Deliverable D300.11

Methodology for Lean-based ECO-driven Product-service & Process Design – First Version

WP 300

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ABBREVIATIONS

BC	Business Case
CA	Consortium Agreement
i.e.	id est (engl. = that is to say)
IPR	Intellectual Property Rights
RTD	Research and Technological Development
S & T	Scientific and Technological
SME	Small and Medium-sized Enterprise
WP	Work package
w.r.t.	With respect to
TPS	Toyota Production System
TDS	Toyota Development System
TMS	Toyota Management System
LPD	Lean Product Development
NPD	New Product Development
OECD	Organisation for Economic Co-operation and Development
MEI	Measuring Eco-Innovation
PSS	Product Service System
PES	Product Extended Service
EDM	Electrical Discharge Machine
SD	System Dynamics
ABM	Agent-Based models.

1 Executive Summary

This report is deliverable *D300.11*, which presents the first version of the Methodology for Lean-based ECO-driven Product-service & Process Design.

The purpose of this methodology is to **guide the conceptualization and design of new PES solutions by applying lean principles and eco-innovation principles** in order to reduce environmental impact and the resources consumption during the production and during the overall product life cycle (promoting the use of more environmental – friendly materials).

This deliverable is the result of the work carried out within the WP 300 Lean-based ECO-driven Product & Process Design, specifically task T310 Methodology for Lean-based ECO-driven Product-service & Process Design. The deliverable presents:

- The Lean principles applicability in the design of Meta Products to achieve a new paradigm that goes beyond lean manufacturing, providing added value services considering individual demands.
- The eco-innovation and eco-design principles applicability in the design of Meta Products for holistic understanding of enterprise sustainability and competitiveness reducing environmental impact and the resources consumption during the production and during the overall product life cycle

The combination of eco and lean principles together with the methodology to help in the conceptualization of Meta Products and production processes, providing added value services considering individual demands.

Therefore this work provides a new framework that brings together the eco and lean principles, practices, guidelines, metrics and methodologies for holistic understanding of enterprise sustainability and competeviness to reduce the environmental footprint and the resources consumption during the production and use phases and to promote the use of more environmental friendly materials.

This document reports the first version of the Methodology for Lean-based ECO-driven Product-service & Process Design. The feedback provided by the end-users during the application of this methodology together with the improvements detected, in T620 Test in Application Scenarios, will lead to a new version of the methodology D300.12 Methodology for Lean-based ECO-driven Product-service & Process Design - Final Version at M36

This methodology is part of **ProSEco methodology** that includes 3 key RTD topics explained in detail in three deliverables in their first and final versions:

- D200.11 Methodology for Collaborative Product Services & Process Design
- D300.11, the Methodology for Lean-based ECO-driven Product-service & Process Design
- D400.11 Methodology for AmI based & Context Sensitive Product-Services -AmI based context sensitivity (WP400)

And they will be integrated in task T540 Integration & Optimisation M23 – M48

2 Introduction

2.1 Document Purpose

This document describes the first version of the methodology for Lean-based ECO-driven Product-service &Process Design, which is one of the core methodologies to be developed in ProSEco.

The purpose of this methodology is to guide the conceptualization and design of new PES solutions by applying lean principles and eco-innovation principles in order to reduce environmental impact and the resources consumption during the production and during the overall product life cycle (promoting the use of more environmental – friendly materials).

Therefore the methodology to be developed needs to use the advantages of both eco and lean toolset in a consistent way in the stage of developing product concept (see in Figure 1). The Lean Management methods could also improve collaboration process in the advanced phases of design.

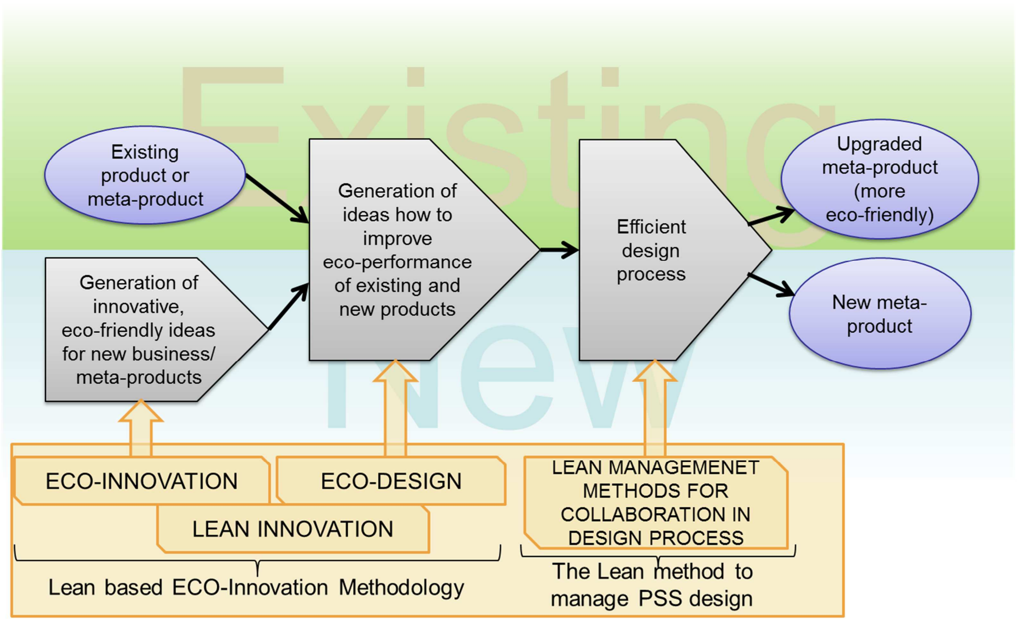


Figure 1. Generic process for the development of a Meta-Product.

The following figure summarizes the whole process that is explained in detail in section *4. Lean based eco-Innovation Methodology* and the eco and lean based toolset that are also explained in detail in section *5 ProSEco Tools Required.*

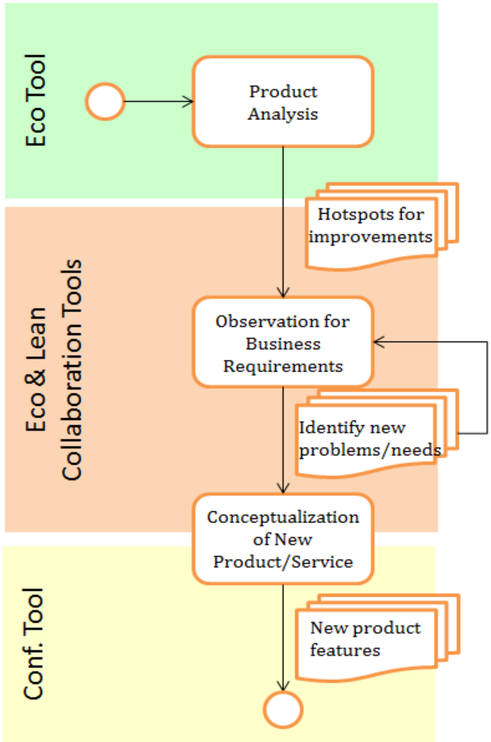


Figure 2. General view of the Methodology for Lean-based ECO-driven Product-service & Process Design

As it can be observed in Figure 2, the process stats with a product-system analysis, partially based on the environmental performance of the current product (taking into account the whole life cycle perspective) in order to identify **improvement areas**, but it has to be completed with a full understanding of the industrial company to address the problems or challenges that could be addressed taking into account environmental issues.

