technology and internet has enabled companies to increase the number of products offered.

Companies are becoming more and more interested in ways to exploit innovative production technologies and ICT for customization. However, it is still challenging to switch from a traditional production approach to a customized approach especially when dealing with long supply chains where customisation can impact on many different levels of the network. Traditional organizations aim to keep their costs low and maintain mass production of products; thus, they can find it difficult to compete in modern and global markets in which companies must quickly adapt to the new customized requests of their customers in order to be successful. Figure 5 shows a representation of the evolution of mass customization over the years.

Many studies have emphasised the need to re-organize internal production processes to address this customization challenge by encouraging strong monitoring of each suppliers' performance in order to provide customers with the proper quality in the proper amount of time. However, that is not enough. The performance of the entire supply chain must be strongly improved in relation to new customization strategies. In fact, although research on customization has recently advanced at company level, much work remains to be done to identify the supply-chain implications of customized productions.

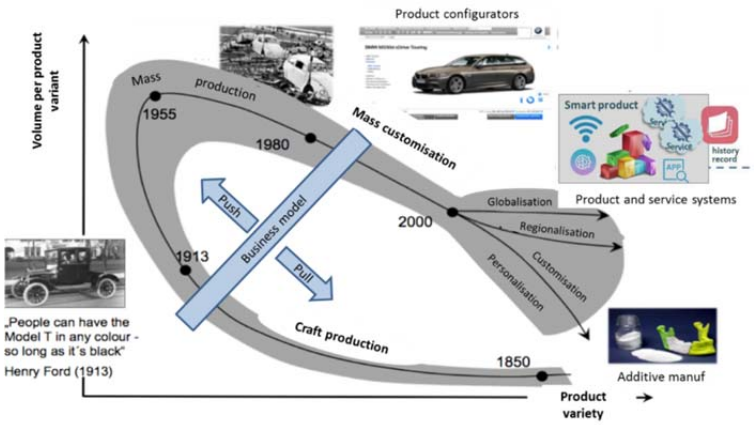

Figure 5. Mass customization along the years
Source: adaptation from Boer (2007)

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2.2.2. Requirements ensuring "technical feasibility" of the mass customization business model

In this section the main requirements (R) for the implementation of the MC business model which are necessary to be met by a company in order to decide if its adoption is feasible or not. For this reason this provides an initial diagnostic analysis to evaluate whether the MC model can be implemented:

- R1. Market demand.
- R2. Technology.
- R3. Flexibility.

R1. Market demand

- **Definition**: the demand for customized products in the market sector addressed by the company and the ability to intercept this demand
- **Why this is required**: the existence of unsatisfied customer needs for customized and personalized solutions is essential in order to undergo the business model. Moreover the company has to be able to understand the actual and future market requirement in order to adapt is value proposition. In MC it is in fact critical to capture new needs and trend thus enabling the provision of innovative, personalized products to new market niches. Moreover, customers must be able to understand the value of customization in order to appreciate and choose the provided solutions. At the same time also companies have to properly assess and evaluate the added cost of the customization to define the right price.

R2. Technology

- **Definition**: The technology needed to implement customization
- **Why this is required**: in order to adopt MC different kind of technologies are necessary all along the supply network also according to the level of customization offered by a company. Such technologies involves the different production steps and include for examples: tools to intercept customer needs, product configuration tools, collaborative design solutions, multipurpose and hybrid machines, highly reconfigurable systems, dynamic supply chain management tools, etc. The presence of small scale plants or pilots inside the company to test and realize small lots represents a plus. A company thus needs to have the financial availability to sustain these investments and be able to select, implement and properly handle the most

proper solutions. This means also that all related necessary skills have to be integrated.

R3. Flexibility

- **Definition**: flexibility in MC is referred in particular to capacity, product and innovation. Flexibility as defined in the INSPIRE project.
- **Why this is required***:* A company willing to implement MC has to incorporate different kind of flexibilities in its capabilities. *Capacity flexibility* is in fact required in order to be able to handle the production of small lots adapting to an high volatile and fragmented demand or also of one-of a kind product in case of highly personalized solutions. This is mandatory in MC in order to quickly respond to customer demand. *Product flexibility* is also a major requirement to offer a wide product range characterized by many different variants, realize it at affordable costs thanks to high reconfigurable machines and systems with reduced set-ups. Also Innovation flexibility is relevant due to the need of easily test and adopt the innovative products and processes required by customization. All these flexibilities are enabled by different factors related both to the technological and organisational levels.

2.2.3. Business model main decision factors to be considered by the relevant stakeholders

In this section, we present a number of factors (F) that are relevant in the decision making process of whether to implement the MC business model or not. The reason why they are relevant and how they impact the outcome of the MC model are detailed as well. The industry feedback during the business cases evaluation and the literature review are the main input for the following factors/parameters:

F1. Flexibility.
F2. Difficulty in identifying market demand.
F3. Customers' centricity.
F4. Logistic costs.
F5. Timely availability of materials and components.
F6. Existence of networks and collaboration.
F7. Production technologies.
F8. Manufacturing costs.

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F1. Flexibility

- **Definition**: flexibility is the ability of a company to respond to changes in its environment[6]. Flexibility has an essential role in the INSPIRE project. It relates in particular to capacity and product flexibility in case of the MC archetype.
- **Main associated criterion**: economic, social.
- **Why this is relevant**: *Capacity flexibility* allows the production of small batches of product or one-of a kind product being able to respond to customer demand. *Product flexibility* enables a producer to increase product variety at reasonable cost and thus be more responsive to customer wishes. Also Innovation flexibility is relevant due to the need to be able to easily test and implement innovative products and processes often required by customization. This calls for the availabilty of small scale plants or pilots inside the company.
- **How it impacts the uptake of the MC model**: In order to guarantee flexibility it is necessary to revise business processes under the organization and technological point of view enabling to manage the realization of small series of a high product variety.

[6] Source: http://www.economist.com/node/14298966

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- **Scoring**:

	Score	
What is the level of your company capacity flexibility for the full implementation of customization?	1	Not flexible (it is very costly to change the amount produced in each season)
	2	Rather inflexible (it is costly …)
	3	Somewhat difficult but still possible to find some solutions in the market
	4	Flexible (production system is configured so to produce different amount of products)
	5	Very flexible (no cost in changing capacity of production system)
What is the level of product flexibility of your company production system?	1	Not flexible (it is very costly to change the product)
	2	Rather inflexible (it is costly …)
	3	Somewhat difficult but still possible to adapt the system to a wider range of products
	4	Flexible (production system is configured so to produce different type of products)
	5	Very flexible (no cost in changing the type of product)
What is the level of innovation flexibility of your company production system?	1	Not flexible (it is very costly to try out new product or processes without facing relevant modification to the plant or investing in pilots)
	2	Rather inflexible (it is costly to try out new product or processes without facing relevant modification to the plant or investing in pilots)
	3	Somewhat difficult but still possible to find a way to test new products and processes
	4	Flexible (production system is able to be adapted and reconfigured to test innovative product and implement innovative processes)
	5	Very flexible (no cost in facing innovative products and processes, e.g. a pilot plants is available)

Figure 6. Scoring on flexibility for Mass Customization business model

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F2. Difficulty in identifying market demand

- **Definition:** the capability to analyze and identify the demand of all possible customers for a specific product or service over a particular period of time in a defined market.
- **Main associated criterion**: economic, social
- **Why this is relevant.** Checking and analyzing the demand behavior is important for predicting market fluctuations over time. The challenge of mass customization is linked to unpredictable and seasonal demand, which is difficult to be forecasted. This is particularly true in case of consumer goods, especially innovative and fashion products which have recently faced the need of an increased number of product variants with a dramatic reduction of products life cycle.
- **How it impacts the uptake of the MC model.** In order to make the demand of their customers more predictable companies have to consider updating their business intelligence: data mining and analysis from different sources enable to make more affordable forecasts of market needs, identify new trends and niches. Big data and data analytics offers new possibilities to retrieve and use information on customer's behaviours and wishes in order to define customization opportunities. According to this analysis is also possible to define the customization level to be adopted.

- **Scoring**:

	Score	
How difficult is it for the company to clearly define the market demand for the pool of customized product that is going to realize?	1	Very difficult (almost impossible to clearly identify a market demand)
	2	Quite difficult (demand is difficult to be investigated due to different reasons)
	3	Not so difficult
	4	Quite easy (demand is present on the market but forecasts are not affordable)
	5	Very Easy (the demand for the value proposition is clear and easily measurable)

Figure 7. Scoring on marking demand

F3. Customer centricity

- **Definition.** Customer centricity means to build the business around the customer, creating a strategic alliance with customer needs and maintaining a continuous, strong win-win relationship through different direct and indirect means.

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- **Main associated criterion**: social
- **Why this is relevant.** With mass customization, customers become part of the design and production process that enables them to get a product that really meets their individual preferences. With MC, products configured (customized) to meet specific needs. The use of information technology has made possible both an increase in the number of product variants offered by companies and the integration of customer in the different business processes.
- **How it impacts the uptake of the MC model.** Concerning internal processes, customer centricity obliges companies to rethink operations strategies in order to proactively respond to challenging market requirements with increased responsiveness, to meet customer needs in a rapid manner. Companies have to keep into account that customer's inputs are important for collection, analysis and interpretation of data to support the definition of value proposition and related manufacturing processes. For this reason a company needs to implement actions to collect his opinion, to know his preferences, to give him the possibility to design and configure the product.

- **Scoring**:

	Score	
How easy is it to integrate (increase customer involvement) in supply chain activities such as design/production/distribution?	1	Not at all central (almost impossible to create a link with him)
	2	Rather difficult to have him central (difficult to create a link)
	3	Quite possible (the company is able to involve the customer only partially is some specific)
	4	Quite easy (the company has started to implement actions)
	5	Extremely easy (the company has implemented actions to collect his opinion and feedback)

Figure 8. Scoring on Customer Centricity

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F4. Logistics costs

- **Definition.** Two factors impact the BM in terms of logistics costs: they are transportation and inventory. Transportation costs refer to the expenses involved in moving products or assets to a different place, which are passed on to another company or the final customer. Industrial companies daily manage outbound and inbound processes.. Inbound logistics refers to the incoming flow of raw material and parts, from suppliers and subcontractors. Outbound logistics relates to warehousing, packaging and transporting of finished goods or product to the customer of the organization.
- **Main associated criterion**: economic, environmental
- **Why this is relevant.** An essential trade off in MC is represented by the maximization of reliability and efficiency of supply networks and the minimization of related transport and storage costs. The need for *transport on demand* is a key enabler for MC: the new supply chain model enabling customized production highlights the need of *transport on demand* twice: both in the upstream and downstream. In fact, in order to have small and less costly warehouses, it is important to keep under control inbound logistic since the number of raw materials and components can increase affecting the transportation and stocking costs.
  Since deregulation of the transportation industry, shipping costs have had more impact on total purchase costs than in the past (Pooler et al, 2004). In this context, applying MC can be critical, mainly for companies managing high volumes of customers and high variety of product/services. The delivery cost of final products to the customer is deeply affecting MC due to the increasing demand for even shorter times and new logistics means, positioning delivery centers closer to the customer (like Amazon lockers) or defining new delivery means (bikes, drones, etc.). Because of the increased number of SKUs and difficulty in forecasting demand for these, there would also be more problems with over/under supply, obsolete products as products are customized and cannot be sold to different customers easily, etc.
- **How it impacts the uptake of the MC model.**, the increasing number of variants related to diversified production of MC leads to increasing internal and external transports.
  Companies, that find it difficult to adapt their internal transports for MC implementation, are suggested to outsource the logistics management. Nowadays transport companies have modern technologies able to manage small batches with smart transportation and inventory. For example Amazon, even if not producing customized goods, need customized delivery: its winning strategy relies on transport companies managing different types of product and trajectories that can

easily enable economy of scale and scope, with a "less negative" environmental impact.

- **Scoring**:

	Score	
Is your company logistics ready for customization?	1	Not at all (almost impossible to manage customized transportation)
	2	Rather difficult to adapt it to MC
	3	Quite possible to adapt it to MC
	4	Easy to manage MC
	5	Extremely easy to adopt to this archetype

Figure 9. Scoring on logistics cost

F5. Timely availability of materials and components

- **Definition:** Raw materials or substances used in the primary production or manufacturing of goods and components need to be available when necessary during the production process along all the supply chain.
- **Main associated criterion**: economic
- **Why this is relevant:** MC strategy stresses the need of having raw materials and components available at the right place when necessary. Managers have to consider whether specific raw materials for new technologies (such as 3D printing) exacerbate this issue due to their intrinsic nature and availability. Moreover due to the increased variety of products in terms of variants and colors, also an increased range of raw materials has to be considered. The management of required raw material will get more complex as a consequence of scattered production sites to meet customized product demand; this requires a better raw materials' sourcing. This calls for an integrated supply chain where upstream partners are able to manage small orders and timely delivery them according to flexible planning.
- **How it impacts the uptake of the MC model:** To achieve material availability at point of use, some issues are relevant: appropriate planning methods; material supply system; recovery plans. This factor is particularly crucial when process and discrete manufacturing need to be integrated in order to realize specific components. In particular, the new scheme for mass production needs improved information sharing and real time evaluations.

- **Scoring**:

	Score	
Does your company have timely access to the right materials and components for customisation?	1	Not at all (almost impossible to manage customized transportation)
	2	Rather difficult ....
	3	Quite possible
	4	Rather easy ....
	5	Extremely easy (....)

Figure 10. Scoring on timely availability of materials and components

F6. Existence of networks and collaboration

- **Definition:** This factor refers to the need for the creation of networks where collaboration of different actors along the supply chain as well as coordination of their activities is assured in order to improve synchronization and integration.
- **Main associated criterion**: economic
- **Why this is relevant:** Applying MC means not just to modify internal company processes, but also transforming the entire supply network. A networked approach is in fact essential in MC in order to be flexible, fast and sustainable in the long term, thanks to the integration of the most suitable partners and suppliers. From upstream to downstream, networking is important:
  - ✓ to guarantee the availability of materials and components suppliers able to provide resources on time
  - ✓ to rely on a transport company that is able to provide the products where and when required
  - ✓ to establish a long-term relationship with customers that will regularly buy products from your company only. This is even a way to reduce the volatility and control the seasonality of the demand. This is relevant both in the B2B and in the B2C scenarios, in particular when addressing individual customers (e.g., Dell's customers configuring laptops online). Due to the rise of new addictive manufacturing technologies, customers can become part of the production process themselves, realizing with their own 3D printing machines customized product simply purchasing the specific source code from the company. Thus companies can use customers as cocreators allowing them customers to create their own products (Gandhi et al, 2013).
- **How it impacts the uptake of the MC model:** The new paradigm of demand-driven supply networks emerges as a collaborative scheme to better respond to consumers' direct signals and needs (Childerhouse et al, 2002). This represents a new challenge for companies as they need to share more information with others. Usually this is

enabled through the definition of long lasting relationships and strategic partnerships based on trust and affordability that define not only quantity, quality, but also innovation and even sustainability of the business relationship. The implementation of MC impact the supply chain also due to the arising need for new business actors as technology providers and service centers for customization. It is also necessary to guarantee a seamless flow of information among partners along the entire supply network in order to guarantee the necessary alignment.

- **Scoring**:

	Score	
Does your company has in place a network of long-lasting and trusted collaborations?	1	Not at all (…)
	2	Rather difficult to create such network
	3	Quite possible to increase the number of collaborations
	4	Rather easy to enlarge the network and add specific actors
	5	Extremely easy to enlarge the network and add specific actors based on needs

Figure 11. Scoring on existence of networks and collaboration

F7. Availability of production technologies

- **Definition:** Production technologies include all machines, systems and equipments necessary to realize a specific product.
- **Main associated criterion**: economic
- **Why this is relevant:** In order to implement MC new production technologies are needed in order to guarantee the levels of process flexibility, product customization and configuration that are not sufficiently supported by traditional production means. 3D printing, additive and hybrid machines are examples. Cost can vary depending on the field of application and technology readiness.
- **How it impacts the uptake of the MC model:** Companies applying MC has to switch their traditional manufacturing process to innovative ones: this impacts in terms of costs, new competencies required and new partners to be included in the business network.

- **Scoring**:

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	Score	
Are the production technologies available to realize the level of customization considered?	1	Very difficult to find in the market (technologies have still low TRL)
	2	Somewhat difficult (prototypes are undergoing final tests)
	3	Somewhat difficult but still possible to find some in the market
	4	Somewhat easy (technologies are on the market but only a pool of suppliers is able to handle them)
	5	Easy (production technologies necessary are available on the market and there are many different suppliers)
Are the production technologies that I have in my company good to realize the level of customization considered?	1	Very old technologies, not adequate
	2	Some can be used to implement some degrees of customization
	3	At least half of my technologies are appropriate for customization
	4	Almost all my technologies are appropriate for customization
	5	My production system is ready to implement customization

Figure 12. Scoring on availability of production technologies

F8. Manufacturing costs

- **Definition.** Manufacturing costs refers to the amount of money that a company incurs in producing a product. From the managerial accounting point, they are composed of: direct materials costs, direct labor costs and equipments and machineries costs.
- **Main associated criterion**: economic, social, environmental
- **Why this is relevant.** Manufacturing costs are affected by MC due to the need for flexible and reconfigurable manufacturing systems capable to handle the increased number of set ups and for specialized operators able to handle new machines, processes and digital technologies. Moreover, material costs increase due to new features and functionalization often related with customized products.
- **How it impacts the uptake of the MC model.** Companies need to update their manufacturing system with new digital and manufacturing technologies necessary for MC and have to train employees for new skills required by them.

- **Scoring**:

	Score	
How much do you think manufacturing cost will increase to implement MC?	1	More than 30%
	2	More than 25%
	3	Between 20 and 25%
	4	Less than 20%
	5	Not very much (less than 10%)

Figure 13. Scoring on Manufacturing Cost

2.2.4. Value Chain and Business Model Challenges

A number of challenges (CH) exist that prevent companies in the process industry from implementing the MC model or realize the untapped opportunities created by the model. In order to make the model work in real life and earn the much needed buy-in of all the relevant stakeholders, we attempt to generate specific/concrete ideas that will help decision makers build strategies/tactics/mechanisms/tools to be added to the general MC model. The ideas presented in this section are based on both desk research and the feedback received from our industry partners through workshops and interviews. We illustrate the main challenges that focus on:

CH1. Technology selection.
CH2. Supply chain configuration.
CH3. Customer inputs.
CH4. Customization level.
CH5. Determining the value of customization.

CH1. Technology selection

- **Description:** In most of the cases, the transition to the MC business model is carried out by introducing new technologies that will play a key role. The choice among the technologies available in the market sometimes is difficult.
- **Response:** Companies need to be supported in making a technology assessment in order to appropriately evaluate their maturity level towards MC implementation, and scanning in the market to understand which is the best solution to close the highlighted gaps. Technology change haves to be accompanied by appropriate training actions. INSPIRE has defined in deliverable D2.1a set of technologies which have been assessed according to the five business model archetypes and for what concerns MC are the following:

- ✓ Equipment manufacturing: addictive manufacturing; sensors, monitoring and control; adaptable and reconfigurable systems; multipurpose and hybrid processes; robotics; internet of things.
- ✓ ICT: modelling and simulations; big data, data mining and analysis. For example, Big data and data analytics offers new possibilities to retrieve and use information on customer's behaviors and wishes in order to forecast market needs, identify new trends and niches and thus identify customization opportunities. Data driven decision models also enable the capability of carefully analyzing the additional profit and cost due to the increased number of SKUs of the MC model.
- ✓ Sustainability: life cycle assessment; materials EOL (dismissal, recycling, separation).
- ✓ Supply chain management: cloud based platforms; dynamic supply chain management; data mining.
- ✓ Design and configuration: product configuration; smart materials (sensor/bio based); 3D scanning; virtual reality and augmented reality.

Sometimes the support of a consulting company can be useful to manage this transition guiding the firm in evaluating its readiness towards the MC implementation and then properly facing the selection of most proper technologies to be adopted, considering all the possible solutions available.

CH2. Supply chain configuration

- **Description:** The proposed business model changes the roles and makes the end customer and equipment manufacturers more important in the value chain. Other actors can be part of the network, since some phases of product personalization might be outsourced to dedicated service providers like for example additive production centers specialized in the production of components. This is a change in the ecosystem dynamics which will receive resistance. In particular, process industry characterized by large companies might have some resistance in applying this model.
- **Response:** Signing contracts and bilateral agreements can be useful in order to ensure the exclusive supply of certain materials. Guaranteeing information sharing and real time evaluations all along the extended supply network is another key enabling element. New companies or start-ups can be created to offer advanced customization services. Fab Labs (fabrication laboratories equipped with a collection of design and modeling, prototyping and fabrication, testing and monitoring, tools, as defined in Mikhak et al, 2002) can have also a role in this business model for their capability to

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produce small scale volumes. Moreover, as already highlighted, companies, that find it difficult to adapt their internal transports the implementation of MC, are suggested to outsource the logistics management to transport companies that have modern technologies able to manage small batches with smart transportation and inventory.

CH3. Customer inputs

- **Description:** Companies find it challenging to identify and understand customer desires, evolving over time. Customer is the starting point of the production process since he gives inputs, feedbacks and directions for product configuration. Moreover there are several inputs that can be collected directly from the product during its use with appropriate means. Managing the circular process connecting marketing, operations and sales can be very hard. When customization allows a customer to design its own product, problems of ownership can arise.
- **Response:** An accurate forecast of market demand can be enabled by business intelligence and big data analytics; moreover, sensor systems can enable the collection of data from product usage in order to study the behavior of the product along its life and to design new product generation. In case the product is designed by customer, companies can define rewarding systems (i.e. lower product prices) or can ask customer to sign specific terms and conditions on IPRs to avoid future claims.
  VIBRAM for example uses sensing devices in its soles and big data analytics in order to monitor and assess their use under specific conditions for ergonomic purposes (e.g. operators which work in high-vibration environments or sportsman which climb at certain altitudes).

CH4. Customisation level

- **Description:** when defining the customization level for a specific product, one of the most important steps is to fix the degree of freedom on which can range the different configuration options in terms of i.e. amount of variants, models, colours, etc.
- **Response:**
  - Appropriate analysis of cost and benefit for the different customization levels should be performed on the basis on factors like: demand forecasting, demand clustering, economy of scale, technological level, and perceived added value.
  - Analysis of materials used in the customized product, considering the lead time for delivery.
  - Design and innovation on products from the consumer perspective, including its own specifications and updates in the design.

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CH5. Determining the value of customization

- **Description:** The analysis conducted on customers' behaviors highlight that they are willing to pay more for a customized product. Defining how much to increase the price is now the challenge, because managers have to keep into consideration many factors affecting the amount of money that the customer is willing to pay. Moreover, customization brings also benefits on the company side. Due to the required increased level of automation and flexibility, the timely management of information, and inventory decrease, costs can be lowered. This aspect should also be included in such evaluation.
- **Response:** The main actions to be considered are:
  - ✓ Monitoring competitors prices of similar products.
  - ✓ Properly evaluating the industrial cost of the new products according to investments and related benefits.
  - ✓ Assessing willingness to pay of customers.
  - ✓ Elaborating proper communication actions to support customer in the perception of the intrinsic the value of customization. This has to be highlighted and showed through advertising and during the purchasing process.

2.2.5. Minor factors affecting the mass customization business model

Some additional minor factors (MiF) that might affect the decision have also been identified:

MiF1. Seamless flow of information.
MiF2. Definition of decoupling point.
MiF3. Definition of postponement strategies.

MiF1. Seamless flow of information

- **Definition.** A seamless flow of information to suppliers, up and down the supply network is necessary to guarantee supply chain integration through an effective coordination of all supply chain processes.
- **Main associated criterion**: economic, environmental.
- **Why this is relevant.** MC calls for a tighter integration of the supply network because of the increased amount of information and data that have to be shared in order to properly handle the exponential combination of variants and options related that have to be managed when dealing with customized production.

- **How it impacts the uptake of the MC model.** Companies need to improve interaction along their business processes considering co-ordination and synchronisation update their information systems and integrate with suppliers and partners in order to guarantee that needed information on material and components flows and production orders are always available and coherent. It is necessary to guarantee information exchange and software application modularity for improvements in data management and exchange, in order to create a seamless flow of information from market to design and development, to production and distribution (Fornasiero et al, 2016).

MiF2. Definition of decoupling point

- **Definition.** The customer order decoupling point identifies the point in the material flow where the product is linked to a specific customer (Olhager, 2012).
- **Main associated criterion**: economic, environmental.
- **Why this is relevant:** The customer order decoupling point is defined as the point in the value-adding material flow that separates decisions related to customer demand made under uncertainty from decisions made under certainty. Within MC it regards the identification of the optimal balance between productivity and flexibility. (Rudberg & Wikner, 2004).
- **How it impacts the uptake of the MC model:** The further downstream the decoupling point (DP) is positioned, the higher emphasis is set on productivity in operations, thus cost is the main competitive priority. Otherwise, a DP fixed further upstream enables a company to achieve a higher degree of flexibility and focus is set on customer requirements. MC requires a technological change that moves the equilibrium point further upstream to provide a higher degree of flexibility, increasing at the same time also productivity (Hill, 2000; Rudberg & Wikner, 2004).