This methodology will be performed by stakeholders involved in the development of new products or businesses (CEO, designer, environmental expert, material expert, IT developer, manufacturing engineer, economist, sales representative, etc.) and, therefore, the collaboration tools of ProSEco will be used during the different stages of this process.

Next important step in this process is to have a clear understanding of the environment of the final users, therefore a deep, empathetic and multidisciplinary **observing process** of their needs, desires and emotions will be needed in order to identify real problems /needs to be solved by ProSEco.

The last part of this process hast to do with idea generation and the conceptualization of new product extended services (PES) and business model perspective with the application of a pertinent mixture of eco-innovation strategies. These strategies may play an important role in changing key elements of a business model (customer, customer value, profits, delivering value to customers, etc.).

2.2 Approach Applied

For the creation of this document, the ProSEco consortium partners have carried out the investigation of information sources available in the literature, on the internet pages of the RTD organisations, ICT providers and industrial companies, as well as information on the current or recent research projects, dealing with topics relevant for the ProSEco S&T objectives. All these activities were supported by the partners' expertise in related areas.

2.3 Document structure

The document consists of:

- **Section 1. Executive Summary** with a short and concise overview of the overall content of the whole document, who is the target of this document, the main results described in it, the interest for the reader and benefits the reader may expect from it.
- **Section 2. Introduction**, which describes the purpose of this document, the position of this document with respect to the whole project, and provides a brief overview of the contents of the document.
- **Section 3. Literature Review and Main Principles behind LEAN & ECO is a** summary description of the fundamentals of Eco-Innovation, Eco-Design, Lean Innovation and Lean Design methodologies
- **Section 4. Lean based eco-Innovation Methodology, which** describes the first draft of the Lean based ECO-Innovation Methodology that will guide the process of new innovative PES creation.
- **Section 5. ProSEco Tools Required** is a summary of thetools and services needed to support this methodology via the ProSEco Platform.
- **Section 6. Conclusions** is wrap up of the main aspects of the document and future steps to follow up with the second version of the methodology
- **Section 7 References** The list of information sources available in the literature to which this document makes reference to.

3 Literature Review and Main Principles behind LEAN & ECO

3.1 LEAN APPROACHES

The term "***Lean Production***" was introduced in the book "The Machine that Changed the World" by Womack, Jones, and Roos [1], first conceived in 1984, as a new "paradigm" supplanting the prevalent mass production system.

Afterwards, the following theoretical paradigms were distinguished:

The term ***Lean Thinking*** was introduced in 1996 in a book title Lean Thinking [2], just in time for the recession of 1997. It told the story of how American, European, and Japanese firms applied a simple set of principles called 'lean thinking' to survive the recession of 1991 and grow steadily in sales and profits through 1996. This book was also a remarkable revolution in production and the authors argue that a lean way of thinking allows companies to transform themselves.

The term ***Lean Management*** was coined to define a new management philosophy, that focuses on maximizing value brought by the organization to its customers and on building smooth flow of products (e.g. by minimizing waste). The idea behind is that if no action is taken to change the way we manage process, people and products we are likely to see failure of lean implementations. The importance of the lean approach has grown in the last two decades and it has become one of the dominant approaches of managing production systems. Also outside of manufacturing lean management implementation is gathering impact.

Therefore, as it is graphically showed in next Figure 3, lean management is an important part of lean thinking and the roots and principles of both are closely connected with manufacturing systems.

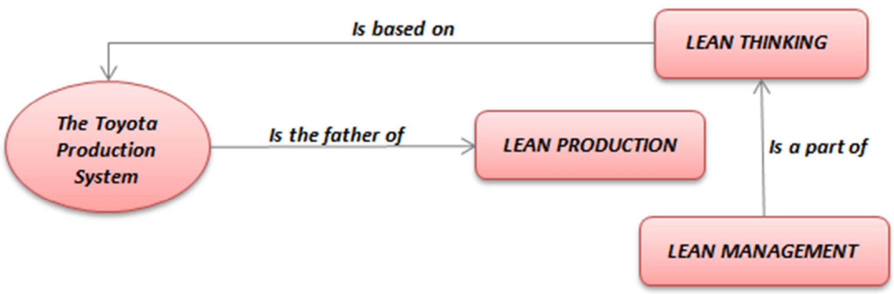


Figure 3. Lean Production heritage

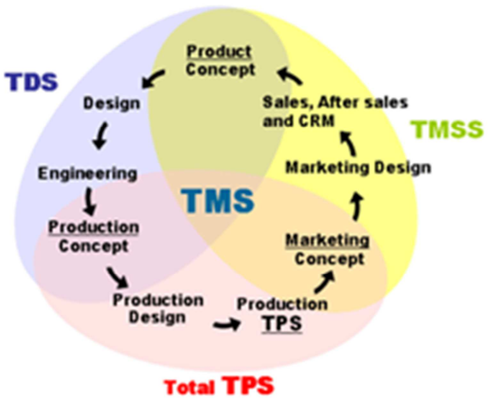


Figure 4. Toyota System

A while later, in 1995, MIT Professor Allen Ward published a study entitled *"The Second Toyota Paradox – How Delaying Decisions Can Make Better Cars Faster"* [3] where he studied Toyota's R&D method in order to determine whether Toyota was also better than its competitors at developing products and services. Allen Ward discovered that Toyota was extremely efficient, also when it comes to innovation.

He discovered that apart from the Toyota Production System (TPS) Toyota also had a ***Toyota Development System (TDS)*** that together with their Sales System, they were all part of an overall Management system (TMS). (See Figure 4)

This study was the bases for C. Sehested & H. Sonnenberg to publish in 2010 the book titled "*Lean innovation. A fast path from knowledge to value"* [4] where they define the ***Lean Innovation*** principles and define it as a new paradigm to getting smart fast, that is: "Do the right thing and do it right"

Therefore, ***Lean innovation*** *can be considered as a new paradigm not based in the production system but in the Toyota Development system and in a general company innovation system (Figure 5).*

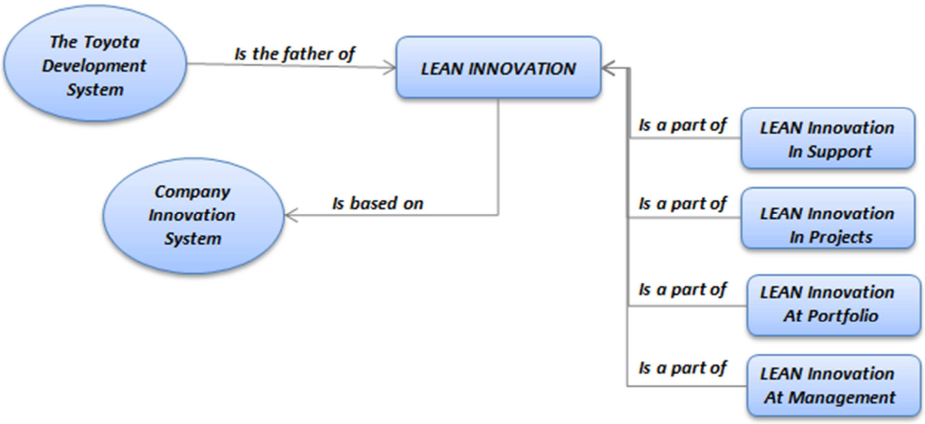


Figure 5. Lean Innovation heritage

There is no clear distinction between Lean Management in product development, Lean Product Development (LPD) and Lean Innovation, because different authors define all these notions in a different way. Some authors in the literature propose to identify LPD with a concept of implementing lean management approach into product development processes, while others propose to identify LPD with a concept of implementing lean innovation approach into product development processes (see Figure 6)

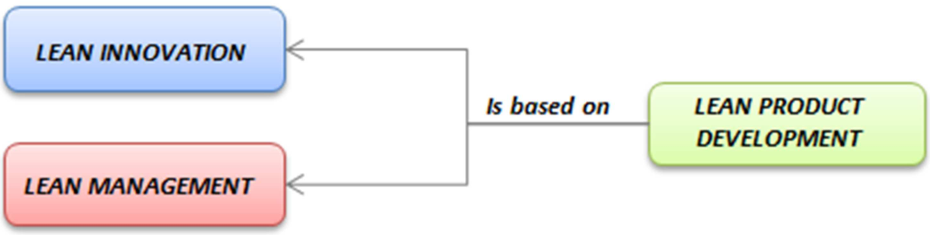


Figure 6. Different approaches for Lean Product Development

For the need of this document and further analysis, it will be assumed that:

- Lean Innovation is focused on defining a product, which responds better to customer real needs. It results in better products (from customer point of view).
- Lean Management in product development is focused on methods and tools to make development process shorter, less costly and error resistant. It results in better performance of development team (e.g. better productivity of designers, less errors in documentation, less reworks, etc.).

This distinction between the both notions is depicted in the Figure 7.

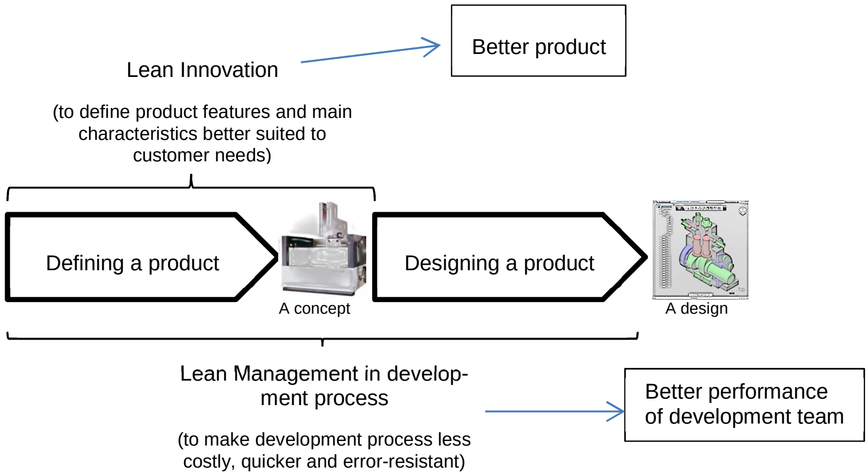


Figure 7. Distinction between Lean Innovation and Lean Management in development process.

In ProSEco the aspects of developing more innovative products from the perspective of customers and eco-performance are crucial and this is why the Lean Innovation concept will be included in **Methodology for Lean-based ECO-driven Product-service & Process Design (deliverable D300.11).** Lean Management itself, as a way to increase performance of development team will be used to improve collaboration process of ProSeco and will be related to D200.11 Methodology for Collaborative Product Services & Process Design.

3.1.1 Lean Innovation

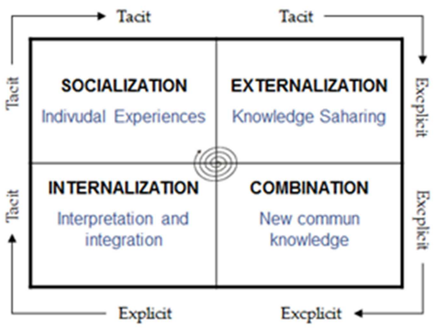
Lean means thin and well-trimmed, that is, working systematically to eliminate non-value processes or activities in order to achieve your goals with the least possible effort.

But thin and well-trimmed doesn't mean the same in manufacturing, management or innovation. Here we point out some of the key differences between lean in manufacturing and lean in innovation:

1. Manufacturing reproduces a known solutions (making several copies) while in an innovation process <u>the end result is unknown</u> when the process starts
2. In manufacturing variation is, by definition, non-value-creating (the more exact the object can be reproduced the better). In innovation we work with both value-creating and non-value-creating variation. Because <u>some variation is valuable as a necessary prerequisite for creating something new</u>
3. In manufacturing all the criteria is known in advance. In innovation processes we do not necessary know all the requirements at the beginning of the process. <u>The criteria is developed continuously as part of the process</u>
4. In manufacturing we deal only with physical objects. In innovation most of the processes take place in the mind of the employees, and <u>the knowledge we work with is rarely visible</u>.
5. The meaning of Waste (or unnecessary work) change from manufacturing to innovation. <u>Waste in innovation is anything that not create customer value</u> (what the customer won't pay for)

Therefore, innovation is about knowledge management and value creation. At the beginning of an innovation process knowledge is usually limited but through the process you learn more about the process and its possible solutions, therefore **innovation is also a learning and prioritization process.**

Moreover, taking into account nowadays companies' problems innovation is **a team learning and prioritization process**, involving mainly 4 steps [5] :



Individual learning

Knowledge-sharing with team

Integration and combination of knowledge

Interpretation and embrace

In a production process, there is a limit of how much costs can be reduced. In an innovation process, however, <u>the primary objective is not to reduce costs</u>. This is not unimportant, of course, <u>but innovation is first and foremost about getting solutions out to the customers quickly and creating solutions that are so innovative that you expand your market or create an entirely new one</u>.