MiF3. Definition of postponement strategies

- **Definition:** in MC postponing the task of differentiating a product for a specific customer until the latest possible point in the supply network is essential (Chase et al, 2006).
- **Main associated criterion**: economic, environmental.
- **Why this is relevant.** Postponement is an approach that supports the creation of more responsive supply chains. Postponement regards the delay of final manufacturing until a customer order is received and is commonly concerned as an approach to mass customization (Skipworth & Harrison, 2006).

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- **How it impacts the uptake of the MC model:** Postponement has a big impact on MC considering that means delaying the timing of the most crucial processes in which final products assume their specific functionalities, features and personalization aspects. Customization processes can be realized only when the information on customer specific needs is collected. For this reason the delay of customization steps are valuable only if customer requirements can be captured quickly and accurately. Products have to be specifically designed in order that postponement is possible (Lee, 1998).

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2.3. Decentralized and Modular production business model

2.3.1. An introduction to the decentralized and modular production archetype

Companies decentralizing their manufacturing split the production processes into smaller pieces that allow producing at different locations or regions. Decentralized and modular production changes the organizational structure of companies given the fact a company can be more effective if it can focus on its core activity and does not do everything (from design to final product). The value chain is broken down over more decision-making units that may be outsourced or procured at different locations[7].

Figure 14 shows the large-scale production supply chain. At the same time, Figure 15 shows the envisioned supply chain for decentralized production (at one customer). The main influencers of the large-scale supply chain are the producing companies. The bulk production is broken-up at a wholesaler and sold to many distributed customers. This is translated into a supply chain based on economies of scale[8].

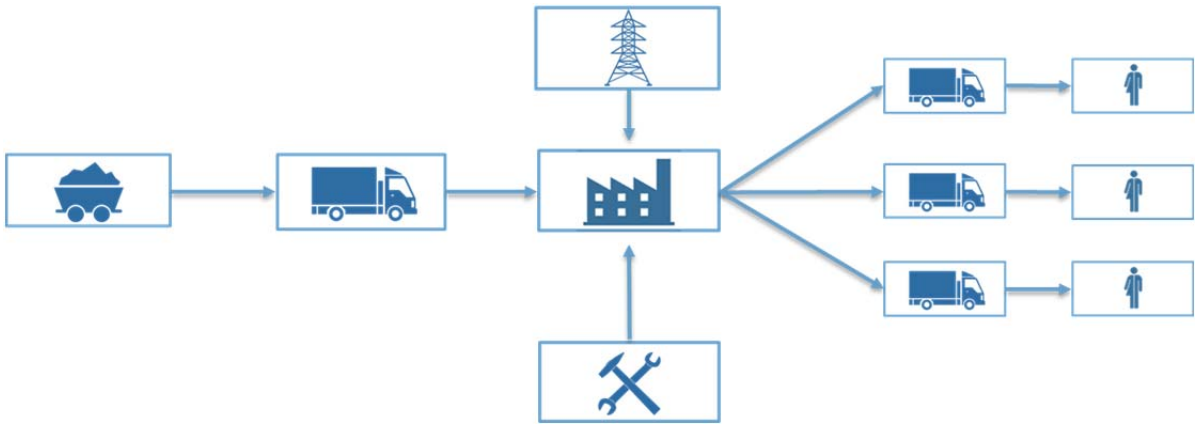

Figure 14. Large-scale production supply chain.

The business case of small-scale production is mainly focused on locating the production facility closer to the customer. This changes a pivotal part of the supply chain in the manufacturing and sourcing stages (Figure 15). Note that the decentralized supply chain is not fixed and can change based on the specific case at hand. The large scale producer elements can either be bypassed or integrated in the new supply chain.[2] In the centralized

[7] Description of the archetype was taken from INSPIRE D1.2.
[8] The case description was adapted from INSPIRE D3.1

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supply chain we saw that the stream became customer specific after the large scale production, the decentralized supply chain can be made customer specific from any point between the feedstock supplier and the small scale facility.

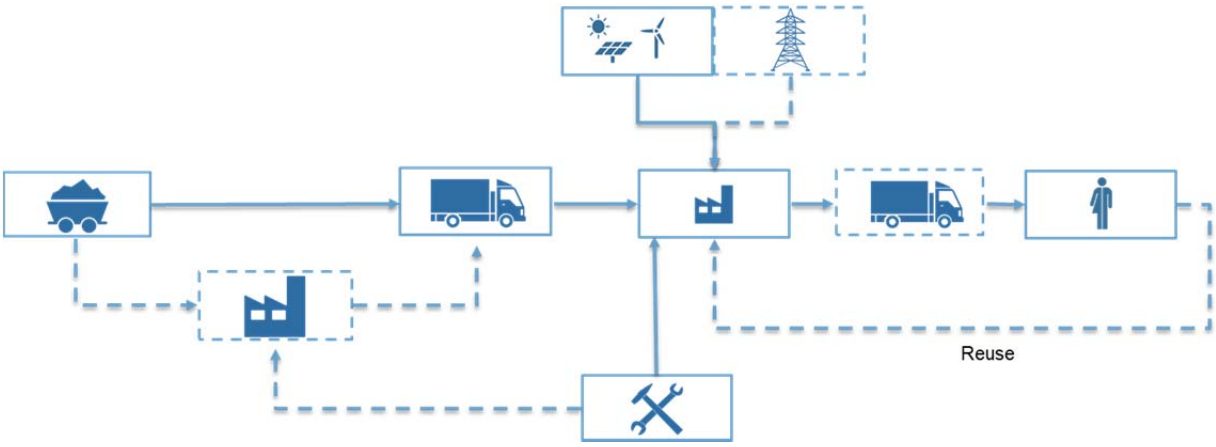

Figure 15. Small scale (decentral) production supply chain. Dotted lines and actors are optional, depending on the case.

In this document, we will consider parameters and requirements for relevant stakeholders of the business model and specific challenges for the decentralized business model. We will relate the inventoried factors and challenges to the roles in the decentralized model and the phases in the diffusion process.

2.3.2. Requirements ensuring "technical feasibility" of the decentralized and modular production business model

The following are the requirements (R) of the decentralized business model to work. The decentralized model would not even be feasible if these requirements are not met. Therefore, this would be one of the first diagnostic analysis determining whether the decentralized model **can** be implemented or not.

R1. Use case for the decentralized concept

- **Definition**: A launching user that adapts the decentralized technology/a new product.
- **Why this is required**: The incentive to go to a small-scale production facility is to reduce uncertainty, i.e. establish independence, so no clear market expectation is needed. However, to start with the concept a first mover has to be available. This first

mover will have a specific use case for the decentralized concept, in which it is clear that the decentralized concept will achieve what the centralized concept cannot.

R2. Feasible location and (perceived safety)

- **Definition**: There should be a feasible location for the facility near a customer.
- **Why this is required**: A decentralized module is placed on a different location by definition. For feasibility of the business model, this should be near customers. The location should be feasible for the specific technology and the supply of feedstock should be easy and cost effective. Also, it should be possible to acquire the location (willingness of the land owner, community rules).

R3. Technology

- **Definition**: The technology needed for the decentralized concept (mainly technology for the small-scale plants) should have a high Technology Readiness Level[9]. In addition, the technology to produce the product should be free to use.
- **Why this is required**: The business case is focused on change at equipment manufacturers. This induces risk on the equipment manufacturers, therefore the development of technology should be finished. If no technology is needed then this requirement is automatically satisfied.

2.3.3. Business model main decision factors to be considered by the relevant stakeholders

In this section, we present a number of factors that are relevant in the decision making process of whether to implement the decentralized business model or not. The reason why they are relevant and how they affect the outcome of the decentralized model are detailed as well.

In the first paragraph factors that are relevant to the archetype are presented. In the second paragraph the most important factors are elaborated and a scoring mechanism for these factors is presented. Then the most important challenges associated with the archetype are discussed.

[9] A Technology Radar with the TRL level of different technologies for decentralized and modular is shown in INSPIRE D2.1

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In literature, the following reasons for distributed production can be found[10]:

- Flexibility.
- Production closer to customers.
- Better and timelier information.
- More motivated employees.
- Taking advantage of lower investment costs.

From Industry input during the Business Model Game[11] other factors were identified:

- Emissions.
- Storage risk.
- Regional impact.

Other identified factors based on industry feedback:

- Lead time of innovation.
- Quality.
- Cost per unit of product.

The following factors (F) are assumed, by expert judgement, to be most relevant to the archetype:

F1. Flexibility

- **Definition**: The ability of a company to respond to changes in its environment[12]. Flexibility is a central topic in the INSPIRE project. It covers capacity, product, innovation, location, feedstock and energy flexibility.
- **Main associated criterion**: economic, social, environmental.
- **Why this is relevant**: *Capacity flexibility* enables a producer to produce at small scale and react better to customer demand. This is especially relevant in upcoming and highly volatile markets.
  Product flexibility enables a producer to vary in products and thus be more responsive to customer wishes. Innovation flexibility makes fast innovation possible.
  Location flexibility enables moveable production. Also plants can be reused in a different location.

[10] Source: https://industrytoday.com/article/centralized-vs-decentralized-manufacturing/
[11] Business Model Game workshop at the A.SPRIE general meeting in Brussels, November 23rd 2017. http://www.inspire-eu-project.eu/wp-content/uploads/2018/01/BMI-Workshop-Game-Report_v4-final.pdf
[12] Source: http://www.economist.com/node/14298966

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Feedstock flexibility enables the use of different kinds of feedstock. This is especially relevant when using biomass or in case of waste recycling.
Energy flexibility is beneficial if plant operation can be made dependent on electricity prices, thus reducing electricity costs.
Any form of flexibility (ability to respond to change) needs to be complemented with monitoring (ability to identify the need for change, e.g. identify the threshold to change location, increase capacity).

- **How it impacts the uptake of the decentralized model**: Flexibility can be seen as a main revenue driver for decentralized production. Higher flexibility means that more benefits from the Decentralized and Modular concept can be realized.

- **Scoring**: Flexibility consists of capacity, product, innovation, location, feedstock and energy flexibility. Therefore this parameter has to be scored either on all these kinds of flexibility, or on an aggregation of these scores. We defined a qualitative scoring of flexibility (1-5) in analogy to the technology scoring in INSPIRE D2.1[13] and INSPIRE D1.1[14]. In the first case flexibility score is the average of the score of all flexibility kinds (see Figure 16 and Figure 17).

		The applicability of the technology to different flexibility profiles. (Tab "Scoring Definition")
Flexibility	Capacity	1 (not capacity flexible) - 5 (very capacity flexible)
	Product	1 (not product flexible) - 5 (very product flexible)
	Innovation	1 (not innovation flexible) - 5 (very innovation flexible)
	Location	1 (not location flexible) - 5 (very location flexible)
	Feedstock (or Input)	1 (not feedstock flexible) - 5 (very feedstock flexible)
	Energy	1 (not energy flexible) - 5 (very energy flexible)
	Total	Average score

Figure 16. Scoring on Flexibility, per type of flexibility. The average score will be between 1 and 5. A higher score means that more flexibility is unlocked by the Decentralized and Modular business model

	Score	
Does the case require or reflect one or more of the flexibility types: capacity, product, innovation, location, feedstock, energy	1	NONE
	2	One type, but with limited impact
	3	One type, having serious impact, or multiple having limited impact
	4	multiple, with 1 type having serious impact
	5	multiple, with more than 1 type having serious impact

Figure 17. Scoring on Flexibility, overall scoring for all types of flexibility. A higher score means that more flexibility is unlocked by the Decentralized and Modular business model

[13] INSPIRE D2.1 Assessment of Relevant Technologies.
[14] INSPIRE D1.1 Selected case studies

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F2. Cost per unit of product

- **Definition**: The cost per unit (e.g. per kg) of product in the new business model. All CAPEX and OPEX related to the production of products are aggregated and translated into a cost per unit.
- **Main associated criterion**: economic.
- **Why this is relevant**: The cost of the product determines the business model for decentralized and modular as it shows the profitability. The unit cost will change due to different factors in the decentralized model. For example, loss of economies of scale will lead to a higher cost per unit. On the other hand, reduction of total (in- + outbound) logistic costs and lower investment due to flexibly scaling up capacity with local market growth are drivers that possibly reduce the cost per unit. If these drivers are negative the feasibility of the decentralized business model will be at risk. In a decentralized production model, companies may also benefit from lower costs for labor, energy or feedstock in specific regions.
- **How it impacts the uptake of the Decentralized model**: In general the cost per unit of product is a major factor of importance in many company decisions. The loss of economies of scale negatively impacts the production cost. This can limit the uptake of the business model, as the profitability may seem lower as in the centralized business model. If this is compensated by other OPEX and/or CAPEX reductions, the net result will positively impact the profitability.

- **Scoring**: The cost per unit of product (e.g. per kg) can be assessed quantitatively if the expected cost (in a decentralized business model) and the cost in the reference situation are known. Otherwise, the cost can be assessed qualitatively using the quantitative scores as a guideline. We look at the percentage change of the cost of the product in the decentralized model compared to the current business model. The cost per unit may increase in some cases; in other cases, it will decrease. Therefore, the scale is both towards the positive and towards the negative.

Score	Percentage increase of unit costs
1	>30 %
2	20% - 30%
3	0% - 20%
4	-10% - 0%
5	<-10%

Figure 18. Scoring on cost per unit of product

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F3. Production closer to customers

- **Definition**: When production is distributed to different locations, the distance to the customer will get smaller.
- **Main associated criterion**: economic, environmental.
- **Why this is relevant**: Producing close to customers will increase responsiveness to customer demand. Capacity and product flexibility are relevant here. Cases are known in which production takes place at the customer location. In this case the customer may become owner of the production plant. Also, a reduction in logistic cost is a driver to produce closer to customers. In some cases, when products have limited shelf life, reducing transport times is an important driver to adopt the Distributed production BM[15]. This feature is especially relevant for the production manager.
- **How it impacts the uptake of the Decentralized model**: the importance of increased responsiveness to customer demand is an important factor whether or not to embrace the Decentralized BM archetype. Other factors are the amount of logistic cost reduction, the interest of customers to run their own production plant and reduction of transportation times in case of products with a limited shelf life.

- **Scoring:** Ratio of average distance to customer compared to the old model. The distance to customers can be assessed quantitatively if the expected average distance is known. Otherwise, the distance can be assessed qualitatively using the quantitative scores as a guideline. We look at the percentage change of the average distance towards customers in the decentralized model compared to the current business model. The expectation is that the average distance will decrease, therefore the scale is scaled towards the negative side.

Score	Percentage decrease of distance
1	>10 %
2	0% - 10%
3	-20% - 0%
4	-20% - -30%
5	<-30%

Figure 19. Scoring on distance towards customer

[15] An example is given on http://blog.fisherbioservices.com/decentralized-manufacture-the-drivers-and-barriers. Also the case from INSPIRE D1.2, where reworking product X would be necessary, is an example where distributed production can help overcome the shelf life problem.

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F4. Taking advantage of lower investment costs

- **Definition**: CAPEX benefits of starting or upscaling a production unit in a decentralized model.
- **Main associated criterion**: economic.
- **Why this is relevant**: Capacity flexible modular production may reduce the investment risk in volatile markets, by starting with a smaller plant, having lower CAPEX. Meanwhile, due to loss of economies of scale, buying a small-scale unit will cost relatively more than in a large-scale model. This is impacted by the equipment manufacturer and relevant for all the other roles.
- **How it impacts the uptake of the Decentralized model**: Investment costs are an important parameter that will impact the uptake of the decentralized model. It determines how deep the pockets of the investing company should be and has in many cases a major impact on the Net Present Value of the business case.

- **Scoring**: The investment costs per module can be considered in two ways:

  (1) The total investment cost of one production unit. This will in general be lower in a decentralized business model, thus reducing the investment risk.
  (2) The total investment cost per capacity (e.g. per tonne of product). This will in general be higher in a decentralized business model, because of loss of economies of scale. An important indicator for this is the n-factor: it reflects the effect of scale in investment costs[16]. Usually equipment like tanks, distillation columns and pipes have a n-factor of 0.6. Modular equipment like plate based techniques (e.g. membranes) have an n-factor closer to 1.0 and are less sensitive to economies of scale. For small scale, modular equipment that will often be used in a decentralized business model, a higher n-factor is positive. The n-factor has in general a major effect on the Net Present Value.

Both elements are important for the scoring of this factor, so a combined scoring mechanism is presented below. We look at the change of the investment costs and capacity in the decentralized model compared to the current business model.

[16] According to this formula: $C_1/C_2 = (V_1/V_2)^n$, whith C_1 = cost in situation 1, C_2 is cost in situation 2, V_1 = volume in situation 1 and V_2 = volumen in situation 2. It is known as the "0.6 rule". See also https://www.sciencedirect.com/science/article/pii/0167188X86900534.

	Score	
1. Will the total investment cost of one production unit increase, stay equal or decrease? 2. What is the (overal) n-factor of the equipment?	1	1. Increase; 2. n < 0.8
	2	1. Increase; 2. n >= 0.8
	3	1. Equal 2. n < 0.8 or 1. Decrease 2. n >= 0.8
	4	1. Equal 2. n >= 0.8
	5	1. Increase; 2. n >= 0.8

Figure 20. Scoring on investment costs

F5. Quality

- **Definition**: The quality of the production facility.
- **Why this is relevant**: The quality of the facility is important for the quality of the product, the safety of the facility and the lifetime of the equipment. However, in small scale (lower investment) cases the lifetime of the facility can be decreased if demand is uncertain.
- **Main associated criterion**: economic, social, environmental.
- **How it impacts the uptake of the Decentralized model**: In early (uncertain) stages of the business model, lowering the quality might not impact the adoption rate (because of short development cycles and uncertain demand) but it will impact the costs and therefore increase the adoption rate.

- **Scoring**: The assessment of the plant / product quality should be done by expert judgement. For this a qualitative scale can be used from 1 (low quality) to 5 (high quality). The quality should be assessed absolute for the decentralized model. It can be possible that a lower or different quality as in the centralized model is accepted for other benefits, e.g. because the local consumption has different requirements or because local feedstock has different qualities

Score	
1	Low quality
2	Relatively low quality
3	Average quality
4	Relatively high quality
5	High quality

Figure 21. Scoring on quality

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F6. Lead time

- **Definition**: The time until the first market introduction of the technology is possible.
- **Why this is relevant**: The lead time is an important factor when investment decisions in the technology are made. Longer lead time until market introduction will increase the risk for the facility owner and decrease the motivation for the customer to commit to the technology.
- **Main associated criterion**: economic, social.
- **How it impacts the uptake of the Decentralized model**: The lead time impacts the uptake of the model in the early development stages. If a long lead time is envisioned, commitment and investment will be hard to gain.
- **Scoring**: The lead time can be assessed quantitatively if (an estimate) of the lead time is known. Otherwise, the lead time can be assessed qualitatively using the quantitative scores as a guideline. We use the actual lead time of the technology in the new business model as parameter and decrease the score as the lead time increases.

Score	Lead time
1	>5 year
2	2-5 year
3	1-2 year
4	0-1 year
5	None

Figure 22. Scoring on lead time

2.3.4. Value Chain and Business Model Challenges

A number of challenges exist that prevent companies in the process industry from implementing the decentralized model or realize the untapped opportunities created by the model. In order to make the model work in real life and earn the much needed buy-in of all the relevant stakeholders, we attempt to generate specific/concrete ideas that will help decision makers build strategies/tactics/mechanisms/tools to be added to the general decentralized model. The ideas presented in this section are based on both desk research and the feedback received from our industry partners through workshops and interviews. Figure 23 shows the envisioned value chain for the decentralized business model including business model challenges. Please note that in Figure 14 and 15 we presented the **supply chain**, which consisted of the material flow and supply chain elements. In the **value chain,** the actors and interactions between the actors (materials, energy, financials, and activities) are shown.

The following challenges (CH) are identified regarding the decentralized business model:

CH1. Ownership

- **Description:** The business model changes the position and the size of the production plant. This means that ownership of a small-scale plant by the conventional large-scale producer is not trivial and possibly does not align with the business goals of the producer. This may become visible by a low score on lead time factors. The challenge with ownership is to consider the willingness to adapt the new business model (for large-scale producers), having to develop new knowledge (for equipment manufacturers) and losing central coordination of multiple plants (for customers).
- **Response:** Consider different ownership models and combining these models when scaling the concept, possible models are:
    - Equipment is owned and operated by the conventional large-scale produces leased to customer or used as a production facility in-house at the customer.
    - Equipment is owned by the Equipment provider and sold/leased to customers.

Equipment is owned by a group of customers and shared, e.g. a cooperative.

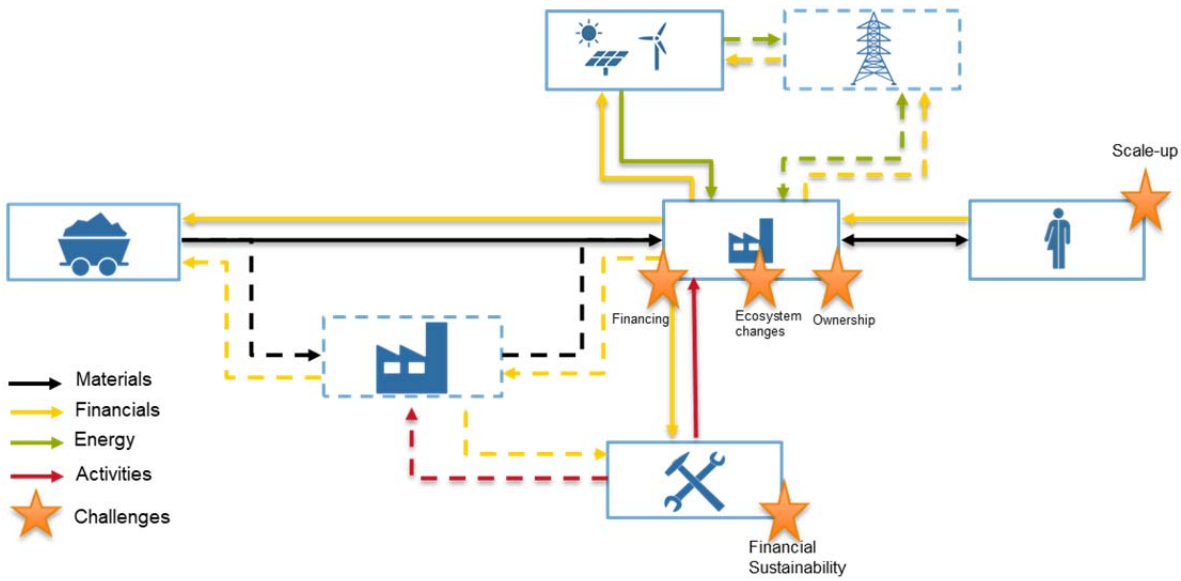

Figure 23. Value chain of the decentralized business model including business model challenges. The dotted connections and actors are optional, depending on the specific case

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CH2. Scale-up

- **Description:** Scaling up of the decentralized production model is will have a large impact on the producer and the equipment provider. However, modular equipment will make upscaling of a single production unit considerably easier, installing and operating a great number of production sites on different locations will be complex. Also competing with the traditional economies-of-scale based companies may be barrier to scale-up.
- **Response:** Utilize local companies and resources (feedstock, energy). Remote management of plants may reduce costs. Digitization of the supply chain can optimize stock and material flows[17]. In the consumer goods sector, development of franchising or production hubs appears to be successful[12]. In some sectors, the "micro factory retail concept" may appear a key to successfully compete with traditional large-scale manufacturers, e.g. in case of microbreweries and automotive where the concept is already applied[18]. MFR is basically a combination of equipment production, sales and maintenance (service). Typically relatively labour intensive. Scaling is executed by 'copying' the MFR in another location.

CH3. Economic feasibility

- **Description:** The small-scale business model reduces economies of scale benefits and replaces these with flexibilities. This means that more variability and financial risk is introduced in the business model if compared to the same scenario. The economic feasibility is directly related to the business case in scenarios that utilize the flexibilities. This challenge can be deducted from a low score on cost per unit of product and relative high investment costs. Also in the feasibility of the model one should look at the depreciation of central assets.
- **Response:** The economic feasibility can be improved by introducing economies of scale at the equipment manufacturer and thus improving the cost of an equipment unit (e.g. by standardization of components, which also reduces cost of maintenance). Another solution for is to introduce economies of scale by central procurement and monitoring of the decentralized plants. Also technical solutions with a higher n-factor, standardization, or inexpensive equipment with smaller lifetimes (e.g. disposable reactors, plastic skids) may contribute to a viable business case.