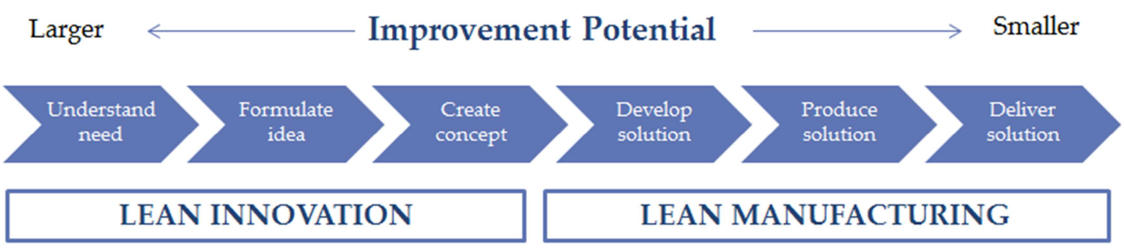


Figure 8. Improvement Potential

While lean production (lean manufacturing) deals with creating value in the late phases of the above process, lean innovation is about creating value in the early phases.

Therefore, to do this **ProSEco will focus on the process where the learning takes place and implement a system for continuous improving that process**. The next *Figure 9* represents the Lean Innovation approach on which the ProSEco lean-based eco-driven methodology will be based to conceptualize new innovative PES.

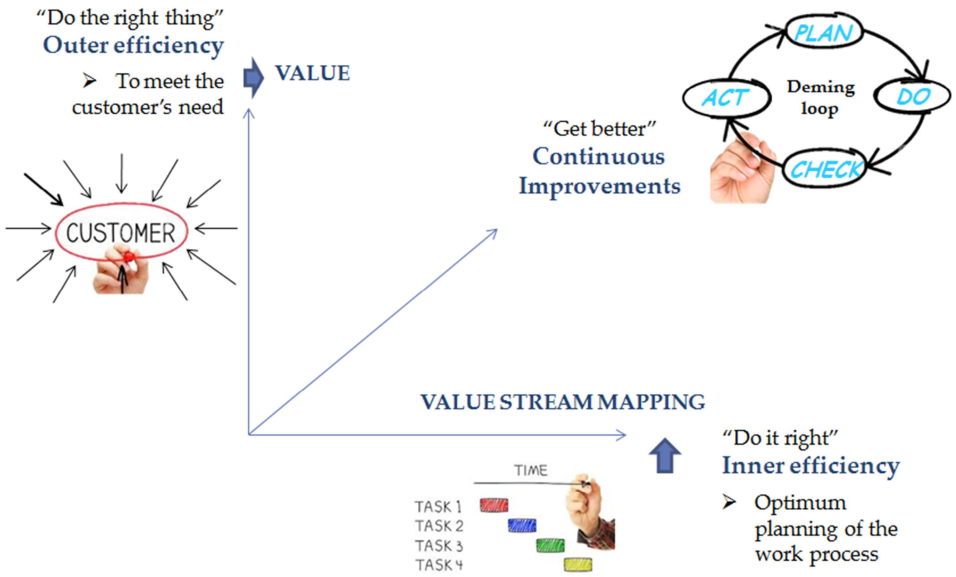


Figure 9. Lean Innovation

3.1.1.1 Lean Principles [4]

The act of creating a new PES conceptualization (*Defining a product*) and the work required to bring that idea or concept into a final form (*Designing a product*) (see *Figure 7*), is part of the New Product Development (NPD) process.

Important criteria of success in this New Product Development (NPD) process lies on differentiating from the competition and to provide convincing customer value. Therefore, the perception of value creation from the customer's point of view is especially important in the PES conceptualization phase of this process.

The goal is to systematically transfer the key principles of lean thinking and lean innovation into the PES conceptualization process.

Gemba ("the real place")

To go to Gemba means going to the place where the "truth is found". This principle is about understanding what happens in real life by experiencing it for yourself before saying how a problem should be solved.

The most obvious example of Gemba is in relation to the users of the solution you are developing or improving, that is experience how the customer receive the products.

Front loading

As we said before, all innovation projects start with a very limited understanding of how the future solution will turn out. This is especially true for projects aiming to create something truly novel as ProSEco case.

Moreover, typically 75% of a product's total life cycle cost is defined a quarter of the way through an innovation process.

Thus, front loading aims to increase the knowledge level in the beginning of a project by:

- allocating more resources of the project from the outset
- postponing decisions until sufficient information is available.

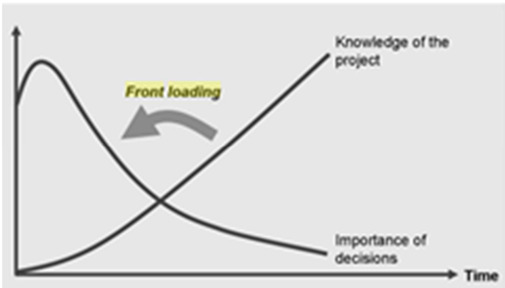


Figure 10. Front loading principle

Visual Management

Visualization can help us imagine a future situation or solution. Visualization can also help make discussions with others about that future and how to get there more specific.

But visualizations are not only good for describing a solution, but also for management or work processes. <u>This principle address the second point of visualizing the process</u>, the first approach of visualizing the solution will be address with the prototype principle.

Therefore, this principle will be needed:

- To visualize management and work progress
- To establish a shared vision, coordination and sense of responsibility among participants

Timeboxing

Timeboxing is when you operate with a fixed lead time so the end time for a deliverable is set in stone.

Learning is a never-ending process, thus, it is necessary to set a fixed deadline for this innovation process.

Takt

To have a regular rhythm in the process

Prototyping

To visualize the solution, in order to talk about it internally, but also, and even more important, to discuss it with the user, that is, prototyping force us to speak the language of the user.

In ProSEco simulation modelling will be particularly useful when prototyping (see section 5.1.5) .

- **Consumption stream mapping**

The key element of the Lean approach is the assumption that modern products and services provided to customers are elements of consumption streams (J. Womack & D. Jones, "*Lean solutions. How Companies and Customers Can Create Value and Wealth Together"* [6]). For example an oven is a product provided to households but in the phase of use it becomes an element of a stream of baking a cake. In this stream a consumer needs to prepare a dough, prepare the oven, then bake the dough, store it, clean the oven and then serve the cake. The producer of the oven has to understand the whole consumption stream to identify key functions and characteristics of the oven. Understanding of the consumption stream is even more important for product-service offers, hence they have greater potential to improve consumption streams.

3.2 ECO-DESIGN APROACH

As we pointed in the deliverable D100.1 and taking into account the eco-union.org approach [7], the eco-design is a key concept towards the sustainability and responsible consumption due to the fact that incorporates new concepts like: the new **system-product** approach, the **life cycle** concept and the integration of **all the actors** implicated in the improvement of all the environmental aspects of the products.

The key issues in the eco-design [7] are:

- The inclusion of environmental aspects into the design process together with others like functionality, security, viability, facticity, etc.
- The prevention of environmental impacts
- The design taking into account the relation between the object and the environment on every stage of the life cycle of the product

In the following subsections, we will explain the meaning of **system-product concept and life cycle concept** in order to understand better the fundamentals behind the eco-design methodology.

3.2.1 LIFE CYCLE CONCEPT

The traditional design process takes into account the production, distribution and use stages, but it used to forget others like: extraction of materials and waste management.

By life cycle of a product we understand the set of stages from extraction, processing of raw materials, production, commercialization, transport, use and waste management, as depictured in Figure 11. The total environmental impact of a product takes into account the consumption of resources and energy and the generation of polluting emissions throughout the whole process. The sum of the inputs (resources and energy) and outcomes (waste and polluting emissions) is what constitutes the total environmental impact.

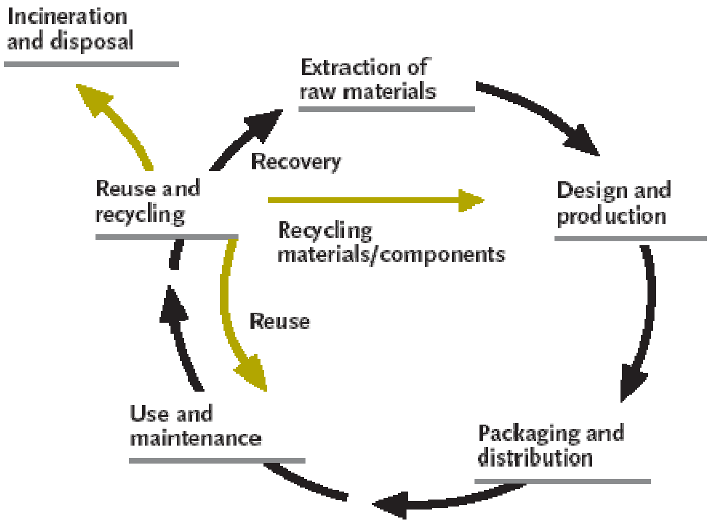


Figure 11. Life cycle of the product

The main goals of life cycle thinking are to reduce a product's resource use and emissions to the environment as well as improve its socio-economic performance throughout its life cycle.

The design is the key process to include the study of these different stages and learn about how to improve them before producing the product. The improvement potential during this stage is greater than in production and therefore the decisions taken during the design are crucial for the future of that product.

3.2.2 System-Product Concept

The system-product concept is a new paradigm that implies to move our attention from the product itself to the system around the product. The eco-design doesn't design just a product as an isolated reality, but the product together with all the aspects, which allow the product to fulfil its function: selected raw materials, production, commercialization, use and consume and waste disposal.

This new paradigm also introduces an environment sensibility and awareness in the companies that participate in this process. Therefore it will be necessary to have the right skills for the environmental assessment of the system-product, resulting in the involvement of professionals of the different areas of the process

Environmental consciousness is linked to creativity and innovations. Discovering the business benefits associated with a green product strategy can be the first step towards developing a more pro-active strategy towards the sustainability. Besides their often greater efficiency, eco-designed products also increase customer safety, are more reliable and of better quality.

3.3 ECO-INNOVATION APROACH

One of the first appearances of the eco-innovation concept in the literature is through Claude Fussler and Peter James (1996) [8], where they give a first definition for eco-innovation as ***'new products and processes which provide customer and business value but significantly decrease environmental impacts'*** (James 1997).

Later on, the Organisation for Economic Co-operation and Development (OECD) launched in 2008 the *Sustainable Manufacturing and Eco-innovation Project* [9], whose aim is to promote the concept of eco-innovation and to stimulate the development of new technological and systemic solutions to global environmental challenges for the medium to long term.

The OECD working definition of eco-innovation is "***the creation of new, or significantly improved, products (goods and services), processes, marketing methods, organisational structures and***

institutional arrangements which - with or without intent - leading to environmental improvements compared to relevant alternatives"

On the other side, the European Commission funded two projects (2006) on measuring eco-innovation: Measuring Eco-Innovation (MEI) and Eco-Drive. These two projects come to the following definition for eco-innovation:

- Eco-Drive "*a change in economic activities that improves both the economic performance and the environmental performance".*
- MEI "*the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives."*

The definition proposed by MEI researchers is considerably broader than the definition of ECO-DRIVE, which excludes pollution control technologies. The MEI definition follows the convention in innovation measurement specified in the Oslo Manual that the innovation does not have to be new to the market; it only has to be new to the company developing or adopting it.

The OECD Oslo Manual for the collection and interpretation of innovation data describes innovation as ***"the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations"*** (OECD and Eurostat, 2005, p. 46). Although this definition generally applies to eco-innovation, eco-innovation has two further significant, distinguishing characteristics:

- It is innovation that reflects the concept's explicit emphasis on a *reduction of environmental impact*, whether such an effect is intended or not.
- It is not limited to innovation in products, processes, marketing methods and organisational methods, but *also includes innovation in social and institutional structures* (Rennings, 2000).

Therefore, eco-innovation and its environmental benefits go beyond the conventional organisational boundaries of the innovator to enter the broader societal context through changes in social norms, cultural values and institutional structures.

Building upon existing eco-innovation literature [9] and as it is addressed in the OCECD Report [10], eco-innovation can be understood and categorized taking into account three aspects; the innovation's target, the innovation's mechanism and the innovation's impact.

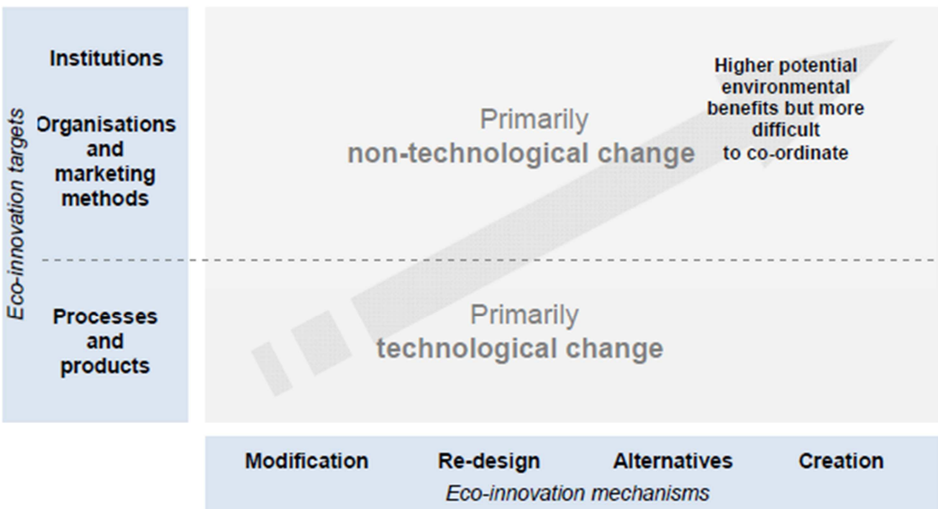


Figure 12. The typology of eco-innovation [10]

Target refers to the basic focus of eco-innovation. Following the Oslo Manual, the target of an eco-innovation may be:

- *Products*, involving both goods and services.
- *Processes*, such as a production method or procedure.
- *Marketing* methods, for the promotion and pricing of products, and other market oriented strategies.
- *Organisations*, such as the structure of management and the distribution of responsibilities.
- *Institutions*, which include the broader societal area beyond a single organisation's control, such as institutional arrangements, social norms and cultural values.