[17] Distributed Manufacturing: scope, challenges and opportunities. Srai, J.S., Kumar, M., Graham, G. e.a., White Rose University consortium, 2016
[18] https://www.just-auto.com/analysis/a-radical-business-concept-for-the-automotive-industry_id86618.aspx

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CH4. Financing

- **Description:** The adoption of decentralized small-scale production plants require an initial investment. This investment should come from companies in the value chain or from investors. Not all parties in the value chain are capable or willing to invest in this new technology. This challenge can occur with a low score on lead time and investment costs.
- **Response:** Improving the business case (as described under economic feasibility) and proving that the business case will be positive, will result in more willingness to invest. The financial sustainability can also be improved by new ownership constructions, through leasing-contracts and/or collective financing by consortia of current actors.

CH5. Technology Innovation

- **Description:** When the technology is in a low TRL level, customers can be unwilling to adopt the current technology as improvement is expected and the current technology will be out-of-date. A low score on lead time can show this challenge.
- **Response:** Work towards a minimum viable product: *The smallest thing that you can build that delivers customer value*[19]. This will lead to early adoption, then innovation flexibility[20] can be used to improve the technology at the site of the customer.

2.3.5. Minor factors affecting the decentralized and modular production business model

Some additional minor factors (MiF) that might affect the decision have also been identified:

MiF1. Better and timelier information.
MiF2. Motivated employees.
MiF3. Emissions.
MiF4. Storage risk.
MiF5. Regional impact.

[19] https://www.interaction-design.org/literature/article/minimum-viable-product-mvp-and-design-balancing-risk-to-gain-reward
[20] Van Kranenburg, Sofra, Verdoes, de Graaff, Small-scale flexible plants - Towards a more agile and competitive EU chemical industry, 2015

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MiF1. Better and timelier information

- **Definition**: Production close to customers will lead to better and timelier information, e.g. when market demand increases or when customers want products to be adapted.
- **Main associated criterion**: economic, social.
- **Why this is relevant**: The supply chain will be straighter forward and responsiveness to customer demand will increase. This is a factor that is relevant for both the customer as the production manager.
- **How it impacts the uptake of the Decentralized model**: When quality and timeliness of information are important, this will favor a decision towards decentralization of production.

MiF2. Motivated employees

- **Definition**: Adoption of the decentralized model will increase motivation of employees in the lower tier of the supply chain.
- **Main associated criterion**: social.
- **Why this is relevant**: According to a study from Harvard University, motivation and creativity of employees grows in case of decentralized production, because lower tier managers get responsibilities[21]. It may also improve efficiency of decision making, by having less hierarchy and knowing the local situation better. This factor will play at the level of the production manager, as the employees of this role will get more responsibilities in the lower tier.
- **How it impacts the uptake of the Decentralized model**: when having local employees will favour turnover, it will positively impact uptake of this BM archetype.

MiF3. Emissions

- **Definition**: The decentralized model has an impact on emissions because of avoided transportation and the possibility to introduce renewable energy sources.
- **Main associated criterion**: environmental.
- **Why this is relevant**: This factor has direct impact on sustainability targets of companies. For instance, 337 international companies committed to setting emission targets in 2017[22].

[21] The Future of Work: How the New Order of Business Will Shape Your Organization, Your Management Style, and Your Life, by Thomas W. Malone. Harvard Business School Press, 2004.
[22] http://sciencebasedtargets.org/2017/09/18/more-than-300-to-set-science-based-targets/

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- **How it impacts the uptake of the Decentralized model**: Companies are setting sustainability targets on emissions and investment decisions are influenced by these targets, so reducing emissions improves adoption by companies. Furthermore, policy makers are set on the Paris agreement goals[23] and emission reduction increases support for the business model.

MiF4. Storage risk

- **Definition**: In the decentralized model, (in-transit) storage sizes of the product are reduced and total storage is reduced because of more just-in-time production.
- **Main associated criterion**: economic, social, environmental.
- **Why this is relevant**: Products can be hazardous or easily contaminated. In the case of hazardous product, reducing the storage sizes will decrease the safety risk. Reducing and distributing the total storage reduces the risk of losing product due to contamination. However, the storage is moved towards the customer and, as well, the safety risk. This factor can be perceived as important by the customer and plays at the level of the production manager, maintenance provider and equipment manufacturer.
- **How it impacts the uptake of the Decentralized model**: The risk of stored hazardous products can be perceived as important by the customer and therefore a barrier can arise. However, the reduction of the total risk can improve the uptake by governmental support.

MiF5. Regional impact

- **Definition**: Moving the facility to the customer increases the possibility to retrieve feedstock locally and/or create possibilities for local SME's.
- **Main associated criterion**: social.
- **Why this is relevant**: Locally sourcing feedstock and services simplifies the relationship with suppliers and improves the local community. However, economies of scale is lost and the local supplier may become too dependent on the buyer.[24] This parameter is relevant for potential customers.
- **How it impacts the uptake of the Decentralized model**: Improvement of the local community will generate more support for the decentralized model from local stakeholders. The loss of economies of scale will have a negative impact on the (financial) business model from the buyer's side of view.

[23] https://ec.europa.eu/clima/policies/international/negotiations/paris_en
[24] https://cips.org/en-gb/knowledge/procurement-topics-and-skills/srm-and-sc-management/global-supply-chains/the-pros-and-cons-of-local-sourcing/#tabs-1

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2.4. Servitization business model

2.4.1. An introduction to the servitization archetype

The Servitization/Product Service Systems (PSS) is a business model archetype that significantly changes the dynamics in a typical value chain. Simply put, this model introduces a new relationship between a "supplier" and a "user/buyer" transforming the "transaction based" interaction (supplier merely selling the product to the user/buyer) into a long-term ongoing relationship, which can include the delivery of services, goods, the supplies, management, knowledge and so on. In addition, this relationship supposes a change in the behaviour of the company. Thus, Matzen and Andreasen (2006) assert a company can improve the product experience by means of service offerings or change how the stakeholders involved in the identified activities interact, to optimize the value creation in these activities. It is important to note that this business model does not only concern two value chain partners (supplier and user), but may also involve other stakeholders in the value chain because services are integrated. An example can be referred to an appliance manufacturer that offers installation, guarantee, maintenance and service based on information and communication technologies (ICTs), where these ICTs are maintained by another company. Figure 24 shows the basic elements of a PSS.

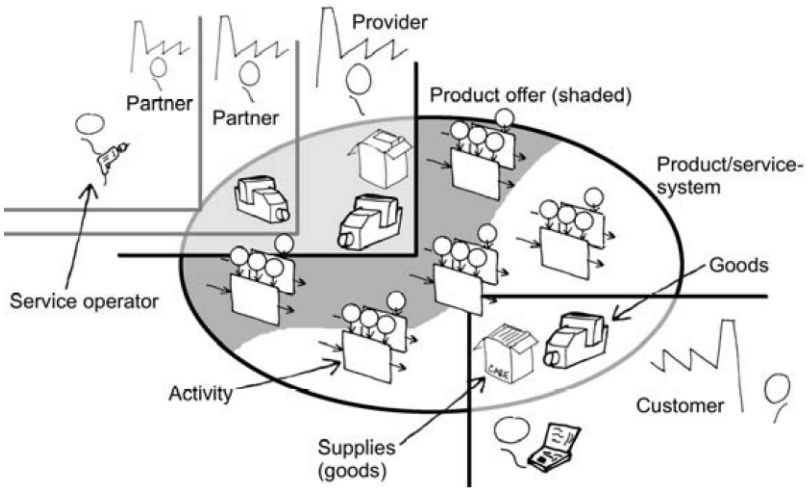

Figure 24. Elements of a PSS
Source: Matzen and Andreasen (2006)

Three categories of PSS business models can be identified[25] (Reim et al., 2015):

- Product-Oriented (PO). The PSS provider offers services related to the product, e.g., maintenance, repair, taking back after use, etc. that is sold to the customer (customer owns the product).
- User-Oriented (UO). The PSS provider still owns the product and ensures its availability/ usability over a certain period of time, e.g., leasing of baby prams.
- Result-Oriented (RO). The PSS provider offers a specified "result (outcome)", instead of selling a bundle of products and services (e.g, suppliers charging for chemical services rather than the sales volume).

The main difference among the categories differ lies in the risks, responsibilities, ownership and shared among the PSS provider and its partners in a value chain.

The successful deployment of this business model depends on several factors and parameters that define the business setting. Therefore, to ensure a smooth transition to the PSS model and successfully deploy this model, a manager needs to consider such factors/parameters. In addition, the model has already been deployed in various sectors, and is known to face unique challenges possibly strongly linked to the factors/parameters, that might hinder its widespread diffusion in process industry.

2.4.2. Requirements ensuring "technical feasibility" of the servitization business model

Here we briefly discuss what requirements exist, which defines whether a specific company **can** deploy the PSS model or not. Therefore, the question we are trying to answer in this section is whether it is possible for the company to "servitize the product", rather than "how good the PSS model is" for the company. We believe this section could serve as an initial diagnostic tool for a manager to quickly evaluate whether the PSS model is technically feasible or not (is the product servitizable and can the firm handle this process?).

R1. Technical capability to deliver service and monitor performance

Information Communication Technologies (ICT) capabilities are necessary for the smooth communication between the supplier and the user as well as for the proper quality control of the process. Internet of Things (IoT) would also be instrumental for the "*servitization of*

[25] An in-depth definition of the PSS concept can be found in INSPIRE D3.1.

revenue streams due to quality of maintenance, consulting, and conducting operations at the client's headquarters" (Kamp, 2016). The author refers to the servitization of revenue streams as "the increase in the percentage of turnover that manufacturing companies obtain from the provision of services, e.g. due to maintenance, consultancy, conducting operations at the customer's headquarters ...)". Finally, use of technological applications related to the Industry 4.0 concept would be necessary in the medium term for "*linking the commercialization of product-service systems with ways of obtaining income (for example, via payment-for-use or depending on the capacity made available to the user)"* (Kamp, 2016). In addition, a *"smartization" of the relations between actors and devices in the value chain can operate as a catalyst for the servitization of business practices and business models"* (Penttinen & Palmer, 2007), helping to identify the parameters of use of assets and processes, such as the state of critical components, and the consumption of (energy) inputs.

R2. In-house (outsourcing) capabilities to deliver the service

The firm (supplier) should have a very good understanding of the user's needs and the technical/financial resources and know-how to be able to deliver the service. The strategic interaction between the supplier and user (the need for a long-term ongoing relationship for the integration of both actors) is necessary for the successful application of the PSS business model. The supplier must be able to evaluate the value of the "user's account" to ensure that the gains from this relationship are positive and sustainable, guaranteeing "financial feasibility" of the model. The supplier also needs to be "technically able" to provide the service and manage the "use" of the product, and this thus also needs a degree of openness on the user's end. It should open its process in order to integrate the PSS.

2.4.3. Business model main decision factors to be considered by the relevant stakeholders

In this section, we present a number of factors that are relevant and need to be factored in during the decision making process of whether to implement the PSS business model or not, given that it is technically feasible. As far as the PSS model is concerned, we believe that the push to adopt this model often comes from the "supplier" as the supplier is the party that needs to "offer" services based on the needs of the "user". Therefore, in this analysis, we mostly focus on the factors/parameters that impact the decision of the "supplier". However, note that many of these factors/parameters also have direct/indirect impact on the willingness of the "user" to participate in this new form of relationship. We also provide the main criterion (among economic, social, and environmental) that the factor belongs to. Please note that the factor may impact multiple criteria. The reason why they are relevant and how they

impact the outcome of the PSS model are detailed as well. Finally, we also mention how each factor needs to be "scored" by the decision makers (e.g., managers) to estimate the "fitness" of the PSS business model.

The following part contains the list of factors that are most critical to the successful deployment of the PSS model and thorough analysis should be carried out regarding these before making a decision. The "fitness" of the model, that is how good (profitable/ environmentally friendly/ socially optimal) the PSS model is, would depend on the overall evaluation of these major factors/parameters. We think that the decision whether the PSS model should be employed or not depends on these critical factors, given that the PSS model is technically feasible.

The factors identified are the following:

F1. Profit ratio.
F2. Overall Degree of Resistance to Change (both for the supplier and the user).
F3. System sustainability improvement relative to the current situation.
F4. Level of risks relative to the current situation.
F5. Capabilities to deliver the service of same/higher quality.
F6. Level of difficulty in clearly defining the scope of service and measuring performance with PSS.
F7. Profit Uncertainty Ratio.
F8. Flexibility.

F1. Profit Ratio=Profit with PSS / Profit without PSS (status-quo)

- **Definition**: Profit (Revenue – Cost) of the "service" for a given "scope" of the service versus the profit from only the sales of the product.
- **Main associated criterion**: Economic.
- **Why this is relevant**: The profit that the "supplier" will make with the PSS model relative to the status-quo when she only sells the product to the "user" will be one of the main determinants of whether the model will be implemented or not for any profit-seeking supplier. The profit that the supplier can potentially make with this model also indicates how profitable the service is for the user, although there is not necessarily an inverse relationship between the two (i.e., sometimes the user may be able to increase his profits if the profit for the supplier goes up). The profit with the PSS model depends on several factors as listed below:

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- The value added with the "service" for a given scope, which will determine the "price" charged for the "service" (if the supplier employs a value-based pricing mechanism as opposed to market-based or cost-based pricing mechanisms). "*The ability to create and capture sustained added value is often seen as the key measure of success of business"* (Tukker, 2004). According to the same author, four key elements can be distinguished: (i) market value (tangible- resources, time input and cost of capital saved- and intangible- e.g. additional priceless experiences); (ii) production costs, including traditional "tangible" production costs and risk premium/ uncertainty related to the solution; (iii) investment needs/ capital needs for PSS production; and (iv) the ability to capture the value present in the value chain. This element includes: the strategic position in the value network defined as the ability to capture value; sustained low barriers for accessing the service; and comparatively high speed on innovation."
- The "cost-to-serve" for a given scope: This will determine the costs (for the product and service provided) that the supplier will incur for delivering the service, and also determine the "total acquisition costs" for the user. Activity based costing and the inclusion of hidden costs (e.g., inventory related costs) must be included in calculating the costs incurred. The "price" charged for the product+service by the supplier will most often depend on the "cost-to-serve", although in some situations the supplier might ignore the costs and even charge the user less than the costs for other long-term objectives (e.g. gaining market share).

- **How it impacts the uptake of the PSS model**: The higher this parameter (ratio) is, the more likely that the supplier will be willing to commit to such an ongoing relationship given that the scope of the service remains the same. We conjecture that the more money the supplier makes with the PSS model, the more she will be able to "share" this additional profit with the user, and therefore a higher profit ratio will make it easier for the user to accept the new business model. On the other hand, this ratio should not be too high such that the "total costs" to the user is not higher than the traditional way of doing business.

- **Scoring**: Assuming that the profits will be positive for the supplier (i.e., we ignore the situations where the supplier might be willing to lose money in the short term with the PSS model for other strategic goals such as gaining market share in the long term), the profit ratio will be a positive real number. To be consistent with the measurement of the other factors, we define following "ranges" for this ratio and associate each range with a score on the 1-5 scale that we use for all factors"

	Score	
How much do you think your profits would change with the PSS model relative to the current system?	1	Profit ratio between 0 and 0.4
	2	Profit ratio between 0.4 and 0.8
	3	Profit ratio between 0.8 and 1.2
	4	Profit ratio between 1.2 and 2
	5	Profit ratio larger than 2

Figure 25. Scoring on Profit Ratio

F2. Overall Degree of Resistance to Change (both for the supplier and the user)

- **Definition**: This factor/parameter describes the strength of the internal resistance to the changes that will be introduced because of the deployment of the new business model (PSS)
- **Main associated criterion**: Social (it has an impact on the morale of the workforce, and it may also lead to job creation or losses based on the new descriptions of jobs).
- **Why this is relevant**: Change management is very critical for new successful deployment of new business models. PSS model implies major changes in how the supplier and user work together, and executives (of both supplier and user) may face significant internal resistance if the objectives/benefits of the PSS model and the phases of deployment are not clearly communicated to the rest of the team. Deloitte (2016) define culture like an iceberg, where the part that can be seen above the waves reflects the isolated behaviors and outcomes that can surprise and even frustrate incoming executives. The bulk of the submerged part comprises the "shared beliefs and assumptions" that are often shaped over generations, and can sometimes punch a hole through titanic corporate initiatives. According to the authors, the not understanding of culture and addressing change when needed can undermine leadership success and corporate performance. Inculcating a service culture involves changing the mindsets of employees habituated to a product centric vision and mental model; it may be the primary barrier for product firms looking to gain from service offerings (Davies et al., 2006). In addition, from the user's perspective, it is necessary that the customer places value on having a need met as opposed to owning a product (Mont, 2002).
- **How it impacts the uptake of the PSS model**: The success of a PSS solution in the consumer market highly depends on being sensitive to the culture in which it will operate (Wong, 2010). In addition, consumers may not be enthusiastic about ownerless consumption, while manufacturers may be interested in pricing, absorbing risks and shifts in the organization, which requires time and money to

facilitate (Baines et al., 2007). The more open people are to new ways of doing business (the smaller the degree of resistance), the more likely that the PSS model will bring in the potential benefits.

- **Scoring**: This factor will be scored on a 1-5 scale as follows (please remember that the higher the score is, the better the PSS will be).

	Score	
What would be the reaction of the current management/employees to the new business model, with all the changes it would bring?	1	Very high resistance
	2	Mild resistance
	3	Neutral
	4	Low/moderate resistance
	5	Negligible resistance

Figure 26. Scoring on Overall Degree of Resistance to Change

F3. System sustainability improvement relative to the current situation ("ratio of "efficiency of the supplier/efficiency of the user")

- **Definition**: The term sustainability has a multidisciplinary use and meaning. Sustainability can be described as the capability of a system to endure and maintain itself. However since the 80s, *sustainability* as a term has been linked to **sustainable development,** defined as: "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*" (World Commission on Environment and Development, 1987) Here, sustainability refers to "more environmentally friendly" operations.
- **Main associated criterion**: Environmental.
- **Why this is relevant**: The changing markets have shifted the focus towards sustainability. Sustainability is linked with the circular economy concept, usually represented by four key principles (Urbinati et al., 2017): product-life extension, redistribution/ reuse, remanufacturing, and recycling. Sustainable use can be achieved by selling functionality instead of products. In addition, sustainability is linked to prolonged life cycles by preserving the usability of the offers (Meier et al., 2010).
- **How it impacts the uptake of the PSS model**: A sustainable system is motivated by the following aspects (Meier et al., 2010): (i) *technical*: an equal focus on product and service development can enable innovations, driving the integration of product and service engineering; (ii) *ecological*: reduce resource consumption by using the machine more efficiently; (iii) *economical*: increasing profit by

delivering services instead of merely selling products; and (iv) *social*: enable high wage countries to protect employment and provide new jobs. On the other hand, countries with low technical qualifications can raise their performance. The PSS models in general are supposed to have a positive impact on the environment as the supplier is in general more knowledgeable on the "use" of the product and the economic incentives are such that "better use" of the product is rewarded rather than "larger sales".

- **Scoring**: This factor will be scored on a 1-5 scale as follows (please remember that the higher the score is, the better the PSS will be).

	Score	
How big an improvement in sustainability do you think the PSS model brings?	1	Significant Negative impact (less environmentally friendly)
	2	Mild Negative Impact
	3	No impact
	4	Mild positive impact (more environmentally friendly)
	5	Significant positive impact

Figure 27. Scoring on ratio of "efficiency of the supplier/efficiency of the user"

F4. Level of risks relative to the current situation

- **Definition**: This factor is a measure of the risks or liabilities (legal, environmental, operational) compared to the current situation. The supplier in general remains owner of the product or the equipment, instead of selling it. This means that a lot of capital is locked and consequently that the risk of ownership of the supplier thus increases.
- **Main associated criterion**: Economic/ Environmental.
- **Why this is relevant**: To describe how the rights and liabilities are distributed among the involved parties (supplier and user), as mentioned in Reim et al., (2015). With the PSS model, the supplier often times owns the product instead of the user and most likely is responsible for the "use" of the product while providing the service, as well as the waste management. Therefore, the party that assumes the risks due to potential adverse events might be different from the current system without the PSS model where the supplier does not need to worry as much once the product is sold and accepted by the user (although this may not be the case, and there are many examples of product recalls where suppliers bear responsibility even after sales). This is especially important for process industry

when the products are hazardous materials, special chemicals that require proper handling, etc.

- **How it impacts the uptake of the PSS model**: A PSS contract is designed to address all aspects related to providing the service and to the statement of the rights and liabilities of the involved parties (Reim et al., 2015). According to the authors, complexity is linked to the quantity of the specific regulations included. In addition, the level to which a contract is formalized is related to "how much of the contract needs to be adapted to each new customer". Contracts set the long-term relationship between the customer and the provider. Moreover, contracts are perceived as the foundations for representing and implementing a particular business model (Richter and Steven, 2009). If the shift from "only selling the product to providing a service" makes the supplier (provider) assume most of the risk, and each user (customer) is different that requires the design of a very specific contract, the deployment and later the diffusion of the PSS model to more customers would be challenging. Therefore, depending on how risks are shared with the PSS model compared to the status-quo will be an important determinant of whether a firm will implement PSS or not.

- **Scoring**: This factor will be scored on a 1-5 scale as follows (please remember that the higher the score is, the better the PSS will be).

	Score	
How big an increase in the legal/operational/environmental risks the supplier face moving to the PSS model?	1	Significant Increase in Risk for supplier
	2	Mild Increase in Risk
	3	No impact on risks
	4	Mild positive impact (less risky for the supplier)
	5	Significant positive impact (risks much lower)

Figure 28. Scoring on level of risks

F5. Capabilities to deliver the service of same/higher quality

- **Definition**: This factor/parameter shows how capable the supplier is able to provide new "service offer". The supplier might either have these capabilities (e.g. technological, operational, human resources-knowledge based) in-house or might have the access to a network of companies ready to provide such services and has the proper relationships to assume the role of value chain orchestrator.
- **Main associated criterion**: Economic/Social/Environmental

- **Why this is relevant**: To ensure PSS business models are implemented successfully, and that the supplier will indeed be able to deliver the service as promised.
- **How it impacts the uptake of the PSS model**: Service companies cannot perform manufacturing tasks independently (Baines et al., 2007). In this context, the partner selection process with the different stakeholders is relevant. In addition, the type of collaboration can be different according to the services offered. According to Reim et al. (2015), three aspects characterize the use of network relationships: type of partners, type of relationships, and sharing and coordination activities. Network building should focus both on the actors directly linked to the PSS solution (e.g. partners, suppliers, customers) and the actors that could provide support and protection to that solution (Ceschin, 2013).
- **Scoring**: This factor will be scored on a 1-5 scale as follows (please remember that the higher the score is, the better the PSS will be).

	Score	
How capable is the supplier to develop in-house capabilities to provide the service or coordinate with other partners in the network that could deliver the service?	1	Supplier is not capable at all to provide the service in the short term
	2	Supplier is somewhat capable to provide the service in the short term
	3	Supplier is as capable as the user to deliver the "same current service"
	4	Supplier can deliver mildly superior (more efficient, sustainable) service than the user currently has
	5	Supplier is capable to deliver significantly better service compared to the current service

Figure 29. Scoring on capabilities to deliver the service

F6. Level of difficulty in clearly defining the scope of service and measuring performance with PSS

- **Definition**: This factor/parameter measures how easy it is for the supplier to define the "scope of the service" to be provided, which will have a big impact on the revenues as well as the ICT costs/ monitoring/ quality costs. As the payment from the user to the supplier usually depends on the "performance of the supplier delivering the service based on the scope", the ease with which the performance can be measured is an important factor.
- **Main associated criterion**: Economic.

- **Why this is relevant**: The definition and/ or scope of the service must include the information regarding characteristics, quality, length and cost of the service. It determines the specifications and responsibilities the supplier is willing to offer regarding the service. It creates an image of transparency in the company and precise expectations, thereby reducing the number of complaints. The performance of the service has associated some operational costs. For instance, ICT costs are related to the investment in the necessary infrastructure for the service performance measurement/auditing. In addition, several costs can be related to the monitoring of the machinery in the client installations and the problems resolution.
- **How it impacts the uptake of the PSS model**: The more precise the definition/ scope of the service is, the better interaction between supplier and customer will be. This will contribute to create an atmosphere of collaboration which will result in a better service operation. The lower the value of this parameter is, the more likely that the supplier would prefer to engage with the traditional way of doing business.

- **Scoring**: This factor will be scored on a 1-5 scale as follows (please remember that the higher the score is, the better the PSS will be).