The target of the eco-innovation can be *technological or non-technological* in nature. Eco innovation in products and processes tends to rely heavily on technological development; while eco-innovation in marketing, organisations and institutions relies more on non-technological changes (OECD, 2007).

Mechanism relates to the method by which the change in the eco-innovation target takes place or is introduced. It is also associated with the underlying nature of the eco-innovation – whether the change is of a technological or non-technological character. Four basic mechanisms are identified:

- *Modification*, such as small, progressive product and process adjustments.
- *Re-design*, referring to significant changes in existing products, processes, organisational structures, etc.
- *Alternatives*, such as the introduction of goods and services that can fulfil the same functional need and operate as substitutes for other products.
- *Creation*, the design and introduction of entirely new products, processes, procedures, organisations and institutions.

Impact refers to the eco-innovation's effect on the environment, across its lifecycle or some other focus area. Potential environmental impacts stem from the eco-innovation's target and mechanism and their interplay with its socio-technical surroundings. Given a specific target, the potential magnitude of the environmental benefit tends to depend on the Eco innovation's mechanism, as more systemic changes, such as alternatives and creation, generally embody higher potential benefits than modification and re-design.

3.3.1 EVOLUTION PRACTICES FOR SUSTAINABLE MANUFACTURING

Manufacturing industries account for a significant part of the world's consumption of resources and generation of waste. Worldwide, the energy consumption of manufacturing industries grew by 61% from 1971 to 2004 and accounts for nearly a third of today's global energy usage. Likewise, they are responsible for 36% of global carbon dioxide (CO2) emissions [11].

But on the other side, manufacturing industries have the potential to become a driving force for the creation of a sustainable society. They can design and implement integrated sustainable practices and develop products and services that contribute to better environmental performance. As we were pointing in the ProSEco D100.1 deliverable, page 36 [12], this requires a shift in the perception and understanding of industrial production and the adoption of new sustainability awareness together with a more holistic approach to conduct this sector.

Indeed, during the last decades the manufacturing industries practices for sustainable manufacturing and development have evolved quite a lot (see Figure 13) from just the pollution control and cleaner production processes to the adoption of a more integrated and systematic methods to improve sustainability performance, working on new business models and environmental partnerships to create closed-loop production systems, (for example by establishing eco-industrial parks where economic and environmental synergies between traditionally unrelated industrial producers).

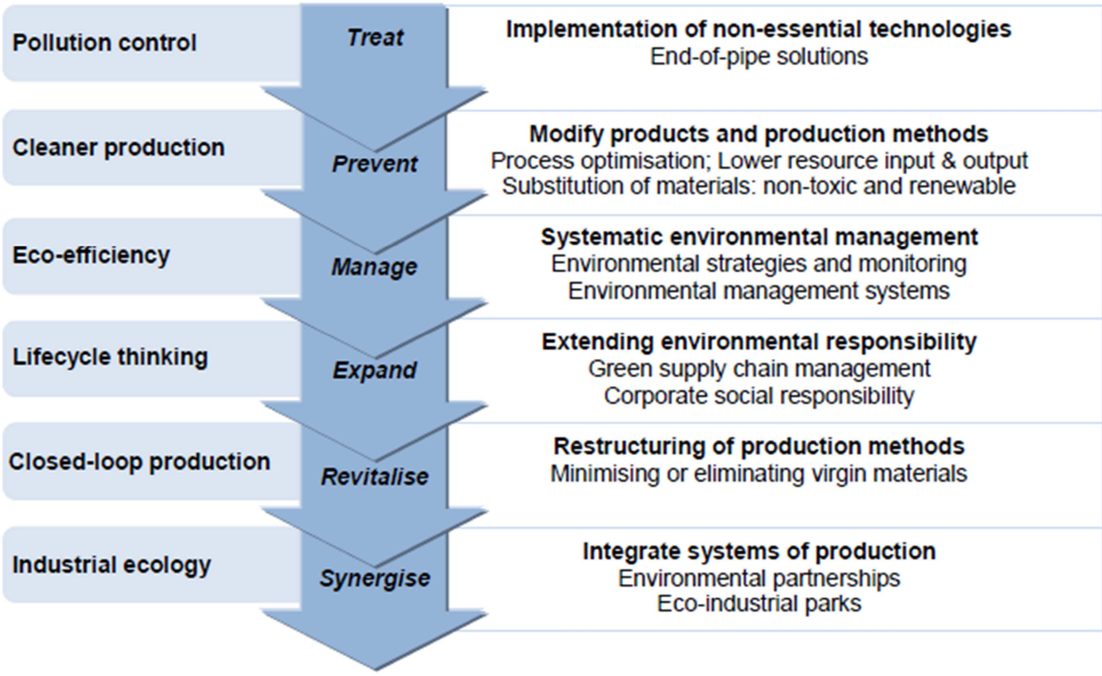


Figure 13 The evolution of sustainable manufacturing concepts and practices [9]

3.3.2 TYPES OF INNOVATIONS

To understand the basic mechanisms of different greening options from the innovation point of view, a distinction between three types of innovations can be made [13]:

- ***Incremental innovation***, which aims at modifying and improving existing technologies or processes to raise efficiency of resource and energy use, without fundamentally changing the underlying core technologies. Surveys of innovation in firms demonstrate that this is the dominant form of innovation and eco-innovation in industry.
- ***Disruptive innovation***, which changes how things are done or specific functions are fulfilled, without necessarily changing the underlying technological regime itself. Examples include the move from manual typewriters to word processors, or the change from incandescent to fluorescent lighting.
- ***Radical innovation*, **this type of innovation is often complex and is more likely to involve non-technological changes and mobilize diverse actors. Radical innovations could include not only the development of radical, breakthrough technologies but also to a reconfiguration of product-service systems, for example, by closing the loop from resource input to waste output ("cradle to cradle") and to the development of business models that reshape the way consumers receive value on the one hand and reduce material use on the other.

Therefore incremental eco-innovation focuses on improving existing goods and services, whereas disruptive and radical eco innovation is about thinking outside of the box and bringing completely novel approaches to market.

3.3.3 ECO-INNOVATION AND BUSINESS MODELS

As we have explained in the previous sections, eco-innovation can be an idea for a new product as well as for making improvements to existing operations, eco-innovation can be focused in a new technology but can also be focus on creating new services or introducing changes at the organizational level or consumer behaviour level.

But what distinguishes eco-innovation from other innovations is:

- It takes the full life-cycle perspective into account
- Eco-innovation results should provide not only economic benefits but also environmental and social ones

The life cycle perspective means that eco-innovation is not simply about reducing input of resources into a single product, but about an overall better use of resources used to deliver certain utility or service. In some cases, it may even mean increasing input of resources in the production process if it is to substantially improve the utility and durability as well as to reduce resource use over the lifetime of the new solution.

Environmental considerations take into account the fundamental system conditions for sustainability, very well explained in The Natural Step Report [14] and summarized in Figure 14:

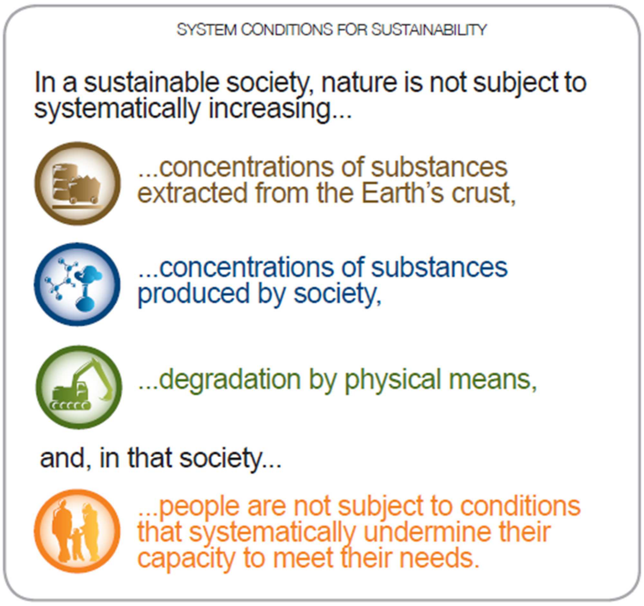


Figure 14. Fundamental System Conditions for sustainability [14]

Taking into account these fundamental sustainable principles, environmental benefits may be:

- Reduce the use of natural resources, substituting certain minerals that are scarce in nature with others that are more abundant, using all mined materials efficiently and systematically reducing dependence on fossil fuels.
- Decrease the release of harmful substances per unit output across the whole life cycle. Natural resources include abiotic resources (e.g. minerals, metals), energy (e.g. energy carrying resources such as oil or gas), biotic resources (i.e. biomass), water as well as land.
- Decrease or eliminate our contribution to the systematic physical degradation of nature through over-harvesting, pollution and other forms of ecological modification pursuing the most productive and efficient use of land and resources and exercising caution in all kinds of interventions in natural cycles and processes.
- Contribute as much as we can to the meeting of human needs locally and worldwide, above all through substitution and dematerialization measures to meet the first three objectives. This means using all of our resources efficiently, fairly and responsibly so that the needs of all people on whom we have an impact, and the future needs of people who are not yet born, stand the best chance of being met

Therefore we can conclude that ***eco-innovation is the introduction of any new or significantly improved product (good or service), process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life-cycle*** [13]**.**

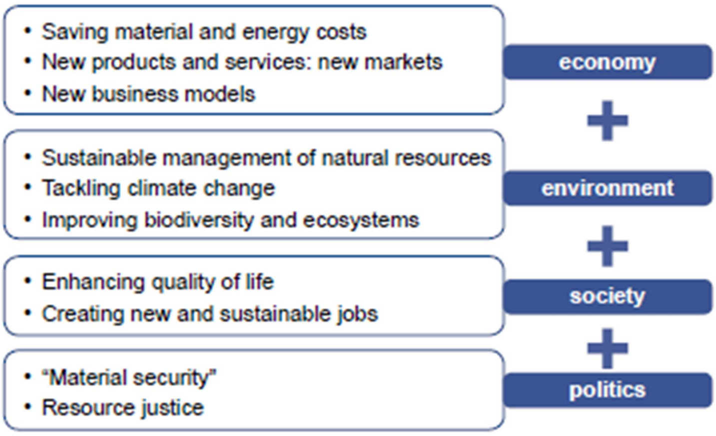


Figure 15. Eco-innovation impacts at different levels

At its core, ***eco-innovation is about creating business models that are both competitive and respect the environment by reducing resource intensity of products and services.*** (see [15]).

Therefore, among the key elements in determining the success of eco-innovation, a special **focus needs to be on the business model**, which brings out eco-innovation to the market and promotes its dissemination. According to Osterwalder et al. [16], "*a business model describes the rationale of how an organization creates, delivers, and captures economic, social, and other forms of values*". A business model is also understood as a holistic approach towards explaining how firms conduct business (Zott et al., 2010).

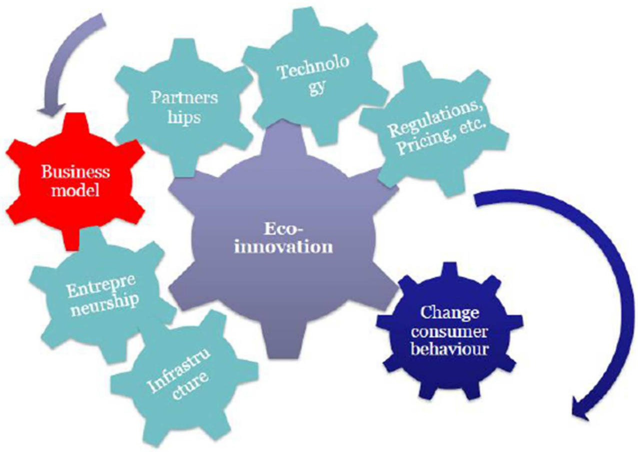


Figure 16. key elements around eco-innovation [13]

The business model approach offers a comprehensive way to understand how value is created and distributed. Eco-innovation aims to create both economic and environmental value, and business models act as a value driver and enabler of green technologies and solutions.

The focus on business models will allow us to have a better understanding on how environmental value is captured and turned into profitable products and services. In concrete terms, the analysis of eco-innovation cases can shed light on whether, to what extent and how environmental values are reflected in firm's value propositions, customer segmentation, use of resources, collaboration patterns and the management of cost and revenue streams.

Innovative business models allow firms to restructure their value chain and generate new types of producer-consumer relationships or even new customer value proposition ideas that could alter the consumption culture, use practices and sustainability awareness of the final consumer.

The business model perspective is therefore particularly relevant to radical and systemic eco-innovation, including how business models and strategies can induce and help diffuse radical eco-innovation and enable systemic changes and transformation.

As the eco-innovation target can be focused at the beginning of the process on the product or on the organization and marketing methods. In ProSEco we will offer both approaches in order to test and evaluate them:

- Setting the target on the product (*PES)* to the market and business transformation
- Setting the target on the business model (business transformation) to the best PES (customer value proposition) ideas.

Moreover, the design of new ***Meta-Products***, which highly personalised innovative functions, will require the evaluation of both, the environmental impact in terms of the product along the overall Life Cycle but also the environmental impact in terms of the new business model.