	Score	
How difficult is it for the supplier to clearly define the "scope" and put in place "objective/verifiable mechanisms" for the performance measurement of the service provided?	1	Extremely difficult (almost impossible to define a clear scope and measure)
	2	Very difficult, requires an iterative process between parties and significant auditing
	3	Somewhat difficult
	4	Somewhat easy, clear scope and objective performance measurement possible
	5	Easy (scope and performance measurement are very straightforward)

Figure 30. Scoring on level of difficulty on defining the scope of service and measuring performance

F7. Profit Uncertainty Ratio = Variability in the Profit with PSS / Variability in the Profit without PSS (status-quo)

- **Definition**: The extent to which the supplier can "predict" what its "revenue streams" in the future will be like, as well as for the user to also "estimate" what "costs" they will incur with the PSS model.
- **Main associated criterion**: Economic.

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- **Why this is relevant**: With the traditional systems, the supplier sells the "product" and the user pays for it. This is a transactional relationship, where the payments and delivery happen at well-defined periods, and the "revenue stream" for the supplier is pretty stable and predictable. With the PSS model, the payment from the user to the supplier depends on the "quality of the service delivered and the performance", which is not as straightforward as "paying based on the amount purchased" with the traditional system. The costs to provide the service are also more difficult to predict in advance. Moreover, the "time when the payment" happens is also different, as it happens when the service is delivered as opposed to when the sales happens. Therefore, both the "amount and the timing of payments" might exhibit more uncertainty for both the supplier and the user with the PSS model.
- **How it impacts the uptake of the PSS model**: The higher this ratio is, the less likely the supplier will be willing to engage in the PSS business model. This is especially true for cash-constrained firms that depend on predictable stable cash inflows.

- **Scoring:** To be consistent with the measurement of the other factors, we define following "ranges" for this ratio and associate each range with a score on the 1-5 scale that we use for all factors".

	Score	
To what extent do you think the variability in profits would increase with the PSS model relative to the current system?	1	Profit ratio between 0 and 0.4
	2	Profit ratio between 0.4 and 0.8
	3	Profit ratio between 0.8 and 1.2
	4	Profit ratio between 1.2 and 2
	5	Profit ratio larger than 2

Figure 31. Scoring on Profit uncertainty ratio

F8. Flexibility

- **Definition**: flexibility is the ability of a company to respond to changes in its environment[26]. This factor measures how flexible (capacity, product, innovation, location, feedstock, energy) is the model under the servitization business model (PSS) structure, compared with current structure
- **Main associated criterion**: economic, environmental.

[26] Source: http://www.economist.com/node/14298966

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- **Why this is relevant**: Under the traditional structure, the companies use the supply chain to process raw materials, transform them in the "product" and delivers it to customer, at which moment it breaks the relationship link with the customer as he/she become the owner of the product. It becomes merely a transactional relationship on which the customer and seller does not carry a link for the use of the product or any additional services that could be beneficial for both parties. Under the PSS business model, the link between customer and seller is tied to the product and services around it, and the manufacturer/seller keeps ownership of the product while the customer exploits its utilization. Therefore, flexibility becomes a key feature for the manufacturer/seller as it will allow its customer to find additional features and services over the traditional model of only owning the product. Moreover, it gives the manufacturer the freedom to expand the features of the product, by increasing the product innovation potential, adding other locations to manufacture, growing the capacity of manufacturing, allowing use of different feedstock and including energy options for manufacturing/transportation processes
- **How it impacts the uptake of the PSS model**: For a successful implementation of the PSS model, the willingness of the customer to pay for an additional service plays a key role (Moira, 2015). As well, customers are shifting from traditional ownership of a product to ownerless solution as they see the benefit (for certain products and services) of receiving additional services over a product rather than only the product (Juneja, 2018). Incorporating (any different) flexibility to the traditional model will attract potential customers and provide current customers with new services, improving their satisfaction.

- **Scoring**: This factor will be scored on a 1-5 scale as follows (please note that the ranking is based on the PSS performance under the principle of "the higher the number, the better the performance").

	Score	
What would be level of flexibility that the company could reach after the implementation of the PSS model?	1	Trivial flexibility
	2	Low/moderate flexibility
	3	Neutral
	4	Minor flexibility
	5	High flexibility

Figure 32. Scoring on Flexibility

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2.4.4. Value Chain and Business Model Challenges

A number of challenges exist that prevent companies in the process industry from implementing the PSS model or realize the untapped opportunities created by the model. In order to make the model work in real life and earn the much needed buy-in of all the relevant stakeholders, we attempt to generate specific/concrete ideas that will help decision makers build strategies/tactics/mechanisms/tools to be added to the general PSS model. In doing so, we first remind the reader of the specific challenge that the PSS model faces and then discuss how to overcome the same recommending innovative solutions. The ideas presented in this section are based on both desk research and the feedback received from our industry partners through workshops and interviews. Below, we present some challenges and potential solutions:

CH1. Definition of the "scope" of the service and complexity of the "relationship/contract" with trusted suppliers/customers.

This challenge is linked with the following factors:

- F2. A clear definition of the scope will allow a better understanding by the employees, which can help to overcome the internal resistance to changes.
- F4. It will allow a higher risk control when working first on a small scale.
- F6. The lower the scope, the lower the difficulty in its definition.
- F8. The relationship of the supplier/ user affects the flexibility of the PSS.

Potential Solutions:

- Start with a simpler/smaller offer, where is possible to identify and efficiently define the main areas covered in the relationship, such as "*managing service delivery (formal governance), managing the relationship, contract administration, seeking performance improvements, and managing changes*" (Office of Goverment Commerce, 2002). These key features will help the parties to set the following steps:
    - Pilot project: for only one product/department/region to enhance the relationship with the possible customers, generate a "beta test" of the offer, assess the results and take concrete actions to implement the project in a posterior stage. The value of the pilot project is that it will not require a complete change in the processes from the different parties but just specific changes in certain areas to meet the proposed goal.

- After the implementation of the reduced scope with the pilot project, is time to define how a full scope implementation is possible. In general, the main objective for the companies is to create standardized processes that can be easily transferred and shared among the different areas within the company. Is important to notice that these processes require collaboration, therefore, some ways of doing so are through different tools like Collaborative Planning, Forecasting and Replenishment (CPFR), Vendor Managed Inventory (VMI), and others, where the parties can define a larger scope and commit to "aggregated results". The following example takes an approach, from a general scope to a more specific scope defined by results and with some specific goals.
    - CPFR → VMI → VMI + application/use of the product → VMI + application/use + take-back and resell

CH2. "Price" to be charged given the "scope" of service

This challenge is linked with the following factors:

- F1. Price is directly linked with the profit obtained given the costs of the service.
- F7. The highest knowledge of revenues streams will positively impact in the profit uncertainty ratio.

Potential Solutions:

- Perform a "cost-to-serve" analysis (e.g., Sales organization costs, Marketing costs, Ordering and cash collection, outbound transportation, Customer-specific services, Returns management).
    - The key feature of the CTS analysis is that a company will be able to "*analyze and quantify the costs associated with each activity involved in fulfilling demand—including procurement, manufacturing, distribution, logistics and sales—at a product and customer level*", using the activity based cost analysis to perform a proper understanding of the "*profitability of a product or product category for each customer and end-point*" (Croxton, Lambert, García-Dastugue, & Rogers, 2002). The problem is that even when the methodology is simple, gathering the required data across the supply chain is a challenge in general. For example, West Monroe Partners worked with one client on identifying the critical cost structure, finding that there existed clients who were draining the profits, and, by identifying these hot-spots, they "*generated*

$5 million in bottom-line value for the organization, and it subsequently resulted in a change in customer behavior that proved beneficial for both parties" (Racciatti, 2016).

- Evaluate "additional revenues" (e.g., from sales of additional products, parts, etc.), contemplating the usage of the "two for the price of one" effect (three for two, etc.) as statistically customers are more likely willing to get a bundle of products rather than just a single product. This can be extended with the services as well, offering additional services in top of the originally negotiated.

- Study the "value" of the service and the willingness to pay by the customer. Is necessary for companies to understand their customer and their needs, determining the willingness-to-pay before any negotiations commences, to develop collaboration and trust, finding the best information to allocate the fair price. Typically, "*salespeople rely on their experience and selling skills to draw out this information using historical data and value-based pricing methodologies to understand how a customer values their products*" (Moira, 2015). This analysis is key to determine the following steps:
    - Calculate the reduction in costs for the user based on what are the specific requirements and negotiations that can be achieved, determining the best solutions for the different parties.
    - Calculate the additional value created for the user because of better products, services, increased "end consumer satisfaction", under the Unique Value Effect, where "*the buyer values the unique attributes of your product/service, willing to make a purchase. In a nutshell, they value your product above others in the marketplace*" (Moira, 2015).
    - LCA, to make sure that all stages of the life cycle add value to the product, reducing waste and determining where some additional services can be offered
    - "Revenue sharing mechanisms" (e.g., the Finnish Energy Service Companies (ESCO) offering comprehensive energy solutions gain their returns by receiving a share of the energy costs saved by their customers. For more details, see Cheschin, 2013)

- Define the range of the price so that a win-win solution is offered. One key example of this is defined by the drugs and pharmaceutical industry, where they find the allocation of prices under the concept of "tiered pricing", purposely intended to "systematically setting higher prices in higher-income markets and lower prices in lower-income markets, such that there is some positive correlation between price and income". in this sense, is possible to conclude that the allocation of prices is "fair" and meets the following two criteria:

- User does not pay more than before.
- Supplier does not earn less than before.
- As expected, tiered pricing does takes a non-traditional approach by shifting from equitable cost structure to a more affordable cost structure, by "*simply charging different prices to different segments of the market for the same product*" (Moon, Jambert, Childs, & von Schoen-Angerer, 2011).

- Incorporate waste management as part of the design of the product, considering how it would impact the use of the product and the service provided. Developed in the early 1990s, the Extended Producer Responsibility (EPR) is an initiative that promotes integration of environmental impacts in the product manufacturing, with the following purposes: "*creating incentives for eco-design of packages and products, leveraging private sector expertise to achieve public goals, internalizing the costs of waste management into product prices, and shifting the financial burden of waste management from municipalities and taxpayers to firms and consumers*." (Lifset, Atasu, & Tojo, 2013). An example of this is the WEEE Directive (Waste Electrical and Electronic Equipment Directive), under which the recycling of this kind of waste is regulated, making producers consider the end of life of their products. Another example is related to the beverage containers, where the used containers can be recycled at retail stores and other locations, and as result an "average of 76% of carbonated beverage containers are recycled while places without deposit laws recycled only recycle 37% of these containers" (Container Recycling Institute, 2013).

CH3. The potential loss due to the uncertainty in payments, costs, performance

This challenge is linked with the following factors:

- F4. The level of risks is directly linked with the typology of risk sharing contracts.
- F7. Schedule payments will make possible to decrease the uncertainty of profits.

Potential Solutions:

- **Risk Sharing Contracts:**
  - **Cost-plus contracts**: user of the service agrees to pay a certain percentage above the unit cost of the product or service provided. User assumes the risk of "unexpectedly high costs". One example of this is given by the construction industry, where the final cost of a construction is difficult or impossible to estimate ahead of time, requiring from the parties "*greater flexibility and more*

transparency for the owner of a property. For the contractor, risk is reduced, because a cost-plus contract guarantees a profit" (Adkins, 2015)

- **Fixed fee contract**: the user pays a fixed price for the service. The supplier assumes the risks related to costs, forces the supplier to perform better to minimize costs. A simple example of this type of contract is the following: consider a webpage design service, which sets a fixed price independent of how complex or simple is the required design, generating large profits in the car that the design is very simple and compensating for losses when the design is complex and the resources allocated surpass the budgeted resources for each individual project (Chu & Sappington, 2009)
- **Linear/incentive contracts**: a hybrid of the above two contracts where the risks, gains, losses are shared by the different parties. As a result of this hybrid method, the "*buyer pays a fixed fee plus some proportion of project cost*" (Weitzman, 1980). However, the compensation occurs when the sharing ratio (proportion of project cost borne by the seller) helps to reduce the overall cost, although it may increase the risks for the contractor. A simple example of this is given in construction industry, where this type of contract "*incentivizes the contractor to bring in the project under budget or to complete it before established time*" (Greiman, 2013).
- **Guaranteed Savings Contracts**: minimum savings and earnings specified in the contract. This type of contract does not look easily understandable, as it looks contradiction may arise. For this, we present a proposed implementation from Pearlstein, which would help to clarify the definition. "*In higher education, one can imagine firms offering guaranteed-savings contracts for the development of a general education curriculum for freshmen and sophomores based on guidelines provided by the faculty. The savings would come from making intensive use of videotaped lectures from the school's best teachers, along with other digital content and off-the-shelf interactive software that monitors student progress through homework exercises, quizzes and tests. Savings could be used to raise faculty salaries and lower student tuition*" (Pearlstein, 2012).

- **Scheduled Payments and Reverse Factoring:** In order for the supplier not to have financial losses, the timings of the payments do not have to be strictly coordinated with the times when the service is provided (regular payments from the user to the supplier can take place even though the service is provided at different time periods to ensure a stable/sufficient profit for the supplier). Scheduled payments spread over time ensuring stable revenue stream for the supplier, which could be made by having a payment schedule with specific dates and rates, allowing for discounted payments if

the payment is made before the defined deadline. On the other hand, there exists entities or third parties (a bank for example) that can help the company to pay earlier (accelerated rate) and take advantage of the discount, under a model called "reverse factoring". One practical example of this is when a bank reaches an entity with financial debts and offers to pay for them and offers a preferential payment rate. In this case, the bank will pay the financial obligations to the first entity, receive a discount and receive the money later at a lower interest rate than the original, but earning more money after the transaction is completed.

CH4. Internal Resistance, especially from the "procurement people at the user"

This challenge is linked with F2 and F8.

Potential Solutions:

- It is important to understand why these changes are happening, set the reasons and benefits, as well as share the fears and address the different concert that company workers might have. For example HP, MasterCard EY, CA and ING (among others) understand that is necessary to discuss why they need to embrace changes, amid the cultural challenges posed by disruption, as "*if they do not innovate, someone else will do, disrupting their markets*" (Sudhaman, 2016).
    - Perform an analysis and clearly communicate the benefits. As brilliantly defined by Ajay Banga (MasterCard CEO), "*internal cultures are often characterized by fear*" (Banga, 2016), therefore is necessary to move away from fear.
    - Spending less time on calculating and producing purchase orders, generating a more efficient use of time of the workers, reducing non value added activities and engaging all parties in a more collaborative environment.
    - Focus on VMI program management, establishing long-term relationships by a well-established communication between the different parties. As seen in the example from P&G, implementation of VMI was a key success factor on achieving the results and tackling the fear of failure.
    - New incentive mechanisms: Tie the performance of procurement personnel to the "service" provided to the end consumer and the "total acquisition costs", and not the "amount purchased/purchase cost". (Banga, 2016) thinks that companies who are willing to change their current processes need to think like an entrepreneur, opening themselves to the changes and embracing them, as these will push the company forward. "*If you're really going to be*

entrepreneurial, then you have to behave like a beginner all the time. Be willing to take a risk," said Banga.

CH5. Increased dependence of the user on the supplier

This challenge is linked with F5. The user depends on the capabilities of the supplier to deliv er the service of same/ higher quality.

Potential Solutions:

- Multiple sourcing. By deciding to have different suppliers is not only possible to reduce the amount of back orders, of companies that relied only in few suppliers in Japan but suffered a large disruption in their production and lost revenues when the earthquake and tsunami landed in 2011, affecting their suppliers (Sheffi, 2015). The companies trusted blindly in a clustering of companies that proved not to be so efficient when the unexpected disruptions occur.

- Purchase similar services from different suppliers for different products has been an strategy largely used by the aviation industry as the airlines require their aircrafts to be in operating conditions at all times. However, airlines do not rely on only one aircraft producer as their fleet consist of different airplanes with different characteristics but with the same goal: transport payload (passengers and cargo). In the specific case of the engines, General Electric provides services to many airlines worldwide under the concept of "flying hours", guaranteeing its customers that their engines, in the different references, will be always in operation conditions. In the other hand, Rolls Royce, also a major engine supplier for the industry guarantees that their engines will be in operation during the entire product life cycle, as the product belongs to the customer. The key difference is the service each of them provide to the industry: GE rents the engine and provides maintenance, while RR sells the engine and offers maintenance at an additional cost

- Provide additional after sales service as it plays an important role in customer satisfaction and retention, as it strengthens the bond between organization and customers. This is a key strategy to follow to engage customers as they get extra value after the product has been sold. However is important to set the limits of the after sales service as this could become problematic if the customer develops an increasing dependence on the supplier. This can be done through signing an Annual Maintenance Contract (AMC), where "the organization promises to provide after sales services to

the second party for a certain duration at nominal costs" (Juneja, 2018). This provides both parties with the limits of the services and the additional cost for "more services" if required.

CH6. Resistance from the "user" to the "ownerless" solution

This challenge is linked with F2.

Potential Solutions:

- Start with a Product-Oriented (PO) PSS model, and then move to "User-Oriented (UO) and Result-Oriented (RO). This can be clearly seen in different industries such aviation (General Electric engines), transportation industry (Uber, Lyft, BlaBlaCar, etc.), housing and hotel industry (Airbnb), etc. The users are moving from traditional ownership of a product to the use of it. Let's take the example of Uber, a growing transportation provider around the world which does not own a single vehicle, as it is a platform aiming to connect people with vehicles and willing to share their car, with people who require to move from one place to other in a city (or even inter-cities). The rider, as a user of the product, is not interested in acquiring the product, solely in the service (transportation) provided. This same example applies for the car rental industry, as the main purpose of the companies is to use the cars as much as they can while on the period of leasing from the car dealer. This, has in some extend, filtered to the banking industry, where the banks offer their customer the possibility to "own" a vehicle under the leasing system, and be able to upgrade to a new one in the near future; the model is simple: while the bank remains as the owner of the vehicle, the customer acts as the user of the product without the responsibility of ownership.

CH7. User's concerns about outsourcing

This challenge is linked with F5. Outsourcing is highly related to the capabilities of the firm. Capabilities affect the possibility of deliver the service with same/ higher quality.

Potential Solutions:

- Limit the service to non-core activities of the user, where the user is interested in the "service/function (e.g., cleaning, cooling, lubricating)" and not the "product" (e.g., chemical). This is a key concern for the user as they can easily choose other service provider or product if they don't feel the new vendor is providing same quality. One option for the company interested in the outpouring is to look into the vendor

references or get a free trial, making sure that the vendor is capable of meeting the quality in-house standards.

- Limit the service to activities the supplier is competent in performing. Outsourcing activities that the vendor will not be able to perform correctly will have a large impact in the service delivery. The key for an appropriate outsourcing is to understand what the "mission critical" processes are, for a company, examining and optimizing them where possible. Then, outsourcing non-core processes is easy to determine and, given that the company working with this will have these activities as part of their core, they will perform in the best possible manner.

- Make sure IP rights are well-protected, as the information shared represents a corporate secret and must be treated correctly. According to the recommendations given by Merino, "*there is no sure-fire way to keep IP under lock and key, but is necessary to remember reducing risk and maintaining competitive advantage when outsourcing*" (Merino, 2016). He suggests three tips to make sure that IP is being considered under the outsourcing umbrella: 1. Know what is being shared, meaning that is necessary to clearly understand the content of the shared information and why is it important. 2. Outsourcing location is important, given that conditions of intellectual property can be different in other territories and this could mean that using it is not illegal in that location. 3. Choose wisely the outsourcing partner, as many times the entities are now based in countries where the same IP laws apply, therefore some unforeseen risks can arise.

CH8. Supplier's concern about "rebound effect" (excessive consumption just because they don't pay for the "amount" anymore, incorrect equipment use, etc.), in case the "user" is still responsible for the "application/use" of the product.

This challenge is linked with the following factors:

- F1. An excessive consumption can lead to a decrease of profits with PSS.
- F3. A "rebound effect" directly impact in the sustainability of the system.

Potential Solutions:

- Perform customer orientation, to incorporate customer requirements in the product design, development, and marketing strategy, changing operations to fit consumer needs. One example of this is the technology industry as it has evolved and adapter

according to the growing and changing needs of the customers, from desktop computers (1990s), to laptops (2000s) and finally tablets and smartphones (2010s).

- Monitor the customer's use/consumption by implementing some metrics and instruments to help tracking with the sole objective of informing what are the real consequences or benefits of the usage profile. One example of this is given by the energy industry, where the solar panel industry is offering additional equipment to users to track their consumption patterns in order to take actions to improve their behavior.

- Define ranges for the use (e.g., "max usage" for given "service", based on past consumption data), allowing users to enjoy of a service within certain limits, that they can go over (if required) but they will be charged for that. One simple example is the mobile carriers industry, as they offer different mobile data and phone calls plans, restricting the user to a limit, however, if the user requires extra mobile data or phone calls, they can do it by incurring in an additional cost.

- Demarcate how the products should be disposed at their end of life, following the different guidelines like the WEEE, and provide the incentives to the users to do it. An example of this is the regulation for proper handling of toxic products in British Columbia, Canada, where the paint manufacturers were required to "set up and fund a system to take back their waste paint, generating the first EPR programs for several products, including flammable liquids, pesticides, pharmaceuticals, oil and gasoline." It works by asking the consumers to pay an "eco-fee" when purchasing the product, funding "the collection and processing of these products when they are discarded" (Recycling Council of British Columbia, 2015), allowing recycling at zero charge.

- Set a service contract, where the responsibilities and liabilities are clear for both parties, and how the warranties can be voided if the user does not use the product with the intended purpose, or what are the obligations of the service provider. For example, "if a doctor makes a contract to effect a cure and fails to do so, he is liable for breach of contract even though he use the highest possible skill. Insurance of such a contract could protect only the medical charlatans. The honorable member of the medical profession is more keenly conscious than the rest of us that medicine is not an exact science, and he undertakes only to give his best judgment and skill. He knows he cannot warrant a cure" (Hanlon, 1964)

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CH9. Initial push to implement the PSS model

This challenge is linked with the following factors:

- F2. The support of public authorities can help to decrease the resistance to change.
- F4. The presence of facilitators can help to decrease the level of risks of the PSS implementation.

Potential Solutions:

- Have support of public authorities (government subsidies, rewards for reduced environmental impact) is key when proposing and implementing new models. In the case of PSS, is proposed that government positions the model by generating a "demand pull" policies, to address these barriers and cultivate market demand. The case of Energy Service Company (ESCo) activity in the UK presents evidence of this support in the regulatory, economic incentive, informative and procurement policies (Hannon, Foxon, & Gale, 2013)

- Have facilitators (to increase engagement, dispute resolution, monitoring and control) as third neutral parties whose interest is to make sure PSS providers and different entities (companies and final users) are working together in a successful implementation.

CH10. Disintermediation of some Supply Chain actors

This challenge is linked with F4. A disintermediation (removal of intermediaries) of some supply chain actors allows decreasing the level of risks to the supplier.

Potential Solutions:

- Increased access ("network") of the supplier by "*removing intermediaries from the supply chain*" (Hickson, Wirth, & Morales, 2006) and helping to connect in a more direct way the supplier with the final customer, allowing better prices for customer and reducing risks to the supplier. Then the new "middleman" has a new role by connecting and adding value to the different parts of the processes. Bhaiya uses Amazon as an example of this new middleman, as it has "*completely redefined what our expectations for shipping costs (free, in most cases) and delivery speed (often same-day) should be*" (Bhaiya, 2017)

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- "Supplier" initiating collaboration, joint venture with "*waste collection agencies, energy suppliers, maintenance/repair companies*" to provide the service to the "user". A recent example of this is given by Boeing, the aircraft manufacturer which last year created a joint venture called Boeing Global Services, "*aiming to provide maintenance, spare parts, retrofits and other services to airline and military customers*" (Boeing, 2018).

2.4.5. Minor factors affecting the servitization business model

The following part presents factors that are somewhat important in the sense that they would make the PSS model more or less attractive. However, they do not play a critical role in the binary decision making process of whether the PSS model should be deployed or not.

MiF1:

- **Definition:** Existence/ effectiveness of incentives to reduce the risk of adverse behavior in the relation between customer and provider.
- **Why this is relevant:** assessing risk carefully and ensuring suitable compensation for the risk-bearing party facilitates the communication and behavior between the parties involved facilitating the problem solution (Reim et al., 2015). The confidence between the stakeholders can be enhanced by identifying and sharing risks in the process.
- **How it impacts the uptake of the PSS model:** The communication between the customer and the provider must be fluent to ensure a proper functioning of the service. The existence of incentives (e.g. through the identification and sharing of risks) between both parts will ensure good communication and predisposition for problems solving.

MiF2:

- **Definition:** Managing complexity in the supply chain.
- **Why this is relevant:** A PSS business model leads to more complex supply chain. Some of the challenges related to complexity of the supply chain are (Meier et al., 2010): risk quantification, forecasting accuracy and data collection. In addition, according to the authors, various factors influence the level of uncertainty derived from the service supply chain. Those include scale of the supply chain, skill requirements, degree of customization and changes in requirements.

- **How it impacts the uptake of the PSS model:** A PSS business model has to deal with the proper integration of the supply chain of the customer and the supplier. Additional suppliers can be added in order to extend limited resources or missing capacities. A non-proper management in the complexity of the supply chain will contribute to the creation of uncertainty and the malfunction of the system.

MiF3:

- **Definition:** Quality of the service: gap between the offered and delivered availability of an industrial good or a service, satisfying the client's needs and expectations.
- **Why this is relevant:** The quality of the service is an essential factor, especially for customer retention. In fact, 65 % of the companies' state low service quality as a cause for substituting their suppliers (Mahnel, 2007). Quality criteria for services are also presented by the authors[27]:
    - Presentation and environment.
    - Reliability, accuracy, correctness.
    - Competence.
    - Politeness, friendliness, cooperativeness, understanding.
    - Authenticity, security.
    - Accessibility and availability.
    - Ability to communicate and socialness.
- **How it impacts the uptake of the PSS model:** A PSS business model is highly impacted by the quality of the service provided. It is directly linked with the customer behavior. The better the perception of the quality, the higher the probability of maintaining customers and attract new ones.

MiF4:

- **Definition:** PSS marketing tactic.
- **Why this is relevant:** To describe how PSS providers interact, communicate, and use customer and market insights to implement their PSS business model (Reim et al., 2013). The strategic application of marketing tactics ensures companies the successful application of their PSS business model.
- **How it impacts the uptake of the PSS model:** "*Marketing aspects are essential to differentiate the business from the competence. They should focus on aspects such as: (i) communicating value, understood as the path through which the PSS provider chooses to differentiate its offerings from its competitors; (ii) extent of interaction with customers, which increases as the company becomes more service-oriented; and*

[27] Developed by Brunner and Wagner (2008)

(iii) marketing insights, mainly related to the functionality and durability of the sold product and the services offered. Potential needs that can be met with future product and service should be identified." (Reim, Parida, & Örtqvist, 2013)

MiF5:

- **Definition:** Technology and service automation (i.e. automated delivery, analysis, maintenance ordering, etc.)
- **Why this is relevant:** the service automation allows a better assessing of the service adapting it and allowing the forecasting of customer behaviors and prevention of failings in machinery. Automation includes remote control of machinery and automated data analysis.
- **How it impacts the uptake of the PSS model:** technology is central to both effective and efficient servitization. Five technologies where identified as the most important in the future of servitization (Dinges et al., 2015):
    - Predictive analytics to predict specific failure modes.
    - Remote communications to adjust/fix products remotely.
    - Consumption monitoring to create customer-specific service offerings. Pushing information to employees or customers via mobile platforms.
    - Mobile Platforms to access the ERP system remotely for maintenance techniques, product details, etc.

2.4.6. Additional challenges that can arise as part of the solutions

Given the complexity of the supply chains and the different characteristics between the parties, there are some hidden challenges that could arise as the result of these interactions. We present some additional challenges that need to be carefully addressed to assure that the implementation of the proposed solutions is possible.

As parties are heterogeneous in their characteristics, likewise the way they store and manage their processes will have several degrees of variation. As expected, some parties are not good on keeping records of their data, meaning that the information sharing becomes a complex task when precision is required.

Inventory management could be difficult if parts are not aligned or if there are no common goals. Therefore is important that the different interested parties state clearly what the expectations are and how they propose to achieve the common goals.

In models like VMI or CPFR is necessary to fix limits and controls on the quantities to be supplied, including and defining properly the minimum and maximum levels of inventory.

When involving another party in the transaction between two parties, such as transportation entity, is necessary that all the involved parties are aware of their roles and how they will collaborate.

Regarding the outsourcing strategy, there are many things that could have a negative effect, such as the lack of transparency or the possibility that the third party is not meeting the local regulations, impacting largely the brand positioning and generating more drawbacks than positive things. As well, the managing of the data is crucial, as the parties will be sharing very private information and any "filtering" could generate in a loss of market share.

2.4.7. Solutions discussion

As explained in the proposed solutions to the different challenges, each of them has its own implementation processes and benefits, when implemented correctly. In this section we summarize the benefits from each of them, not without reminding the reader that the proposed solutions must be customized for each industry and company, and that these are tools that need a proper follow up.

Reducing inaccuracy on payment times. This is perhaps one of the most important outcomes that a company would expect when dealing with these challenges, as this will help the company with the working capital. The proposed solutions that can help on this goal are: contracts, schedule payments and monitor the customer's use/consumption.

Adjustment on conditions. As in any given industry, conditions may change over time due to several reasons (economical, natural disasters, regulations, etc.) and companies need to be able to adapt easily and in a timely manner. The proposed solutions that can help on reaching this goal are: Study the "value" of the service and the willingness to pay by the customer, contracts, multiple sourcing, different suppliers, work with public entities (government), disintermediate parts of the supply chain and evaluate costs along the supply chain (cost-to-serve).

Customer behavior changes over time. As products evolve and change, so does the customer needs and their behavior. Also, this is impacted by how the company is "teaching" the customer on the use of its products. To make sure that there will be consistency between what companies intends the customer to do and what it actually does, the following proposed

solutions aim that goal: willingness to pay of the customer, pilot projects, from Product-Oriented (PO) to User-Oriented (UO) models, Monitor the customer's use/consumption, Customer orientation and Define ranges for product use.

Please note that this brief discussion intends to give the reader a general idea about the biggest concerns for companies: working capital, changes on the market conditions (man-made and natural) and finally changes in the customer behavior. To have a more detailed overview about the individual practice, we advise the reader to find the corresponding example in the "Challenges and potential solutions" section.

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2.5. Reuse, Recycling-and Sustainability business model

2.5.1. An introduction to the Re-use, Recycling and Sustainability archetype

This section provides a brief introduction to the **Re-use, Recycling and Sustainability (RR&S)** Business Model Archetype and provides a short overview of this document. A RR&S business model is based on the principle of and aims to work towards a Circular Economy. The Circular Economy concept describes a regenerative economic system in which resource input and waste, emission, and energy leakage are reduced by **slowing**, **closing**, and **narrowing** material and energy loops.

This system has a range of potential advantages on the economic and environmental performance of organisations. Reduced resource consumption potentially lowers energy and material costs and reduces the depletion of finite natural resources. Minimised waste and emission leakages pre-empt increasingly strict regulatory requirements, saves waste management costs, and reduces toxicity and land use. (Geissdoerfer *et al.*, 2017)

A RR&S business model is aiming to leverage these advantages by narrowing, slowing, and closing resource loops within the organisation and its value network (Bocken *et al.*, 2016). See Figure 33.

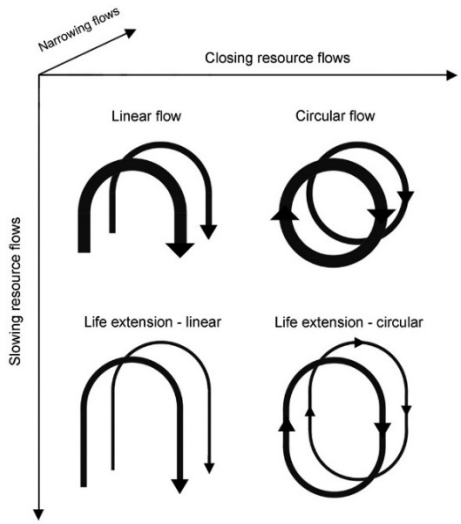

Figure 33. Slowing, closing, and narrowing resource loops
Source: Bocken et al. (2016)

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The introduction of such a business model has impact on both upstream (changed collaboration with raw material suppliers) and downstream (collection of waste) value chain partners as well as on the value proposition (e.g. new recycling, extended producer responsibility or industrial symbiosis services).

Although many businesses initially adopted sustainable strategies in response to public pressure, many now recognise the economic benefit of incorporating sustainable practices within business. As public awareness of environmentalism and sustainability continues to grow, the issue of business sustainability will continue to exert pressure on new and existing business. By committing to sustainability policies, strategies and business models, companies can effectively reduce the environmental damage caused by operational processes, generate positive PR and reduce resource and energy costs thus improving brand perception and increasing their overall profitability.

The successful deployment of this business model depends on several factors and parameters that define the business setting. The model has already been deployed in various sectors, and is known to face unique challenges possibly strongly linked to the factors/parameters, that might hinder its widespread diffusion in process and manufacturing industry and their value chains, which also depends on the type of RR&S business model. INSPIRE literature search, a selection of industrial case studies[28] and contacts with industrial counterparts have highlighted **different forms of this business model archetype** (see Table 5), which have been taken into consideration in defining factors, challenges and potential solutions that determine the potential of the adoption of a circular business model.

[28] INSPIRE Deliverable D 1.1 – Selected Business Cases

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RR&S Business Model Type	Example
In-company R&R of (critical) materials within the same primary production process	REE4EU **recycling of (Critical) Raw metals from magnets**. Using (in-company) side streams from magnet production and end-of-life waste from Rare Earths containing products (electronics, cars, windmills) to produce Rare Earth alloys for magnet production. An industrial scale plant with an efficient and cost-effective method of extraction based on integrated high temperature electrolysis (HTE) and Ion Liquid Extraction (ILE). The Business Case includes a direct production contributing to secure an Independent European Rare Earth Elements Supply Chain, which is currently controlled by extra-EU (mostly Chinese) stakeholders.
Value-chain R&R: Re-use or recycling of (critical) materials within the same value chain	
Cross-sectorial re-use or recycling (R&R): Recycling of side-streams or end-of-life materials into other applications/sectors	**Diaper recycling plant by FATER** (joint venture Procter and Gamble and Angelini, Italy): Used diapers can be recycled and become street furniture and many other items of daily use; cartons for industrial packaging and fertilizer. The technological process of recycling, developed from FATER patents, generates plastic granules and high quality and completely sterilized organic-cellulose material, using steam for eliminating all potential pathogens and odours. From 1 ton of used products 75 kg. plastic and 225 kg. organic-cellulose material can be obtained.
Industrial Symbiosis: Use of side streams of industrial processes as a resource for other industries	**Smart Delta Resources (SDR).** An initiative of eleven power and raw material-based industrial companies in the Delta region joining forces to strengthen the competitive power of the Zeeland industry by smart joint resource-strategies, mainly targeted at Industrial Symbiosis (IS). A joint organisation and ownership of the IS objectives, leads to the identification of "waste to resources" opportunities between industries, defining joint infrastructures and finance models to foster take-up.

Table 5. Examples of different forms of the re-use sustainability Business Model Archetype

Depending on the type of RR&S business model, the impact on the value chain varies. Often new value chain configurations (e.g. through the introduction of new dedicated intermediary stakeholders such as recyclers) need to be set-up to favour adoption of this business model. Each of these configurations requires a different combination of "functioning" (profit making or at least sustainable) business cases in order for the business model to be adopted and maintained.

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Figure 34 schematically visualises these different business case combinations in the value chain.

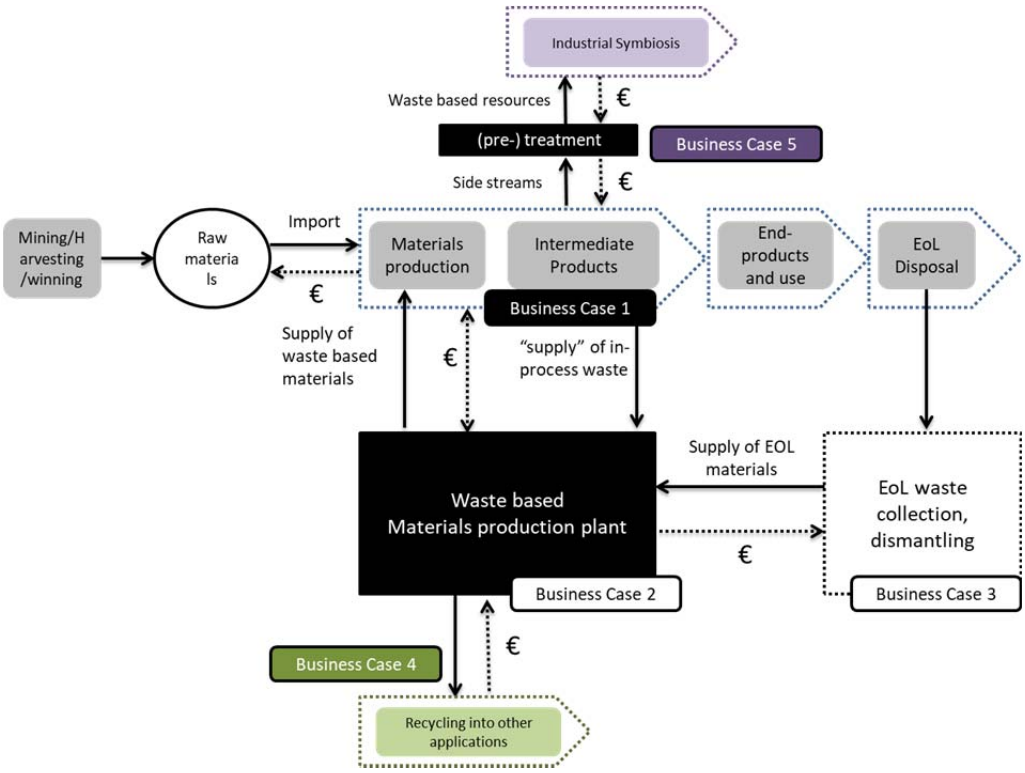

Figure 34. Required combinations of business cases in different RR&S value chain configurations

Hence depending on the RR&S business model type, the following combinations of business case alignments can occur:

- **In company R&R:** The value chain of **in-company re-use or recycling** of (critical) materials within the same primary production process, sometimes requires minimum one "functioning" business case (e.g. if limited external treatment of side streams before re-use is needed). In other situations, e.g. if more demanding side-streams (in-process waste) treatment is needed, a combination of "functioning" business cases 1 and 2 is required;
- **Value chain R&R:** The value chain of **re-use** of (critical) materials **within the same value chain** most of the times requires a combination of "functioning business cases" 1 and 2 but also 3;

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- **Cross value chain R&R:** The value chain of **recycling of side-streams or end-of-life materials into other applications**, requires a combination of "functioning" business cases 2, 3 and 4
- **Industrial Symbiosis:** The **industrial symbiosis** value chain of use of side streams of industrial processes as a resource for other industries, requires "functioning" business cases 1 and 5

The commonality of these RR&S business model variations is that the business model design mostly requires alignment of two or more value chain stakeholders. This needs to be taken into consideration when analysing and interpreting feasibility, decision factors and challenges described in the next paragraphs.

2.5.2. Requirements ensuring "technical feasibility" of the RR&S business model

This section is discussing the requirements for the RR&S business model archetype to work. This is the discussion of conditions that are absolutely necessary for the implementation of the archetype, hence the "technical feasibility" of the business model archetype. The question we are trying to answer in this section is whether it is possible for a company or a value chain to introduce the RR&S model rather than "how good the model is" for the company or value chain. This section could serve as an initial diagnostic tool for a manager to quickly evaluate whether the Re-use model is technically feasible.

R1. Technical capability to introduce the RR&S model

- **Definition**: The technologies needed for the RR&S concept (mainly technology for dismantling of end-of-life products and (pre-) treatment of waste materials) should have a high Technology Readiness Level[29], and should be free to use.
- **Why this is required**: In the case of circular business models, the technical feasibility is determined by the availability of the necessary re-X (reuse, remanufacturing, recycling, etc) technology for the sorting, dismantling (of end-of-life), (pre-) treatment and re-introduction of the materials involved. From a pure feasibility point of view, this is mainly restricted by the materials, since most mechanical assemblies can be disassembled in a not non-destructive way with existing technology. These technical feasible processes are not necessarily viable for the organisation, which is discussed in the next section.

[29] A Technology Radar with the TRL level of different technologies for decentralized and modular is shown in INSPIRE D2.1

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R2. Availability of re-usable or recyclable side streams or waste

- **Definition**: There should be sufficient side-streams or recoverable (end-of-life) waste streams available
- **Why this is required:** For the feasibility of any of the defined RR&S business model types (see Figures 33 and 34), sufficient critical mass of re-usable side-streams or recoverable end-of-life materials need to be available (in Europe, or at least at reasonable geographical distance) to be introduced as feedstock or resource into the primary production process.

R3. Flexibility in feedstock and resource use with primary producer

- **Definition**: flexibility in feedstock and resource use is referred in particular to the capacity of the primary production unit to (re) introduce recycled materials or resources in its production process, besides virgin sources.
- **Why this is required***:* A company or value chain willing to implement one of the re-use or sustainability business model types, in some cases may have to incorporate different kind of flexibilities in its production capabilities, unless we are considering a "drop-in" materials or resources. *Feedstock flexibility* is in fact required in case it needs to be able to handle the introduction in its process of alternative feedstock or resources that could be of different quality or spec than virgin sources.

2.5.3. Business model main decision factors to be considered by the relevant stakeholders

This section describes factors that determine the potential of the adoption of a re-use sustainability business model for the improvement of an organisation's economic, environmental, and social performance. The factors will be described with each time: Definition, main associated criterion and why this is relevant:

The next six factors in the three dimensions: (1) economic, (2) environmental, and (3) social are applicable for the Re-use model. The factors are:

F1. Profitability.
F2. Market attractiveness.
F3. Strategic alignment.
F4. Resource consumption

F5. Capability to organise waste collection
F6. Maturity of and trust in RR&S solutions

F1. Profitability

- **Definition**: Profitability is a central criterion for all privately-owned business. This factor contrasts the value that the RR&S model can create, given the specific market conditions, industry, resource and capabilities, and value proposition of the organisations involved in the value chain, with its influence on the cost structure.

- **Main associated criterion**: Economic.
  - How does the RR&S model affect expenses of the business(es)
  - How does it affect the income generated; revenues?
  - How does it affect secured resources; operations and purchasing?
  - How does it affect the cost structure; stable cash flow and investments (payback)

- **Why this is relevant**: It is one of the most important performance indicators for most profit-oriented organisations. The different elements in the Circular Economy provide considerable potential for cost reduction (e.g. by substituting virgin raw materials or resources with potentially cheaper recycled alternatives). However, this potential cannot be realised in every organisational and value chain context and there are risks that can lead to the reduction of revenues (e.g. lower perceived value of recycled materials and remanufactured goods) and an increase in costs (e.g. smaller batches and more manual work). Furthermore, as indicated, to make the Re-use business model archetype work, it is often important for multiple value chain stakeholders to be aligned. The profitability (or economic sustainability) criterion needs to be met for each of the stakeholders involved.
- **How it impacts the uptake of the RR&S model:** The cost of collection and (pre-) treatment of waste (side streams) plays a key role in realising profitability in the re-use business case. These costs depend on different factors, i.e. de cost of the treatment technology (e.g. remelting metals such as magnets to extract critical raw materials like neodymium) is very energy intensive, disassembly of products and materials, such as End-of-life electronics (WEEE) to separate small amounts of re-usable pure enough materials, can be too costly to generate a business case, unless volumes are large enough, market price of recycled materials can be lower due to lower quality (perception). Also, the geographic distance of (e.g. EoL) waste and the impact on logistic costs plays a role.). Trade-offs between local collection of waste, treatment

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and re-use versus logistics towards central treatment units need to be taken into consideration. For industrial symbiosis it needs to be considered if new infrastructures (e.g. pipelines) need to be built (CAPEX) to enable waste-to-resource concepts.

- **Scoring**: The overall profitability needs to be assessed for each involved and aligned stakeholder, estimating a trade-off between the different elements that either increase or reduce profitability. This would ideally be done based with detailed business case calculations for each involved value chain stakeholder, but for a first assessment the potential interest can be assessed based on the following scoring.

Factor			score
F1. Profitability.	**Expenses**	1 (higher expenses) - 5 (less expenses)	
	Income generated	1 (lower income) -5 (higher income)	
	Secured resources	1 (less secured) - 5 (better secured)	
	Stable cash flow	1 (more instable) - 5 (more stable)	
	Investments (payback)	1 (high investments) - (low investments)	
		Total	0
		Average	0

Figure 35. Scoring on profitability

F2. Market attractiveness

- **Definition**: Market attractiveness is a central company-external criterion for most privately-owned business. The factor considers the size, the growth and competitiveness of markets in which the re-use models that are feasible for an organisation, given its resource and capabilities core competencies.

- **Main associated criterion**: Economic, social.
  - Market size
  - Potential market growth rate
  - Competitivity
  - Entry barriers
  - Opportunity to differentiate products

- **Why this is relevant**: This factor considers the potential size (or relevance), growth and competitiveness of markets for circular business models that are feasible for an organisation. Re-use business models can focus on considerably different markets

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than the current business model of the firm, e.g. in case of "repurposing" of side streams to other applications or sectors. This is the case of recycling in-process or end-of-life waste (e.g. plastics) as a material for other products. The same counts for using process side-streams as resource for other industries (industrial symbiosis). The attractiveness of these markets are a relevant indicator for the economic viability and sustainability of the circular business models and for the possible interest of a company (or multiple aligned companies in the value chain) to invest in such a business case.

- **How it impacts the uptake of the RR&S model:** Profitability elements described above play a role in the market attractiveness. The attractiveness of re-use driven markets will be a key driver or barrier for the adoption of the model and will determine their long-term survival. This may be based on a predicted growth in customer pressure for greener products, and the opportunity to differentiate products towards competition. On the other hand, there may be other drivers such as environmental strategies or legislation that motivate a company or value chain to go for the RR&S model. For example, a foreseen ban of difficult to recycle flexible multilayer packaging may drive a company to find packaging solutions that are based on recycled or recyclable materials. In such case the market attractiveness plays a less dominant role in the decision making. This needs to be considered.

- **Scoring**: Whereas the market attractiveness ideally should be based on quantified estimations of a potential future market size and growth rate, it also needs to take into consideration how the RR&S model impacts competitive position and product differentiation in the market place (e.g. greener or cheaper products). At the same time, such a market relevance needs to be compensated for other factors that may be the "real drivers" for taking-up this model (e.g. legislation, pressure for green and sustainable solutions).

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Factor			score
F2. Market attractiveness.	**Market size**	1 (lower) - 5 (higher)	
	Market growth rate	1 (lower) - 5 (higher)	
	Competitivity	1 (lower) - 5 (higher)	
	Entry barriers	1 (higher) - 5 (lower)	
	Opportunity to differentiate products	1 (lower) - 5 (higher)	
	Relevance of the market attractiveness (e.g. other reasons are more important)	1 (higher) - 5 (lower)	
		Total	0
		Average	0

Figure 36. Scoring on market attractiveness

F3. Medium to longer term strategic alignment

- **Definition**: Other strategic goals beside profit and market attractiveness can differ considerably between organisations and markets. We group the contribution that the adoption of the RR&S model would imply in the factor 'strategic alignment'. Examples for strategic goals are longer term positioning (sustainability), market domination, customer benefit or public perception or benefit.

- **Main associated criterion**: Economic, environmental, and social.
  - What are the essential goals for the organisation?
  - Which one would be a deal-breaker?
  - How would the adoption of the RR&S model contribute to achieve these goals?

- **Why this is relevant**: There can be considerable commitment to certain strategic goals by organisational decision makers, which can be based on a broad range of motivations. As a consequence, these goals can trump other indicators and become a decisive basis for the evaluation of the re-use business model adoption. Depending on the organisation and the responsible decision makers, strategic alignment can be the most important factor in the uptake of the model.
- **How it impacts the uptake of the RR&S model:** A trend towards pressure to create shareholder value may lead to the impression that targeting re-use and recycling could go against strategic alignment. However, taking a more strategic medium to longer

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term approach could be beneficial and turn a re-use approach into a winning strategic choice, anticipating the impact of emerging policy pressure (Paris agreement to reduce CO2 impact) and being one of the first to be ready for the future circular economy. Unilever for example shows that making sustainability choices can lead to shareholders value while fostering longer term sustainability. This may also lead to "self-regulation" with other value chain partners, making the re-use and recycling the preferred strategic solution as all value chain partners buy-in to this regulation and hence becomes the market standard. Whatever the situation, it is likely that a choice for the RR&S needs to make sure that there is a strategic alignment, not only within a single organisation, but within and between different organisations in the value chain. For example, a company may want to increase the level of re-cycled materials in its products due to strategic choice for green products. This often requires a strategic alignment with another value chain partners to collect, sort and separate this material in end-of-life products. These can be private (waste management) companies as well as public organisation (e.g. cities or regional governments) that made a strategic choice (and an economically sustainable business case) to favour recycling.

- **Scoring**: The strategic alignment of the Re-use business case can be scored for various internal strategic factors, as well as with respect to potential alignment with strategies of other essential value chain partners.

Factor			score
F3. Strategic alignment.	**Longer term market stability**	1 (lower) - 5 (higher)	
	Longer term shareholders value	1 (lower) - 5 (higher)	
	In line with current top management strategy	1 (lower) - 5 (higher)	
	Product development strategies aligned with its customers' needs	1 (lower) - 5 (higher)	
	Strategic alignment with other essential value chain partners	1 (lower) - 5 (higher)	
		Total	0
		Average	0

Figure 37. Scoring on strategic alignment

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F4. Resource Consumption and security

- **Definition**: Resource consumption describes the increase or decrease in energy and material consumption as well as availability (security) that would follow from the adoption of a circular business model. This factor depends on the current and expected energy and material efficiency and how much resources can be recovered along the value chain and after the use phase of the product.

- **Main associated criterion**: Environmental, social.
  - How does it affect the consumption of non-renewables?
  - Is there an efficient use of energy?
  - How does it affect the use of raw materials?
  - Is there a re-use of waste streams?
  - What about the resource security?
- **Why this is relevant**: The depletion of finite resources is a key environmental concern. To reduce resource consumption or secure resource availability is one of the key potential benefits of the RR&S model, which tries to keep materials and energy in the system to reduce raw resources input. The wish or need to reduce dependency on import of essential (critical) raw materials from non-European or geo-politically less stable and reliable sources, also makes recycling an interesting alternative to secure availability of raw materials. Environmental responsibility also can play an important part in the communication to the stakeholders including customers and investors.
- **How it impacts the uptake of the RR&S model:** Resource consumption: re-use and recycling in principle leads to resource reduction (used material instead of virgin) and reduction of CO2 impact, unless the resources needed to collect, (pre)treat and transport the waste materials outweigh the savings on virgin materials. This could be especially the case with metals or composites where energy intensive (pre) treatment is necessary. This may be solved by new emerging low energy treatment solution or direct reconversion of components of the waste back into the primary production chain. e.g. rare earth containing metals from magnets to be directly treated for re-use, without extraction of rare earths. Also, large scale collection of end-of-life waste to be centrally treated to recycle materials may impose significant resource usage in logistics. Local collection, treatment and re-use could offset the resource consumption related to large scale centralised treatment and re-use.

- **Scoring**: All scoring factors ideally will be quantified in a LCC (Life-cycle cost) analysis, combining the impact for each individual value chain partners, as well as taking a full value chain view (the impact on the full life-cycle of the material). A first

indication of the relevance of this factor for the company and/or the aligned value chain can be obtained through the following scoring.

Factor			score
F4. Resource consumption.	**Consumption of non-renewables**	1 (higher) - 5 (lower)	
	Efficient use of energy	1 (lower) - 5 (higher)	
	Use of virgin raw materials	1 (higher) - 5 (lower)	
	Re-use of waste streams	1 (less re-use) - 5 (higher)	
	Resource use in logistics	1 (higher) - 5 (lower)	
	Resource security	1 (lower) - 5 (higher)	
		Total	0
		Average	0

Figure 38. Scoring on resource consumption

F5. Capability to organise collection of a critical mass of re-usable waste materials

- **Definition:** The potential that the value chain stakeholders ensures that the sufficiently available re-usable or recyclable waste materials or resources are captured.
- **Main associated criterion**: economic, social.
- **Why this is relevant:** The RR&S business model requires that re-usable or recyclable waste materials and resources are available in sufficient volumes and that the value chain stakeholders are capable to organise that they will be captured and valorised in such a way that the business model will be sustainable.
- **How it impacts the uptake of the MC model:** Depending on the type of RR&S business model type (in-company re-use or recycling, value chain or cross value chain re-use and recycling, industrial symbiosis), this factor may be of different importance. In the case of in-company recycling, this factor may be less critical (easier to organise as under control of a single organisation and likely on a single location). In the case of (cross) value-chain recycling, multiple partners may need to collaborate e.g. local authorities to collect end-of-life products and materials, waste management companies to sort and (pre-treat), recycling companies to prepare and product manufacturers or process industries to re-introduce in their primary production process. In some cases, such value chain processes and organisations are already in

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place, in other situations they need to be set-up by value chain partners (e.g. create new recycling companies). To foster impact of the RR&S business model in the value chain, trust between partners can be a decisive factor.

- **Scoring**: The scoring requires a careful and qualitative analysis of the full value chain to be involved in the RR&S business model, their capabilities and reliability to implement the model.

Factor			score
F5. Capability to organise collection of a critical mass of re-usable waste materials	**sufficient side-steams or waste materials can be recovered**	1 (difficult) - 5 (easy)	
	Value chain processes to collect, (pre)treat and re-introduce in place and developed	1 (low development) - 5 (in place)	
	Amount of value chain partners that need to be aligned	1 (higher) - 5 (lower)	
	Level of trust between the value chain partner to be involved	1 (lower) - 5 (higher)	
		Total	0
		Average	0

Figure 39. Scoring on capability to organise collection of a critical mass of re-usable waste materials

F6. Maturity of and trust in RR&S technologies

- **Definition:** RR&S technologies need to be of a sufficient Technology Readiness Level[30].
- **Main associated criterion**: economic. social
- **Why this is relevant:** In the case of RR&S business models, some re-X (reuse, remanufacturing, recycling, etc) technologies for the sorting, dismantling (of end-of-life), (pre-)treatment and re-introduction of the materials involved, or relatively new or emerging. To implement RR&S often mature but sometimes still relatively innovative technologies may be needed in order to guarantee cost-efficient collection and pre-treatment of (waste) materials and feedstock flexibility in the primary production process where the recycled material is re-introduced. The impact of these solutions on the status-quo and related cost can vary depending on the field of application and technology readiness.

[30] A Technology Radar with the TRL level of different technologies for decentralized and modular is shown in INSPIRE D2.1

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- **How it impacts the uptake of the RR&S model:** Companies applying RR&S may have to accept relatively novel technologies and non-virgin materials within their primary industrial and business process. This impact in terms of costs, new competencies required, new partners to be included in the business network as well as trust and confidence in the new solutions.

- **Scoring**: economic factors have been scored above. In this part we score the level of impact and change that the novel RR&S solutions may have on the primary process, and related confidence by the company in such solutions.

Factor			score
F5. Maturity of and trust in RR&S solutions.	**How easy is it to find adequate mature RR&S technologies**	1 (difficult) - 5 (easy)	
	Level of impact/change of the new technologies on the primary production process	1 (low impact) - 5 (high impact)	
	Level of maturity of required technologies	1 (lower) - 5 (higher)	
	Level of trust in the new RR&S technologies	1 (lower) - 5 (higher)	
		Total	0
		Average	0

Figure 40. Scoring on maturity of and trust in RR&S solutions

2.5.4. Value Chain and Business Model Challenges

This section gives a short overview of potential "challenges" that exist for taking-up the RR&S business model(s). These challenges cause a typical company in the process/manufacturing industry to end up with a "lower score" for some of the factors above. We provide possible solutions which may increase the scores and make the take-up of the business model more attractive.
The following five key challenges have been identified for the RR&S business model(s):

CH1. Ownership and responsibility
CH2. Economic feasibility
CH3. Market value and acceptance
CH4. Financing

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CH5. Trust and liability

The importance of each of these Challenges vary according to the RR&S business model type, as indicated in Table 6.

RR&S BM types / Challenges	In-process R&R	Value chain R&R	Cross Value-chain R&R	Industrial symbiosis
Ownership and responsibility	X	XX	X	XXX
Economic Feasibility	X	XX	XXX	X
Market value and acceptance	X	XX	XXX	X
Financing	X	XX	X	XXX
Trust and liability	X	XX	X	XXX

Table 6. Level of importance of the RR&S challenges vs RR&S BM types

In the following paragraph we elaborate how each of the challenges plays a role in one or several of these BM types. We also provide some suggestions to improve the potential of the business model archetype, based on our literature search, case studies and industrial contacts. For each of them we indicate how it may impact the scoring of the factors indicated in the previous section.

CH1. Ownership and responsibility

- **Description:** As the RR&S often introduces new roles in the value chain to enable collection, pre-treatment and re-introduction of recycled materials in the primary production, the question is where the ownership and responsibility for the new business model lies. In some cases, this is straight forward e.g. an existing recycling company sees a business opportunity to buy end-of-life waste, treats it and sell it back into the primary production chain. In other situation, things are not so obvious, such as in value chains where no such company exists, the business case is less convincing or not within the core-business of any of the value chain partners (e.g. often the case with industrial symbiosis). Also, regulation plays its role here, as waste is often strongly regulated and – depending on the country (no EU regulation exists yet) –to be re-used or recycled, waste needs to follow particular procedures (e.g. can only be treated by authorised parties).

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- **Solution:** Various solutions are available to solve such situations. Some of them include:

  In the case of (cross) value chain R&R:
  - An existing recycling company, takes on new technological solutions (e.g. on a licence base from the technology developer) and builds a new business to introduce new recycling solutions within or across different value chains.
  - A completely new recycling company is being set-up to manage the new R&R opportunities, possibly (partly) owned by other value chain partners with an interest to re-introduce the recycled materials from their product.
  - A producer takes the responsibility for its product and the embedded materials throughout the value chain i.e. extended producer responsibility (EPR), including take-back schemes of the used materials. This can lead to new value propositions by this producer based on the servitization concept[31]. An example of such a case can be chemical leasing. See http://www.chemicalleasing.com/ from the United Nations Industrial Development Organisation (UNIDO) that provides further explanation of this business model, including various case study examples, lessons learnt from 10 years of UNIDO's work in the domain and a practical toolkit that can help companies to learn in a systematic way how to integrate Chemical Leasing in daily operations at plant level. The toolkit can also be find here http://chemicalleasing-toolkit.org/
  - In the case of regulatory bottlenecks, the value chain partners need to carefully consider their business case(s) in the light of the so-called "end-of-waste criteria" [32]and which are the entities legally authorised waste collection, treatment and valorisation. It needs to be considered that relative legislation is mostly national and cross-border transportation of materials qualifies as waste may generate complications. Solutions to be considered are to set-up regional or national (not cross-border) re-use or recycling business cases in collaboration with authorised waste treatment companies.

  In the case of Industrial Symbiosis:
  - A new intermediary organisation can be set-up between two or more industries to manage the industrial symbiosis between them (e.g. collect waste streams, treat it and transport it to other industrial users as a resource).

[31] See 2.3. in this document for description, requirements, challenges and practical solutions for the "Servitisation business model"
[32] http://ec.europa.eu/environment/waste/framework/end_of_waste.htm

- A new intermediary organisation can be set-up by an industrial park (e.g. its management company) to manage the industrial symbioses between multiple industries located in the park, as such also providing a service to these industries and offering an attractive Industrial Symbiosis eco-system for new industries that are looking for a location.
- An on-line platform can be used (if existing) or created providing the opportunity for industries that have re-usable side streams, to offer these to whoever is interested to valorise them as a resource. Several regional[33], private[34] as well as European[35] initiatives are available or emerging that aim to solve the ownership issue related to valorisation of industrial side-streams, leveraging on the platform economy concept.

CH2. Economic feasibility

- **Description:** Scale and buy-in from other industries can play an important role in in establishing economic feasibility of the RR&S business model, especially for (cross) value chain recycling and industrial symbiosis. In-company R&R is a straight forward case, in which the cost of recycling either is or is not sustainable. This must be offset against the costs of buying virgin feedstocks in the process. Most of the times, recycling in this case should be economically feasible unless side-streams are really small. This may be different in (cross) value chain R&R, in which the combined cost of collection, (pre)treatment and re-introduction of the recycled materials from different value chain partners may be prohibitive to the business model. Within Industrial Symbiosis it is even found that the "*risk and uncertainty linked to the difficulty to identify cost-benefit and return on investment ex-ante*" is considered to the number 1 barrier to IS transactions[36]. With (cross) value chain R&R, collection of end-of-life products is often a local or regional business, which may lead to a low critical mass of recyclable materials. Economies of scale may require transport to a central location for treatment to be re-used, posing questions regarding the economic sustainability due to logistic costs.
- **Solution:** The economic feasibility may be improved by creating critical mass of re-usable or recyclable materials in the value chain. If more industries or end-of-life waste collectors (e.g. local authorities) in the value chain collaborate and adopt this

[33] http://www.residuorecurso.com/en/inici
[34] https://www.organix.suez.fr/
[35] http://sharebox-project.eu/
[36] See EU publication on Industrial Symbiosis: https://publications.europa.eu/en/publication-detail/-/publication/174996c9-3947-11e8-b5fe-01aa75ed71a1/language-en

practice sufficient volume of re-usable waste materials may be generated to justify an investment in (pre) treatment plants. In this context it is essential that all the different business cases from involved value chain partners (e.g. of the waste management company, the recycler and the primary producer) will be profitable. Some practical solutions to be considered here could be:

- A gradual upscaling strategy could be applied where first in-company re-use and recycling is pursued, later this may be combined with value chain collection and R&R. This could start locally (e.g. in an urban context), then expanded to regional, national or even cross-border re-use (cross-border transport of waste needs to be regulated and allowed though).
- Introducing incentives for end-users (e.g. citizens or other players) to collect end-of-life waste and bring it to a number of local collection centres. This could reduce cost of collection and increase the volume of end-of-life materials to be re-treated and used. This can be organised in collaboration with public authorities (e.g. reduced waste taxes in case of separate collection and recycling, or using container deposits). However, this can also be done through private initiatives e.g. with the involvement of product brands. For instance, customer loyalty programmes have been designed to this end. An example is the diaper recycling initiative from FATER/Procter and Gamble in which parents are incentivised to return used diapers for recycling, offering a client card and points that can earned by returning used diapers. These points can be used to acquire new diapers. Modern ICT (e.g. behavioural apps) could be used in this context to foster collection[37].
- If critical mass at one location is too small to justify a single local treatment plant, but multiple locations would offer sufficient critical mass, a possible solution is to develop smaller scale mobile waste treatment solutions that can move from one location to another. A few inspirational examples of such a solution are available in the market[38] [39] or under development[40] [41]. This solution is in line with the "Modular Production" Business Model Archetype as discussed earlier in this document. Further information on that business

[37] Antonis Mavropoulos, Mobile Applications & Waste Management: Recycling, Personal Behavor, Logistics, March 2013 - https://www.researchgate.net/publication/276181634_Mobile_Applications_Waste_Management_Recycling_Personal_Behavor_Logistics
[38] https://inhabitat.com/worlds-first-mobile-recycling-plant-turns-trash-into-tiles/
[39] https://www.kiverco.com/en/products-solutions/mobile-recycling/picking-station
[40] http://www.mobileflip.eu/
[41] https://cordis.europa.eu/project/rcn/105213_en.html

model, its challenges and related possible solutions can hence be found in paragraph 2.3.

- Another option for this same case would be to apply a "hub and spoke" solution, where local collection and pre-treatment is combined to reduce volumes and weight and only afterwards the pre-treated materials are transported to a central location for separation and upgrading, before launched on the market. For an example see http://publications.iowa.gov/23381/
- The cost of collection and recycling may furthermore be reduced by standardisation. An example could be to use standard markers in plastics enabling waste treatment companies to easily recognise and separate out re-usable plastic streams of sufficient and homogeneous purity.

- **Impact on the scoring of the factors:** The proposed solutions may impact F1 (Profitability), F2 (Market attractiveness) and F5 (Capability to organise collection of a critical mass of re-usable waste materials).

CH3. Market Value and acceptance

- **Description:** Market value may depend on the acceptance of consumers of products with recycled materials (e.g. plastics from recycled diapers). Clients (B2B) sometimes prefer virgin materials as they think consumers do not appreciate recycled materials or the quality of such materials is lower, leading to a lower market price, and hence lower market attractiveness.
- **Solution:** Creating awareness about the benefits of recycled materials, taking an LCA approach could be a good solution and brand "green products" as qualitatively adequate and competitive and hence increase market attractiveness. Also taking a longer term more strategic approach and position oneself as a first mover in the emerging circular economy may eventually generate benefits.

  Various tools are available to support this approach. A free Value Chain footprint analysis tool originally targeted at small companies is available from the University of Manchester[42] providing case studies and starting point LCA information in different LCA cases from multiple sectors. CCaLC2 is the second generation of the CCaLC carbon foot printing tool that enables quick and easy estimations of life cycle greenhouse gas emissions along different supply chains. CCaLC2 for Windows provides a standalone desktop application for you to perform your CCaLC analysis without requiring Microsoft Excel. It provides a powerful tool for reducing and managing carbon footprints of products, processes or supply chains. The

[42] http://www.ccalc.org.uk/software.php

methodological approach follows the internationally accepted life cycle methodology as defined by ISO 14044 and PAS 2050. Market acceptance could be built by collaboration in the value chain, and sharing more knowledge on where which material can be found in the products and in Europe (e.g. material passport in the value chain

- **Impact on the scoring of the factors:** The proposed solutions may impact F2 (Market attractiveness) and F3 (strategic alignment).

CH4. Financing

- **Description:** The creation of plants for disassembly and pre-treatment require an initial investment. This investment should come from companies in the value chain or from investors. Not all parties in the value chain are capable or willing to invest in this new technology. This is especially the case if profitability and market attractiveness are relatively low compared to the companies' core business. In some cases (joint) infrastructures are required to facilitate treatment, sharing or transporting of waste and side-streams, malign them available as a resource (e.g. sometimes the case with Industrial Symbiosis). This may require significant investments that a single value chain partners is not willing to take (also an ownership issue).
- **Solution:** Improving the business case (as described under economic feasibility e.g. by increasing the critical mass through value chain collaboration) and proving that the business case will be positive (e.g. through a gradual upscaling strategy), may result in more willingness to invest. The financial sustainability can also be improved by new ownership constructions, through leasing-contracts and/or collective financing by consortia of current actors.

  For larger scale investments with a societal benefit, public institutional investors are an interesting option. Large pension funds are sometimes interested in investing in sustainable infrastructures[43]. The European Investment Bank (EIB) also offers investments that promote sustainable growth and job creation[44]. This is especially interesting if larger scale investments for recycling infrastructures (e.g. a pipeline to connect industries for sharing waste-heat or waste-gases turning them from waste to resource).

[43] https://www.theguardian.com/sustainable-business/public-pension-funds-sustainable-investment-pioneers
[44] http://www.eib.org/projects/regions/european-union/index.htm

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- **Impact on the scoring of the factors:** The proposed solutions may impact F3 (strategic alignment), F4 (Resource Consumption), and F5 (Capability to organise collection of a critical mass of re-usable waste materials).

CH5. Trust and liability

- **Description:** Collaboration in the value chain for waste recycling or re-use requires trust between value chain partners. This is especially the case where an important share of the companies' feedstock would depend on the recycled materials. An example could be the situation where end-of-life critical raw materials (rare earths) would be collected and recycled in large amounts, with the purpose to reduce the dependency on import from less reliable extra-European stakeholders. This would also be the case, when through industrial symbiosis a company's process depends from a waste-to-resources stream of a neighbouring company. In both examples, trust and liabilities need to be organised, institutionalised and contractualised.
- **Solution:** In the case of (mutual) interdependency for (recycled) resources it is advisable to create a joint economic interest by "institutionalising" the collaboration or "contractualising" the liabilities in combination with territorial vicinity.

  That can be done by:

  - Joint ownership of the legal entity that has the responsibility and economic interest to manage the value chain recycling process (e.g. a recycling company, or other intermediary)
  - Setting-up "ESCO type of collaborations", with clear liabilities for non-delivery of resources. An ESCO is a public or private organization that traditionally provides energy services but in this context, provides integrated waste solutions to its customers. An "Environmental Service Company" ("Esco") implements a customized environmental service package (consisting typically of planning, building, operation & maintenance, optimization, resource purchase, (co-) financing, user behavior ...)[45]. The "Esco" provides guarantees for all-inclusive cost and results and takes over commercial and technical implementation and operation risks over the whole project term of typically 5 to 20 years (source: Bleyl+Schinnerl). When speaking about waste, re-use or sustainable business models the 'Esco' is supposed to focus on improving waste efficiency hence waste savings. Typical for Esco's in the re-

[45] This business model fits the "servitization" model. Please refer to the specific section in this document for more information about that Business Model Archetype

use archetype is the provision of 'waste-reduction-performance' contracts, where a contractual guarantee is given to the customer on the estimated waste savings, but also waste management can be guaranteed through a performance contract.

Whereas ESCO's offer new business models for energy optimisation[46] e.g. in industrial parks, it may provide inspiration for new business models in dealing with for instance optimisation of water usage or industrial symbiosis. We did not find dedicated sites with information, tools and templates for this application of the ESCO model, however practical tips, tools and contracts from the ESCO application to the energy world may offer a useful starting point.

This very comprehensive page contains a model contract template and companion documents to help you launch energy efficiency projects through Energy Savings Performance Contracting (ESPC): https://www.energy.gov/eere/slsc/model-documents-energy-savings-performance-contract-project

Template for ESCo contract – short version: http://task45.iea-shc.org/data/sites/1/publications/IEA-SHC-T45.C.2.3-INFO-ESCo-Contract-template-short-version.pdf

Institutional and contractual arrangements alone may not suffice to foster take-up of this business model. It is well known that RR&S collaboration that crosses companies' borders such as value chain R&R and industrial symbiosis " *needs trust, personal intimacy, commitments and interests between the stakeholders of an industrial symbiotic systems (Almasi et al., 2010).*" [47] Local to local networks (e.g. in industrial parks or urban eco-systems) may hence be essential to foster this business model.

- **Impact on the scoring of the factors:** The proposed solutions may impact F5 (Capabilities to organise collection of a critical mass of re-usable waste materials), and F6 (Maturity and trust in RR&S solutions).

[46] http://www.buildup.eu/en/news/innovative-esco-business-models-and-energy-management-strategies-0
[47] Agnese Tomassini, "The emergence of industrial symbiosis in the Rotterdam harbor region; the role of social proximity and place attachment", January 2016.

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2.5.5. Minor factors affecting the Re-use business model

The following part presents factors that are somewhat important in the sense that they would make the RR&S model more or less attractive. However, they do not play a critical role in the binary decision-making process of whether the RR&S model should be deployed or not.

MiF1. Corporate Social Responsibility (CSR)

- **Definition**: Describes impacts on societal and environmental spectrum of the organization as result of shifting from traditional business model to circular business model. This factor groups a range of impacts of the transformation to a circular business model on the local and wider societal environment of the organisation. This includes sponsorship activities, corporate philanthropy, pro bono work, social sabbaticals, etc.
- **Main associated criterion**: Environmental, social.
    - What influence the re-use model has on the CSR portfolio?
    - Value for the stakeholders (and investors)
    - Partnerships
    - Social interest in the local economy
    - Impact of the operations on the environment
    - KPI's to follow up the CSR
    - How does the model influences the communication strategy?
    - How does the business model influence the perception of the organisation for the different stakeholders?
- **Why this is relevant**: CSR measures are important in the communication with a range of different stakeholders. They help to mitigate risks from these stakeholders in the organisational environment and build up political and societal goodwill and can potentially improve the relations to suppliers and other value chain partners, as well as attracting and retaining talent.
- **How it impacts the uptake of the RR&S model**: Personal responsibility of decision makers as well as responsible organisational strategies and culture are a relevant motivation for the uptake of the related solutions. Social responsibility is one of the key considerations in this context. Social considerations play an important part in the communication through different stakeholders in the value chain and may favour the uptake of the RR&S business model, together with the other previously mentioned factors.

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MiF2. Motivated employees

- **Definition**: Adoption of the RR&S model will increase motivation of employees due to their engagement in sustainability and societal relevant work.
- **Main associated criterion**: social.
- **Why this is relevant**: not only does decentralized production increase motivation of employees (see under Business Model Archetype Decentralised production)[48], but also the benefits of employee's engagement in sustainability activities at work[49].
- **How it impacts the uptake of the RR&S model**: The proven sense of engagement and motivation on employees is likely to provide an additional incentive (beyond the key factors mentioned above) for managers and decision makers to foster the take-up of RR&S business models.

2.5.6. Additional challenges that can arise as part of the solutions

Given the complexity of the supply chains and the different characteristics between the parties, there are some hidden challenges that could arise as the result of these interactions. We present some additional challenges that need to be carefully addressed to assure that the implementation of the proposed solutions is possible.

- Public Policy & Climate Change: Climate change is the most significant challenge of current and future generations. It affects all aspects of our economy, society, and environment. Companies need to play a greater role in decarbonizing the economy and building resilience to climate impacts.
- Collaborating for Sustainability: Most sustainability issues require systemic change, and systemic change requires collaboration among stakeholders. Businesses need to speak with one voice with competitors and affected stakeholders to tackle sustainability challenges.
- Measuring & Reporting Sustainability: Given the proliferation of sustainability rankings and reporting standards, businesses need to know how to streamline reporting to reduce redundancy, resolve inconsistencies, and produce a positive impact...

[48] The Future of Work: How the New Order of Business Will Shape Your Organization, Your Management Style, and Your Life, by Thomas W. Malone. Harvard Business School Press, 2004.
[49] Serafeim, George, Robert G. Eccles, and Tiffany A. Clay. "Caesars Entertainment: CodeGreen." Harvard Business School Case 111-115, March 2011. (Revised August 2012.)

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- Sustaining Sustainability Programs: There is still an incomplete, inconsistent understanding of what sustainability means for business. Sustainability needs to be a core part of business activities.
- Educating Consumers
  Sales of sustainable, socially responsible products and services are not reflective of the efforts invested in their development. Businesses need to better understand how to measure, classify, and market sustainable products and services in a way that avoids greenwashing and instead positively influences consumer behaviour.
- Creating a Long-term Orientation
  Turbulent financial markets, unstable consumer purchasing patterns, changing trade agreements, and inconsistent public policies make it increasingly difficult to act for the long-term. Businesses need a way to reconcile short-term and long-term perspectives.

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2.6. Emerging Energy Carriers (EEC)

2.6.1. An introduction to the emerging energy carriers archetype

A trend is seen in the energy sector which moves from central fossil power plants to decentralized renewable energy production (for example solar, wind or biomass). Solar and wind power are large contributors to renewable energy production and are of major importance to realize sustainability targets. These power sources have as a drawback that they are inflexible; it is not possible to shift the amount of power at will, others than curtailment.

The chemical industry is an energy intensive industry. This is because of energy intensive processes but also because energy is used as and for feedstock production (e.g. natural gas or electrolysis for hydrogen production). Trends in the energy sector can therefore influence the chemical sector. Energy use is seen as a cost center and as a large part of the carbon footprint in the chemical supply chain. Chemical companies are therefore looking to optimize their energy use and sourcing[50].

At this point the energy sector and the chemical industry can find each other. The chemical industry can provide flexibility to the energy sector by offering demand-response and energy storage functionality. In exchange the energy sector can provide low cost electricity to the chemical sector. This is in short what the *Emerging Energy Carriers* (EEC) business model archetype represents.

Figure 41 shows the traditional supply chain: a central energy supplier delivers energy to a chemical producer, which produces chemicals in a large scale central production plant.

[50] Description of the archetype was taken from INSPIRE D2.1.

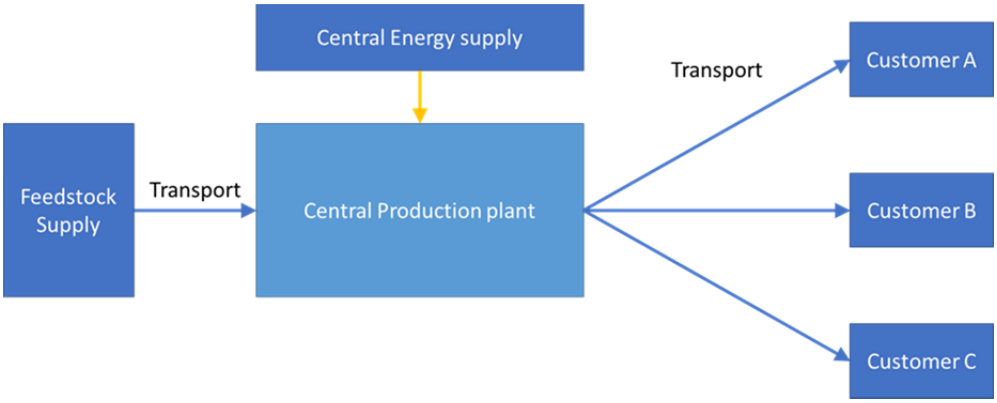

Figure 41. Traditional supply chain emerging energy carriers

In the future supply chain, chemicals will play a role as energy carriers in two ways[51]:

- Through **demand-side response:** The chemicals producer, that produces chemical product from (sustainable) electricity allows an electricity grid operator to reduce (or shut down) the production to reduce power shortage in the grid. The chemical producer receives a fee when this service is used by the grid operator.
- By **electricity storage**: A chemical product, or a byproduct, with high energy capacity and electrical conversion properties is stored. In case of an electricity shortage the stored chemical can be used for electricity production.

Examples of energy carriers are hydrogen, ammonia, methanol and formic acid. They can be produced through electrolysis.

In the future supply chain not only the electricity supplier is relevant, but also the grid operator. The electricity provider sells electricity and is responsible for energy availability. The grid operator is responsible for the electricity network. The network had to be balanced and enough capacity should be available. In future business models also Energy Service Companies (ESCo) will become relevant.

In Figure 42 and Figure 43 possible future supply chains are shown. Figure 42 shows the supply chain of a large scale chemicals producer, which provides services to the electricity grid. In Figure 43 the supply chain in a decentralized model is shown. In this case local power, from solar or wind, is used to produce chemicals. Feedstock may be taken from

[51] See INPSIRE D2.1.

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locally available sources (e.g. H_2O for hydrogen production or nitrogen for ammonia, which is produced from air in an air separation unit).

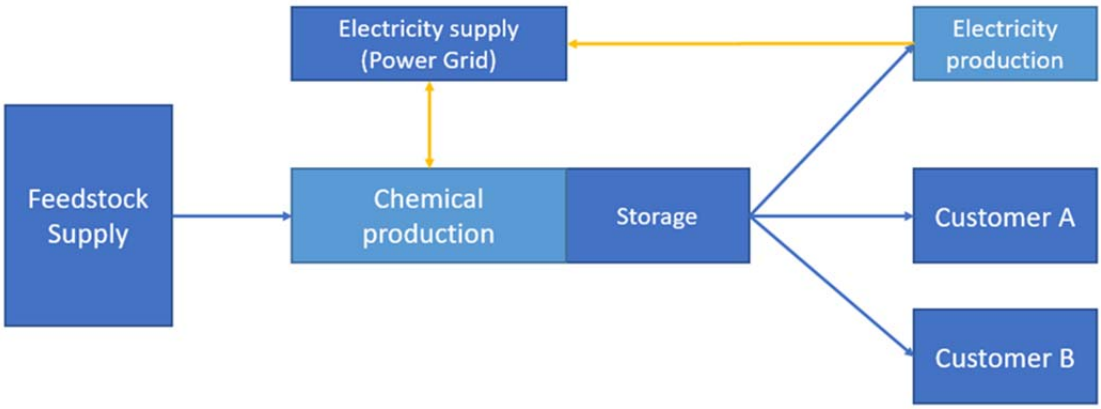

Figure 42. Production of emerging energy carrier in a traditional large scale plant, where services to the power grid are added

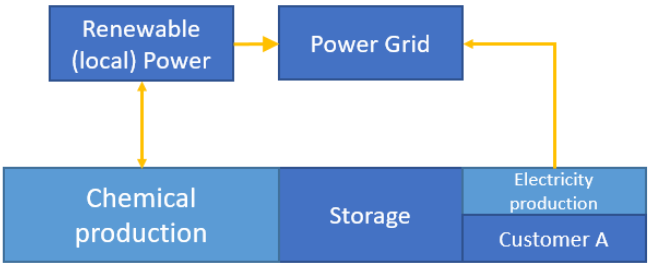

Figure 43. Production of emerging energy carrier in a small scale modular plant, where services to the power grid are added

2.6.2. Requirements needed for the energy carriers business model

The following are the requirements of the Emerging Energy Carriers business model to work. The EEC model will not be feasible if these requirements are not met. Currently, meeting these requirements is still a challenge. It is however expected that the EEC model will become important in the future, when electricity from renewable has a major stake in energy supply.

The following requirements should be met:

R1. Viable business models.
R2. Installed electrolyser capacity.
R3. Sustainable energy availability.

R1. Viable business models

- **Definition**: A business model should be in place where all important roles are fulfilled and services and products to be delivered to the different stakeholders are clear. Also the ownership, revenue models and cost accounting should be clear.
- **Why this is required**: A viable business model is always a prerequisite. In case of the EEC model, it is not obvious yet how the business model can look like.

R2. Installed electrolyser capacity

- **Definition**: There should be sufficient electric consumption or production capacity in place to deliver the required flexibility to the electricity grid.
- **Why this is required**: To deliver demand response services, electricity supply to chemical producers should be made flexible. This is possible when energy carriers like hydrogen are produced from electricity. Sufficient capacity should be in place to deliver a significant contribution to flexibility in electricity supply.

R3. Sustainable energy availability

- **Definition**: Sufficient sustainable energy should be available to produce the energy carriers.
- **Why this is required**: Energy carriers will be produced from renewable electricity sources like wind and solar, at moments of electricity oversupply and thus low prices. Currently installed capacity of renewable energy is insufficient for the model to work at large scale, but it is expected that installed capacity will grow significantly in the next decades.

2.6.3. Business model main decision factors to be considered by the relevant stakeholders

In this section, we present a number of factors that are relevant in the decision making process of whether to implement the EEC business model or not. The reason why they are relevant and how they impact the outcome of the EEC model are detailed as well.

In the first paragraph factors that are relevant to the archetype are presented. In the second paragraph the most important challenges associated with the archetype are discussed. In case of the EEC model, a scoring mechanism as was developed for the other archetypes has been left out. The reason for this is that the baseline of all factors presented is a feasible financial business case. Constructing this business case is essential, but cannot be done by means of the envisaged tool that will be developed in the INSPIRE project.

Factors relevant to the archetype

For the electricity sector (both for the electricity provider and the grid operator):

- Need for flexibility in the grid.
- Cost of flexibility.

For the chemicals producer:

- Possibilities for flexible production of energy carriers.
- Availability of electricity at low prices.
- Shortage of electricity in the market.

In the EEC archetype two stakeholders (and their interests) are of major importance: the electricity provider and the chemicals producer. The following factors are assumed, by expert judgement, to be most relevant to the archetype:

For the electricity sector (electricity provider and grid operator):

F1. Need for flexibility in the grid

- **Definition**: The ability to balance demand and supply in the electricity grid.
- **Why this is relevant**: Wind and solar energy are volatile. When the stake of solar and wind in the energy mix increases, this will lead more and more to periods of over- and undersupply. At moments of undersupply there is a need to reduce electricity demand. Demand response services can contribute to this. Also electricity can be generated from energy stored in energy carriers. At moments of oversupply the surplus of electricity can be used to produce energy carriers.
- **How it impacts the uptake of the EEC model**: The need for grid flexibility is in the heart of the EEC model. It brings the needs of the energy sector and the chemical industry together.

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F2. Cost of flexibility

- **Definition**: The cost of the flexibility options provided by chemical producers.
- **Why this is relevant**: The chemical providers will be prepared to deliver the desired flexibility to energy providers, if they are (financially) compensated. Both for the demand response services and the storage option costs will be made by the chemical producer. In case of storage there is also a significant energy loss in the process of turning electricity into a chemical and vice versa.
- **How it impacts the uptake of the EEC model**: In general the costs are a major factor of importance in many company decisions. The energy provider will compare the EEC model to other options (like batteries and hydrostorage) to gain the desired flexibility, both on costs and other factors like capacity and functionality.

For the chemicals producer:

F3. Possibilities for flexible production of energy carriers

- **Definition**: Technologies for the production of energy carriers should be available at affordable cost levels. The chemical producer should be able to meet requirements of flexible production of energy carriers. He should be able to cope with flexible production profiles. Technical requirements should be met, like getting production space and storage capacity available.
- **Why this is relevant**: CAPEX levels of electrolysers should get lower to compete with traditional, less sustainable alternatives. The flexible nature of production by means of electrolysis is rather different than current continuous or batch production profiles. When chemicals are used as energy carriers, storage periods will get longer, thus more storage capacity is needed. In case of offshore production of energy carriers, space is an important factor.
- **How it impacts the uptake of the EEC model**: The chemical producer will only adopt the EEC model when he is equipped to produce the energy carriers and production facilities are affordable.

F4. Availability of electricity at low prices

- **Definition**: There should be sufficient time frames when electricity prices are low enough to produce.
- **Why this is relevant**: The electricity price is the main cost driver in the business case for the chemicals producer. Electricity prices are volatile and volatility will increase

when more electricity from sustainable sources (wind, solar) becomes available. The time frames when the electricity price (marginal cost) is lower than marginal revenues determine the operational hours of production. Sufficient operational hours are vital for a positive business case.

- **How it impacts the uptake of the EEC model**: A positive business case is a major factor of importance for a company to make a positive investment decision for producing energy carriers. The business case depends highly on electricity prices and their volatility.

F5. Shortage of electricity in the market

- **Definition**: There should be sufficient time frames when electricity prices are high enough to make converting energy carriers into electricity profitable.
- **Why this is relevant**: Energy carriers can be used for generation of electricity, but also as a fuel or chemical feedstock. Energy carriers will only be used for generation of electricity when the value is higher than use as fuel or feedstock. This is only the case when there is a shortage of electricity and electricity prices are high.
- **How it impacts the uptake of the EEC model**: A positive business case is a major factor of importance for a company to make a positive investment decision for producing energy carriers. The business case depends highly on electricity prices and their volatility.

2.6.4. Value Chain and Business Model Challenges

A number of challenges exist that prevent companies in the process industry from implementing the EEC model or realize the untapped opportunities created by the model. In order to make the model work in real life and earn the much needed buy-in of all the relevant stakeholders, we attempt to generate specific/concrete ideas that will help decision makers build strategies/tactics/mechanisms/tools to be added to the EEC model.

The following challenges are identified regarding the EEC business model:

CH1. Viable business case.
CH2. Viable business model.
CH3. Regulations.
CH4. Storage.
CH5. Response times.

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CH6. Viable business case

- **Description:** Currently the production of energy carriers is not economically viable.
  - For the electricity provider, storage and grid flexibility are extra costs compared to the current situation. They will however become necessary in the future more sustainable energy mix.
  - For the chemical producer, in most cases (for hydrogen and derivatives like methanol and ammonia) producing chemicals/energy carriers in a traditional, less sustainable way is currently more economic than production by electrolysis.
- **Response:**
  - Utilise low hanging fruit. When market uptake for electrolysers increases, CAPEX is expected to drop.
  - Start with pilots for energy carriers with most economic potential like hydrogen.
  - Stakeholders, including society should accept the fact that sustainability comes at a price (CO_2 avoidance costs), especially in the first years. A higher Willingness-to-Pay for sustainable alternatives may bring a positive business case within reach.
  - Governments can stimulate sustainability and uptake of the EEC model by subsidies, thus making business cases more attractive in the first years. This may be either CAPEX subsidies or subsidies on electricity tariffs for producers of energy carriers. Higher ETS prices or other regulations that promote low carbon options will also be favorable for a feasible business case for EEC.
  - Develop revenue models that increase financial feasibility for both stakeholders. An example is development of a floor pricing mechanism: the chemical producer guarantees a minimum price for electricity to the electricity provider in exchange for a structural price discount per MWh.

CH7. Viable business model

- **Description:** Currently the EEC model is not implemented at a significant scale yet. New cooperation between stakeholders from the energy and chemical sector are required for working business models.
- **Response:**
  - Research should be done to viable business models for the EEC archetype.
  - Validate business models in real life by setting up pilots.

- Regulation should support these business models (see below).

CH8. Regulations

- **Description:** Regulations are needed that enable and support the EEC model.
- **Response:** Develop regulations that enable and support the EEC model[52]. Governments should develop regulations together with the electricity and chemical sector. This should be done preferably on EU level, because both the electricity and chemical market are international markets. Relevant topics are:
  - Stimulation of sustainable alternatives.
  - Adaptation of connection capacity pricing. Currently connection tariffs are based on capacity. This is however a burden to the uptake of the EEC model for producers of energy carriers, since they will need a high capacity connection to produce energy carrier by electrolysis and to deliver electricity to the grid
  - Current energy regulation classifies storage as an energy generator. Also increasing integration of renewable energy is not supported as building extra renewable energy. The classification as energy generator results in conditions that are unfavourable for storage to be used in business models that support grid operators.

CH9. Storage

- **Description:** In the energy carriers' model, excess energy is converted to an energy carrier (possibly hazardous) and stored. Sufficient storage capacity should be available, especially when the EEC model is applied to ensure availability of energy supply for a longer time period (e.g. to prevent shortages in winter). Of course storage should be safe. Also contamination of energy carriers should be avoided to prevent from lost product.
- **Response:**
  - Research safety issues of storage at large scale of different energy carriers (hydrogen, ammonia, etc.). Develop safety solutions where needed.
  - Pay attention to planning of storage locations and capacities.
  - Make risk analyses and mitigation plans per location.

[52] Current relevant regulations are RED (Renewable Energy Directive), FQD (Fuel Quality Directive) and ETS (Emission Trading System).

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CH10. Response times

- **Description:** Currently the most reliable business model for demand-response is to increase grid resilience[53]. However, using demand-response for grid resilience needs a response time (the time that is needed for the electricity use to shift upward or downward) of (~10) minutes. If this cannot be achieved, this model cannot be implemented for the Imbalance market and the potential for the Day Ahead market cannot be fully utilized either.
- **Response:** Both technologies and business processes should be designed on short response times to utilize full potential of the model.

[53] Behrangrad M., *A review of demand side management business model in the electricity market,* Renewable and Sustainable Energy Reviews 47, 2015.

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Chapter 3.

Conclusions

This document proposes novel and innovative business solutions that would help remove barriers and provide new opportunities for more flexible networks in European industry. More specifically, five business model archetypes have been identified:

(i) Mass customization.
(ii) Decentralised or modular production.
(iii) Servitisation.
(iv) Reuse and sustainability.
(v) Emerging Energy Carriers.

The business model decision factors that need to be considered by relevant stakeholders before making the decision to employ those business models have been identified. This list will be essential for the validation of the business models (deliverable D3.3) and the quantitative tool that will be developed and presented in Deliverable D4.2.

Moreover, based on the challenges/ opportunities identified in deliverable D3.1 of the INSPIRE project and the feedback from our industry partners (through workshops and interviews), we present novel tactics/ strategies/ mechanisms/ tools to be added to the different business model archetypes that would enable value chain stakeholders successfully implement those business models.

In Table 7 the identified major factors that affect the adoption of the business model archetype are clustered as follows:

Factors	**Mass Customization**	**Decentralized & Modular**	**Servitization**	**Reuse**	**Emerging Energy Carriers**
Customer	Customer Centricity	Quality	Service Scope Definition	Market Attractiveness	
	Timely availability of material and components (lead time)	Lead time of innovation	Capabilities to deliver a *better* service		
	Market Demand	Production closer to customers			

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Cost	Transportation Cost	Cost per unit of product	Profit Ratio	Profitability	Availability of electricity at low prices (from Chemical)
	Timely availability of material and components	Taking advantage of lower investment costs		Resource Consumption	Cost of flexibility (from Electricity)
		Lead time of innovation			Shortage of electricity in the market (from Chemical)
Capabilities	Production Technologies		Capabilities to deliver a better service	Maturity of and trust in RR&S technologies	Possibilities for flexible production of energy carriers (from Chemical)
	Timely availability of material and components		Overall degree of resistance to change (agility)	Capability to organise waste collection	
	Existence of networks and collaboration				
Flexibility	Flexibility (product)	Flexibility	feedstock/capacity / location/ innovation	Feedstock /location	Need for flexibility in the grid (from Electricity)
Risk			Level of risks		
			Profit Uncertainty Ratio		
Sustainability			System sustainability improvement	Resource Consumption	
				Capability to organise waste collection	
Corporate Identity	Customer Centricity			Maturity of and trust in RR&S technologies	
				Strategic Alignment	

Table 7. Summary on the factors of the five archetypes

Per archetype (column)

In this section we briefly capture the overall perspective, or main rationale, on the factors that affect the adoption of the business model archetype. These could be kept in mind when interpreting the factors.

- **Mass Customization**

Essentially this archetype is about **product properties** that meet individual needs following the 'Long Tail' philosophy, but at reasonable prices. Obviously this requires a deep (and consequently automated) **coordination** with potential risks in the transport movements involved. In the other archetypes the product is essentially not changed.

- **Decentralized and Modular**

Location or capacity flexibility are key drivers for the choice of this archetype. This is extremely technology driven in the sense that the technology and the product must be suited for a small-scale or modular approach. This implies that it must have a certain **degree of "Plug 'n' Play"**, due to higher levels of standardization, but also to avoid specific engineering and complex maintenance. Even though the expected lower efficiency can to some level be **compensated** by avoiding transport and human resources and potentially higher quality or shorter lead times, the technology must be efficient enough (N factor), as compared to the conventional large scale. That remains a great challenge.

- **Servitization**

Servitization is a 'delicate' business model archetype in the sense that 'conventional' product or service delivery is in most cases still an alternative. This archetype is mostly about **re-aligning incentives and a shift of risk** from user (back) to the supplier. This archetype is not so much driven by technical feasibility, although certain capabilities are required or beneficial, as it is about mutual acceptance of the new relationship. In this sense this is a very specific archetype. This is why the 'risk' cluster of factors is unique (it doesn't mean that risk is not relevant for the other archetypes).

Furthermore, when taking the view that any business based on servitization requires capability flexibility to be able to switch on and off multiple customers effectively. If the servitization includes physical equipment at the users' end, location flexibility is also required. As well, innovation flexibility for the different services around the product is necessary. Lastly, servitization creates a new paradigm for the customer, where almost any additional service provided generates value for the customer, increasing its willingness to pay higher prices for the supplementary benefits.

- **Reuse**

The reuse archetype is more than the other archetypes dependent on **collective action** and belief in sustainability. It is thus typically a supply chain, or at least multi actor, endeavour. Consequently fair **distribution** of cost (for equipment and collection activities) and benefits (e.g. cheaper of more reliable supply of sustainable feedstocks) is a core design principle (which could be enabled by supply chain transparency). This is why the 'sustainability' and 'corporate identity' clusters of factors are unique to this archetype.

This archetype may be implemented combining different elements from the different archetypes, aiming to accomplish the goals. For example, combining Decentral or Modular and Servitization will generate more environmentally friendly reused products with add-on services around sustainability; combining Mass customization and Emerging Energy Carriers could create small factories of renewable energy, using customized and reused wind turbines, for example. The reuse archetype can easily be embedded on any other archetype.

- **Emerging Energy Carriers**

The need for emerging energy carriers can be seen as a consequence of the energy transition towards renewable energy. This comes with a high volatility in supply. As a consequence energy prices become volatile. And it is the **economic opportunity to provide a buffer** for the surplus or shortage of electricity that would be the main driver for this archetype. Depending on surplus or shortage, "supplier" and "customer" of electricity swap roles. So, even though sustainability plays a huge role in the overarching transition, we do not recognize this as a major factor for adopting this archetype. Clearly this archetype (also) depends on availability and applicability of the equipment and product.

Per cluster (row)

In the Table 7 we clustered all the identified major factors for adoption of the business model archetype (Note that some factors are part of multiple clusters). This clustering reveals some expected overlap and some interesting differences. The overlap can be explained by factors that are 'obligatory' in any **strategic business investment**. In general these are summarized as **strategic fit and "risk/reward"**. Strategic fit means that any substantial investment will have to contribute to the company's strategic objectives. The reward is characterized by the specific revenues, that obviously depend on the market outlook and customer values, and by the cost aspects, that obviously depend on operational expenses and the capital and organizational investments required to implement the archetype. The risk aspect is also related to uncertainty in the market, but also in applicability and availability (feasibility) of

the technology. The risk/reward criterium is typically considered from a portfolio perspective (i.e. in conjunction with other investments) and reflects also the company's risk appetite.
In all cases these "obligatory" factors will have a 'couleur locale' in the business model archetype. And in all cases availability of **technology and organizational capabilities are prerequisites**. In addition, dynamics and agility/ resilience play a key role.

- **Customer**

In the business model archetypes major factors are related to the customer or user, but in different ways. Factors that are positive for the customer typically are part of **increased revenue**. In Decentralized or Modular a driving factor is to be able to be **close to the customer** and potentially provide increased speed, quality or independence. For Mass Customization the **individual customers' specifications** as an informational flow are centric, whereas in the Reuse archetype the **'sustainability' rationale** is potentially predominant. The latter is also visible in two 'clusters' that are mostly related to the Reuse archetype: Sustainability and Corporate Identity. The latter basically implies that some companies actively and deliberately choose to have sustainability as a primary objective and design principle in their business endeavours. For some cases in Servitization, this may be the case too, but it is probably not as dominant.

- **Cost**

Obviously costs of investing and operating the archetypes are always a factor of consideration. The archetypes have a difference in emphasis. We highlight two remarkable items. The first is the lead time. An improved (shortened) lead time not only has benefits for the customer (increased revenue or retention), but also may result in less inventory (but not necessarily so!), which decreases cost. For the EEC archetype the need for flexibility is for the grid operator typically a cost.

- **Capabilities**

In all archetypes the adopting organisations need to meet some prerequisites in terms of applicability of their product and availability and feasibility of the technologies. Also the organizational capabilities to change and to collaborate more intensively with others (specifically Mass Customization and Servitization) is needed. On top of that in all cases a mindset shift is needed. In Decentralized or Modular the shift is from economy of scale to economy of chain, but also to move from engineered custom solutions to standardized equipment. In EEC the mindset shift basically is that a product is a product and/or an energy

storage. To move to mass customization, it is necessary to re-couple and integrate steps upstream in the supply chain, instead of decoupling and local optimization. The mindset shift in Servitization is based on a continuous unburdening of the customer and focus on the performance rather than an activity or output. The mindset shift for Reuse is based on design of the material flow (and energy use) as a primary design principle in conjunction to economic and value design principles.

- **Flexibility**

In line with the high-level trends and threats identified for the European processing and manufacturing industries, for all business model archetypes a **certain need for flexibility** is a major factor, albeit that the archetypes thrive on different forms of flexibility. Decentralized or Modular build on needs for capacity and location flexibility. EEC builds on the need for energy flexibility (by using the product's dual function). Mass Customization implies product flexibility. Servitization typically needs capacity and potentially also location and feedstock flexibility. Reuse draws on feedstock and location flexibility (different types of materials and different sources).

- **Challenges**

The identified challenges typically can be related to the 'obligatory' strategic fit and risk/reward related factors. For EEC regulatory requirements are specific. For Servitization the user's behavior as a response to changed incentives, e.g. rebound effects, are very specific. At this point no further insights are derived from the identified challenges.

Conclusions on the solutions

The presented challenges along the document introduce the reader to the general overview of the difficulties that the different archetypes could face; as well, solutions are proposed, aiming to help the reader to easily understand the major implications for each of them, and to have a general idea on how these could be implemented (or even replicated). Nevertheless it is important to highlight that these are not the only challenges and/or solutions, but are the most common ones according to the desk research and interviews conducted with industry practitioners.

In Table 8 we clustered the identified **solutions for challenges that affect the adoption of the business model archetype**. These are the solutions that are directly related to **major factors.**

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Factors	Solutions	Mass Customization	Decentralized & Modular	Servitization	Reuse	Emerging Energy Carriers
Cost	**Value Capturing** (Pricing, Cost reduction, added services)	Cost and benefit analysis on customization options	Create economies of scale at equipment manufacturer	Perform cost-to-serve analysis	Creation of critical mass of reusable or recyclable materials in the value chain (e.g. by applying incentives for end-users)	Pay attention to planning of storage
		Monitor competitor prices	Technical solution with a high n-factor	Evaluate additional revenues	Smaller scale mobile treatment solutions	Create Willingness to Pay for sustainability
		Assess willingness to pay		Study the value of the service and willingness to pay	Apply a "hub & spoke" solution, where local collection and pre-treatment is combined	Develop revenue models that increase financial feasibility at the chemical and energy side
				Define the range of the price so that a win-win solution is offered.	Create a joint economic interest by "institutionalising" the collaboration or "contractualising" the liabilities in combination with territorial vicinity	
				Use monitoring on customers use/consumption to give customer insight	New ownership constructions through leasing contracts and collective financing	
				Provide additional after sales service	Standardisation	
				Demarcate disposal at end-of-life and provide incentives to do this		
Capabilities	**Capabilities Development**	Support in making technology assessment	Technical solution with a high n-factor	Analysis on Internal resistance, and create new incentive mechanisms	Take a LCA approach and brand "green products"	Design technologies and business processes on short response times to utilize the full potential of the model
		Use of data analytics and BI in market forecasts	Use innovation flexibility	Have support from authorities		Research safety issues of large scale energy carrier storage
		Communicate with the customer on value of customization	Work towards minimum viable product	Generate collaboration environment (facilitators, interested parties, stakeholders, customers, etc.)		Make risk analyses and mitigation plans for storage
		Give rewards for new designs made by customers	Utilize local companies and resources			Research on viable business models

			Digitization of the supply chain			Make use of Government incentives
			Remote management for cost reduction			Develop regulations that enable and support the EEC model
Customer	**Customer Relationship Management**	Signing contracts and bilateral agreements	leasing-contracts or collective financing	Create Risk Sharing Contracts	Creation of critical mass of reusable or recyclable materials in the value chain (e.g. by applying incentives for end-users)	
		Sign contracts on IP Rights	Equipment owned by a group of customer and shared	Set service contracts with customers with clear responsibilities and liabilities		
				Scheduled payments and reverse factoring		
				Provide additional after sales service		
				Persuade customer to embrace proposed models (i.e., ownerless)		
Supply Chain	**Supplier Relationship Management**	Raw materials supply directly to customer	Equipment owned by equipment provider	Purchase similar services from different suppliers	Set up a new intermediary organisation.	
		Smaller batches, higher customized product volumes	Moving manufacturing centers closer to the customer	Multiple sourcing	Create or use an online platform.	
		Customization / manufacturing centers closer to the customer		Collaboration strategies with supplier, such as Joint Venture	A producer takes the responsibility for its product and embedded materials throughout the value chain.	
				Increase access of the supplier to the supply chain and connect them to the customer		
				Incorporate waste-management as part of the design of the product.		
				Define ranges on the use with customers		

Table 8. Solutions for challenges that affect the adoption of the business model archetype

The solutions related to factors can be clustered in some solution directions. As explained in the "challenges and potential solutions" section, there exist a set of major concerns that are the common denominator among the different solutions. Therefore, in this section we briefly

capture the overall perspective, or main rationale, on the possible solutions to the adoption challenges of the different business model archetype. For a more detailed explanation, we encourage the reader to check the challenges and solutions section for each of the archetypes.

- **Cost**

The solution towards cost challenges are related to **Value Capturing**. The solutions can be found in different directions, such as **cost reduction** solutions (economies of scale, high n-factor for technologies). Cost reduction strategies can be used to create more value in the business model and thus improve the economic viability. **Pricing** solutions will optimize the relation between the price of the product/service and the willingness to buy the product. Creation and evaluation of Willingness-to-Pay and monitoring competitor prices are examples. It is also possible to **add services** to the product, mainly seen in Servitization, to increase the value of the product. This can be related to consumption monitoring or end-of-life services.

- **Capabilities**

Regarding the capabilities, it is possible to see that solutions are related to **development of capabilities.** The different solutions can be linked to different strategies such as technological advances, risk management and collaboration. The **technological advances** around the design of products and process to fit into innovation flexibility models, digitization of supply chain, data analytics, and work towards minimum viable product models will provide archetypes with the tools to satisfy everyone involved. **Risk management** is a key feature, as it involves safety issues of large scale, communication initiatives (customers and other entities) and the inclusion of local companies and resources in the model. Finally, **collaboration** with authorities, facilitators, stakeholders, customers, etc., provides the archetype with the necessary tools to implement satisfactorily the proposed model.

- **Customer**

Customers are the most essential part of the models as without them, no model will have a purpose. Therefore, solutions should be tailored to **customer relationship management**, considering the different opportunities to generate **trust** and **satisfaction.** The first one, **trust**, could be gained by long time relationship with the customer, but, to reach this relationship it is necessary to properly design contracts and bilateral agreements, and make sure that both parties understand clearly their responsibilities and liabilities. On the other hand, **customer satisfaction** can be improved by additional services after sales, making the customer feel

engaged with the product, being persuaded to embrace the new models (i.e., ownerless solutions, shared products with different customers, etc.) and having a clear definition of the payment schedule. These solutions, as simple as they might look, create a solid communication bridge and boost confidence between suppliers and customers; lastly, everything will rely on the acceptance of the product and service around it, and the good performance of the company (or parties) on delivering the service promise.

- **Supply chain**

The supply chain enables the archetypes to transform raw materials from suppliers to finished products for the customer. The main focus of the solutions is on **supplier relationship management** as these are the first stage on the final product manufacturing. The solutions must be tailored in both ends of the supply chain, the **sourcing** and the **customer** sides, considering the supplier as the key actor. From the **sourcing**, it is possible to have different suppliers, multiple sourcing locations and generate different collaboration strategies with suppliers. From the other end, **customer** side, it is possible to move the manufacturing closer to the customer, generate smaller batches of highly customized products, and incorporate the customer in the design of the product to properly manage the waste of the product after defining the proper use of it.

Introduction of new business models

The beforehand proposed grouping does not include some features particularly related to the introduction of new business models under the different archetypes. Therefore, Table 9 shows the particular solutions related to this.

Solutions	Decentralized & Modular	Emerging Energy Carriers	Mass Customization	Servitization	Reuse
Scaling	Develop franchising or production hubs	Utilize low hanging fruit	Collaborate with Fab Labs	Start with a simpler/smaller offer to start identify and build up the scope: From CPFR to VMI, following VMI plus an application, following VMI plus an application plus take-back and resell.	An existing recycling company takes on new technological solutions and build a new business model.
	micro factory retail concept	Start with pilots for energy	Create start-ups	Start with Product-Oriented and then	A completely new recycling

		carriers with most economic potential		move to User-Oriented and Result-Oriented.	company is set up to manage the new R&R opportunities.
			High customization levels through local sourcing and distribution	Have facilitators as neutral third parties to promote	
Financing	Improving the business case to achieve financing	Validate business models and cases by setting up pilots	Corroborate investment cost	Perform cost-to-serve analysis	
	Collective financing				

Table 9. Solutions for challenges that affect the introduction of the new business models

- **Scaling**

In the business model archetypes multiple solutions are related to the scaling of the business model. Two options are possible: (i) Scaling WITHIN business model and (ii) Scaling OF business model. All new models have challenges related to scoping, increasing market share and developing capabilities for (i) one company, or (ii) multiple instanes. These challenges are tackled by individual solutions related to the major factors (Value Capturing, Capabilities Development, CRM and SRM). Some solutions address more factors at once to employ scaling of the business model. This can tackle **cost** by utilizing low hanging fruit, **capabilities** by collaborations and **customer** factors by starting with a small offer and build up the scope.

- **Financing**

It is important to properly assess the finances before implementing the new business models. Multiple solutions are related to the different costs and of implementing the business model and revenues generated by the same. These solutions aim to **improve** the business performance by **collective financing**, properly **setting up pilots**, evaluating and **corroborating** the investment cost and, lastly, performing an accurate **cost-to-serve analysis**. There are multiple challenges related to costs, but can be easily foreseen and tackled to ensure the successful development of the model.

Final closing remarks

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This document presents the business model decision factors that need to be considered by relevant stakeholders before making the decision to employ different business model archetypes (mass customization, decentralised or modular production, servitisation, reuse and sustainability, and Emerging Energy Carriers). The factors that are common to all archetypes are cost and flexibility. The other factors are focused on the customer, capabilities, risk, sustainability and corporate identity.

In addition, some challenges that the different archetypes could face are presented, and some solutions are proposed. The challenges and solutions presented in the document should not be taken as the only possible challenges to be faced, but as a general insight of what could go wrong for a large number of companies (according to literature review, desk research and interviews) face when introducing new business models. We present examples to show that the proposed solutions have been proved to work under different contexts and for a wide range of companies and industries; nevertheless, these are not the only plausible solutions for the challenges.

As it can be perceived by the reader, most of the challenges could arise due to different issues such as misalignment between the product/service provider and the user, lack of understanding the financial impact of the business model (both costs and revenues), lack of understanding the impact on customer service level, lack of a clear and well-defined scope, the obligations not being clear, the expectations not properly set, the potential risks not identified, or existing miscommunication or mistrust among the different parties. Therefore, it is necessary that the parties can establish a deep trust and not a shallow confidence for a successful implementation of the different business models for each archetype. For further information and detailed explanation about the Factors, Challenges and Solutions, per archetype, we advise the reader to review the corresponding sections.

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Appendix

In the Appendix, we present different approaches, definitions, and some case studies to introduce the reader to these solutions and practices. As well, these practices are related to the different challenges presented in the previous section, providing insights about how these could be tackled (or diminished) by implementing them.

Collaborative Planning, Forecasting and Replenishment (CPFR)

A well-known business practice "*that combines the intelligence of multiple trading partners in the planning and fulfilment of customer demand*" (GS1, 2013). The "simplicity" of the approach relates in the planning process for retailers and vendors, as it is responsible for determining product placement by location and by delivery, and where they must work together to "*build and modify assortment plans based upon financial plans, historical sell-thru data, market trends and production schedules*" (GS1, 2013). In this way, companies can share key information that is valuable for the purpose of increasing the performance of the supply chain. The main benefits of the CPFR are: sharing information to improve the responsiveness for changes in customer demand, inventory reduction along the supply chain (10-30%) and overall cost reduction.

Vendor Managed Inventory (VMI)

Defined as "*the optimization of the supply chain management in which the vendor of products is responsible for maintaining the retailer's inventory data record*" (Esper & Waller, 2014), the VMI offers several advantages to both parties of the supply chain, as it the vendor keeps track on data of low inventory and performs the supplying part, reducing the lead time and the possibility of stock-out for the distributor. For example, using VMI, "*Procter & Gambler (P&G) manages the inventory of its customers, eliminating the need for customers to send purchase orders*" (Grean & Shaw, 2002).

The main advantage for P&G was that they were able to understand the demand trends directly from the customer, understanding its behaviour and being able to react ahead of time. In the other hand, form the distributor point of view, the advantage was to reduce the amount of inventory they needed to hold, reducing the cost and obsolete products, having the right item in stock at the moment that the final customer was looking for purchase. P&G case shows that is not necessarily a relation of power that convinces the parties to work together under the VMI model, as their first collaboration was with Walmart, using one of P&G's key SKU: Pampers baby diapers.

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Reverse Factoring

Known also as "Supply Chain Financing", the Reverse Factoring is explained as "*a business and financing processes that link the various parties in a transaction (buyer, seller and financing institution) to lower financing cost and improve business efficiency*" (Becker Professional Education, 2017).

From the buyer point of view, this set of solutions allows cash flow optimization, permitting buyers to generate extensions on the payment terms to suppliers. By increasing the time it takes to pay a supplier, the effects on several financial metrics (e.g. days payable outstanding - DPO) are at increased performance and, primarily, allow to free up cash that would be inefficiently "trapped" along the supply chain. Buyers then can use this increment in cash flow for investments in several initiatives (competitive, operational, innovation) to drive additional growth (PrimeRevenue, 2016).
From the supplier point of view, they can mitigate the effect of payment term extensions by getting early payments (typically as soon as an invoice has been approved by a buyer) from a third party (usually a financial entity). For the supplier, receiving the payments earlier impacts positively their budget, being able to have that money beforehand. At the same time, the supplier can offer some discount to receive the money in a timelier manner (PrimeRevenue, 2016) .

As can be seen, Reverse Factoring provides short-term credit that optimizes working capital for both the buyer and the seller. This thus generates a win-win situation for both parties, as the buyer optimizes its working capital and the supplier generates its operating cash flow. As a whole, the supply chain can also find feasible offering returns to the different shareholders as dividends or stock repurchases.

Performance Based Logistics (PBL)

Performance Based Logistics, also known as Performance Based Life Cycle Product Support was first defined by the Office of the Assistant Secretary of Defense for Logistics and Material Readiness [ASD (L&MR)] as "*PBL is synonymous with performance based life cycle product support, where outcomes are acquired through performance based arrangements that deliver Warfighter requirements and incentivize product support providers to reduce costs through innovation. These arrangements are contracts with industry or inter-governmental agreements*" (ASD (L&MR), 2014). The key differentiating element from the PBL are that the arrangements are tied to "*Warfighter outcomes and integrate the various product support activities (e.g., supply support, sustaining engineering, maintenance, etc.) of the supply chain with appropriate incentives and metrics. In addition, PBL focuses on*

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combining best practices of both government and industry" (ASD (L&MR), 2014). In other words, it creates a strategy based on performance outcomes, with clear lines of authority and responsibility, for a product support package of a product. As originally developed, it was intended to serve the warfare purposes but it extended to other industries.

The main advantages that the PBL offers are: having a measurable work description, appropriate contracts and strategies to meet the deliverables, set metrics linked to the contract requirements, cost reduction initiatives, linkage between different entities (government and commercial entities), estate clearly risks and rewards sharing and finally synchronize the product support arrangements (ASD (L&MR), 2014) (David, Newman, & Kotzian, 2016)

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Case studies

In this section we present some case studies where the previous methodologies were implemented, showing the results and the benefits of implementation. In some cases, the results were satisfactory and in other were a complete disaster, showing that the methodology per-se is not a solution but a tool that needs to be carefully applied and with a close follow up.

1. Applying Performance-Based Logistics Contracts in the NAVY

Kirk & DePalma (2005) describe how the NAVY implements the PBL methodology and how much money is actually invested by the aviation and maritime in these type of contracts (Figure 44).

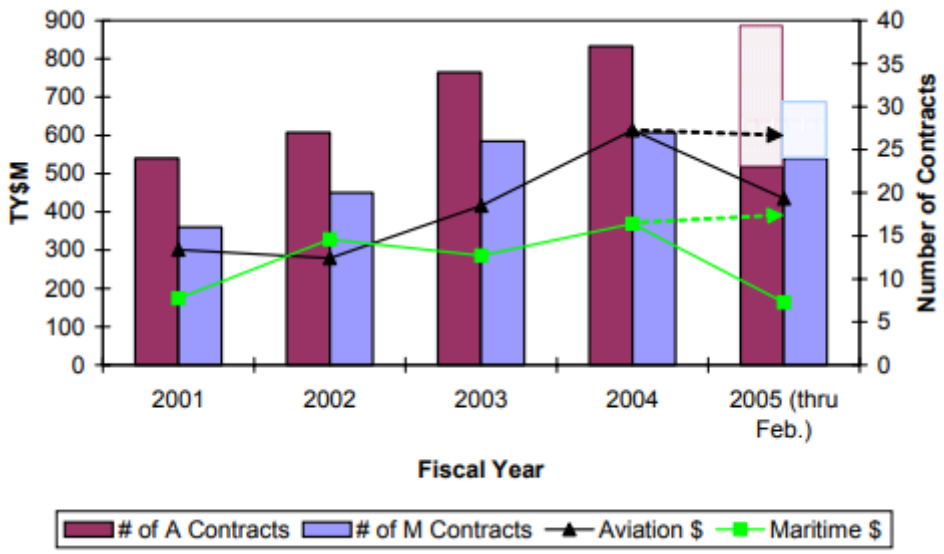

Figure 44. Funding for aviation and maritime PBL contracts in 2005
Source: Kirk and De Palma (2005)

The way how these contracts were estimated is using the firm price or the fixed-firm price for each period of time, considering number of flying hours and cost adjustments for any changes in future. Also, they have a "not to exceed" ceiling amount, which includes any potential additional fees.

a. Inadequate PBL contract

The contract for the Joint Service Electronic Countermeasures System Tester (JSECST) is an example of an inadequate PBL contract, as it does not specify what the obligations from the contractor are and the annual expenses granted, as it only quantifies the total amount of money for the full 10 year period. As well, it does not specify specific actions to be taken if contractor fails to fill the requisitions. The contractor seems to have little incentive to maintain or improve the performance of the JSECST system.

b. H-60 FLIR system, PBL contract

The implementation of the PBL contract shows how effective the implementation of a PBL contract can be, increasing the effectiveness of the requisition fill rates, decreasing the price of the maintenance, and decreasing the number of removals for a malfunctioning FLIR (as can be seen in Figure 45).

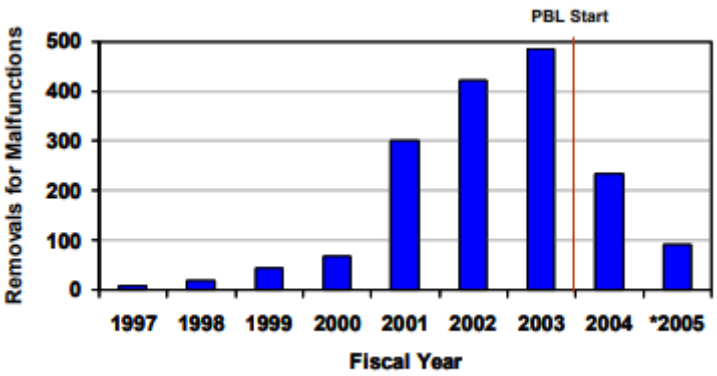

Figure 45. Number of removals for malfunctioning FLIR
Source: Kirk and De Palma (2005)

In the contract were well specified the benefits for the contractor in terms of number of flight hours before the FLIR service; thus, the contractor had specific goals and incentives to increase the reliability of the service and decrease the overall cost in the long run.

As learnings from the implementation of the PBL arrangements, the equipment maintained under PBL experience better availability for mission-tasking, is more reliable, and better maintained than equipment repaired under transactional arrangements.

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2. Implementing VMI in Robert Bosch North America

SupplyOn VMI designed a system for Robert Bosch North America (RBNA) automotive division in 2003 and implemented the solution in the Charleston plant in North Carolina. As a result, the plant was able to communicate a daily ship schedule and pull signal matching requirements with the plants' production schedule.

The solution allowed "*material planner to set inventory levels and have the VMI module inform the supplier of their next shipment quantity, receipt material in a most efficient manner and monitor shut downs and shortages very easily*" (SupplyOn AG, 2010). The implementation of the VMI reduces the "*daily inventory levels by 30 percent, premium freight by over 70 percent, and ensure the delivery performance of our suppliers is at the highest levels*" (SupplyOn AG, 2010).

3. Reverse factoring implementations

In the panel discussion led by The Trade Advisory, two stories were shared regarding the implementation of reverse factoring, both of them with opposite results. The learnings from both panelists shows how important and critic is to have full control of the project and do a close follow-up.

a. Kyriba's success story

Eric Riddle, from Kyriba mentioned that the goal of the $10 billion firm in the consumer packaged goods space was to free up working capital because of a specific reason: executive requirement. "*The program, which only involved 35 suppliers initially, still ended up freeing up $75 million in working capital in the first year, in large part because of executive alignment between the CFO and CPO and sponsorship and involvement by the CEO*" (Busch, 2016).

The success of the project was having the executive board well aligned with the project, as well as a strict support from the procurement and accounts payable team members, who helped in the development and design of the program.

b. Wells Fargo horror story

In the other hand, Stephen Elson mentioned that misalignment was the root cause of what Wells Fargo calls their "horror story" example. In the case of the company, only treasury and accounts payable department were involved in program design, there existed little to none

communication with the suppliers "*as procurement was not fully onboard with the initiative and suppliers were given a choice on whether they opted in or not*" (Busch, 2016). As part of the chain of errors, timing was completely wrong as "the implementation of the program also happened to coincide with an ERP system conversion" making things complicated and ensuring that data was not being shared properly, lapidating definitely the project.

4. Scheduled payments

This is perhaps one of the "simplest" solutions to implement, yet difficult as it requires an incredible amount of coordination and agreements along the supply chain members, that could benefit all the interested parts and have a positive overall outcome.

Significant delays in processing and reconciling invoices are the norm in everyday supply chain, including "long Days Sales Outstanding (DSO) for accounts receivable (A/R), and significant funds held in Working Capital to deal with uncertainties in inflows and outflows" (Hausman, 2005). Automation solutions, currently available from many providers, show high potential for reducing processing costs significantly as these offer enhanced visibility (less uncertainty in accounts receivable and accounts payable), increasing the working capital and reducing the "trapped money" along the supply chain. "*Furthermore, they also accelerate the process of procuring goods, which in turn, accelerates payment and invoice reconciliation, and they reduce DSO. By streamlining financial flow processes through the use of electronic payment solutions such as purchasing accounts, distribution accounts and electronic invoice presentment and payment (EIPP), system challenges can be addressed and cost savings can be achieved, shifting company financial resources to more business-critical areas."* (Hausman, 2005).

Simple solution implemented by General Electric, creating a supplier Web portal and applying Electronic Invoice Presentment and Payment, brought them the following benefits: drop in paper invoices, reduction of resources allocated for account payable, reduction in defects of invoices and increased the payment efficiency. As a positive side-effect, GE also improved its ability to forecast cash flow requirements.

5. Apparel industry under Circular Business Model

If a manufacturer of clothing would like to relocate to Europe, they might consider a circular business model, using end-of-life cloth as an input material for a recycling process. Following the classification by Richardson (2008) the business model could look like the following:

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(1) Value proposition: Cheaper, more environmentally friendly apparel

(2) Value creation and delivery: Collect old cloths from customers at point of sales, clean the cloth, decolour it, cut it in squares, sew the squares into new apparel, sell as extra line in own retail stores.

(3) Value capture: Fixed price per item sold in retail store

This would be so easily technically feasible that the production process could be performed in most households with a needle and thread, a kitchen and washing machine.

This circular business model scenario would perform very well in most of the factors, with the exception of profitability and market attractiveness. These factors are ranked quite highly since they jeopardise the financial self-sufficiency of the new business model.

There are no easy solutions to improve the challenges in these areas and the organisation would have to put great emphasis on environmental goals to be willing to cross-subsidise this business model.

Therefore, the analysis would probably go on to the next scenario or archetype, which is consistent with current relocalisation trends in the apparel industry, which favour small businesses for circular business models or relocalisation for quick reaction times to new fashion trends for larger companies.