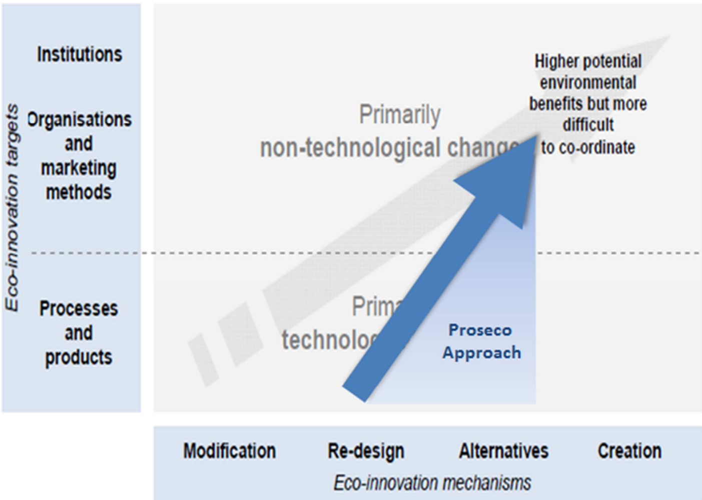


Figure 17. Proseco approach

Therefore, an important effort will need to be made to revisit the concepts of value and profitability that drive those Meta-product and then new business models, and to reconsider the balance between the dual objectives of short-term profitability and long-term sustainability.

3.3.4 Business model Definition

Business models combine all the core components of business strategies and operations that create and deliver value to the customers as well as to the firm. The components of business models typically include strategic decisions on customer segmentation, products and services (or value propositions) to offer, business and research partners to engage with, resources to create and channels to deliver value, as well as the underlying cost structure and revenue streams to ensure economic viability of business.

Business models have been well studied in the business and management literature since the 1990s but there is still no unique definition or understanding across the literature as researchers frequently adopt idiosyncratic definitions that fit the purposes of their studies, but that are difficult to reconcile with each other [17]. The existing definitions only partially overlap, giving space to numerous interpretations.

Business models are considered in multiple ways including:

- Interpreting business models as a conceptual framework, mode, or abstraction of the firms current and future plans.
- Providing an intermediate layer of business understanding between business strategy and actual processes.
- Considering business models as a tool for managing the firm or an intangible asset for supporting strategic decision-making.
- Seeing business models as service logistics often presented as a flow chart.
- Applying business models for explaining how the firm creates value for themselves and stakeholders.

Despite these differences in conceptualisation Zott, et al., [17] also found some emerging common ground:

1. The business model is emerging as a new unit of analysis
2. Business models emphasize a system-level, holistic approach towards explaining how firms do business
3. Organizational activities play an important role in the various conceptualizations of business models that have been proposed, and
4. Business models seek to explain how value is created and captured.

Alexander Osterwalder took an important step in the world of business models by proposing a model of ontology with nine blocks and also rules of relationships among them; this is a tool that facilitates and improves clarity on the activities of design, evaluation, and innovation of business models due to its holistic nature and the simplicity of the concepts. This tool, combined with others and with a methodology based on the interaction of collective intelligence [16], turns out in significant opportunities for business innovation (Figure *18*).

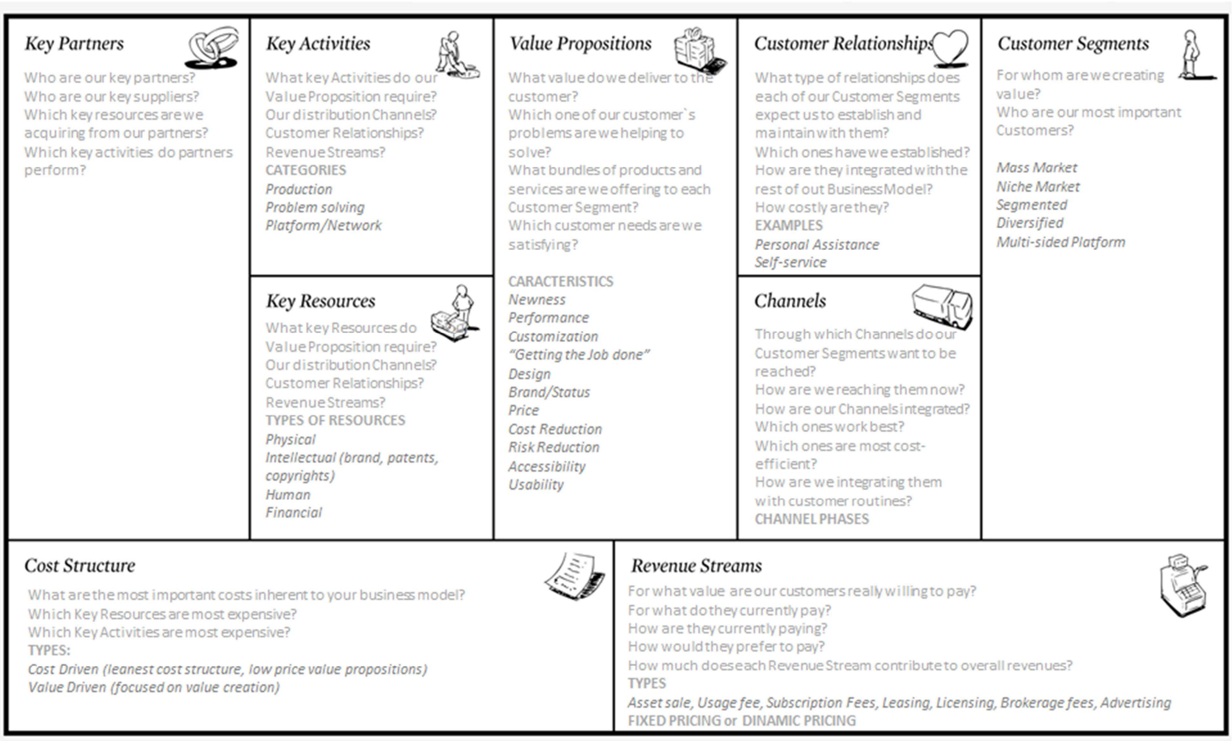


Figure 18. Osterwalder & Pigneur Canvas Model, 2009

However, in the typical approaches to business models, environmental sustainability is rarely at the core of value propositions. These aspects may us believe that in ProSEcoit is necessary to develop a working concept of business models to analyse radical and systemic ***eco-innovation Business***. As the

community increasingly recognises the challenges of climate change and resource scarcity, these issues need to be internalised in the building blocks of the firm's strategy and operations.

3.3.5 DEFINITIONS OF PRODUCT EXTENDED SERVICES (PES)

There are various definitions of Product Service Systems, (PSS), for example, [18] defined PSS as a ***marketable set of product and services capable of jointly fulfilling a user's needs*** , that is, when a firm offers a mix of both products and services, in comparison to the traditional focus on products.

The initial move to PSS was largely motivated by the need to cope with changing market forces and the recognition that services in combination with products could provide higher profits than products alone. Faced with shrinking markets and increased commoditization of their products, these firms saw service provision as a new path towards profits and growth.

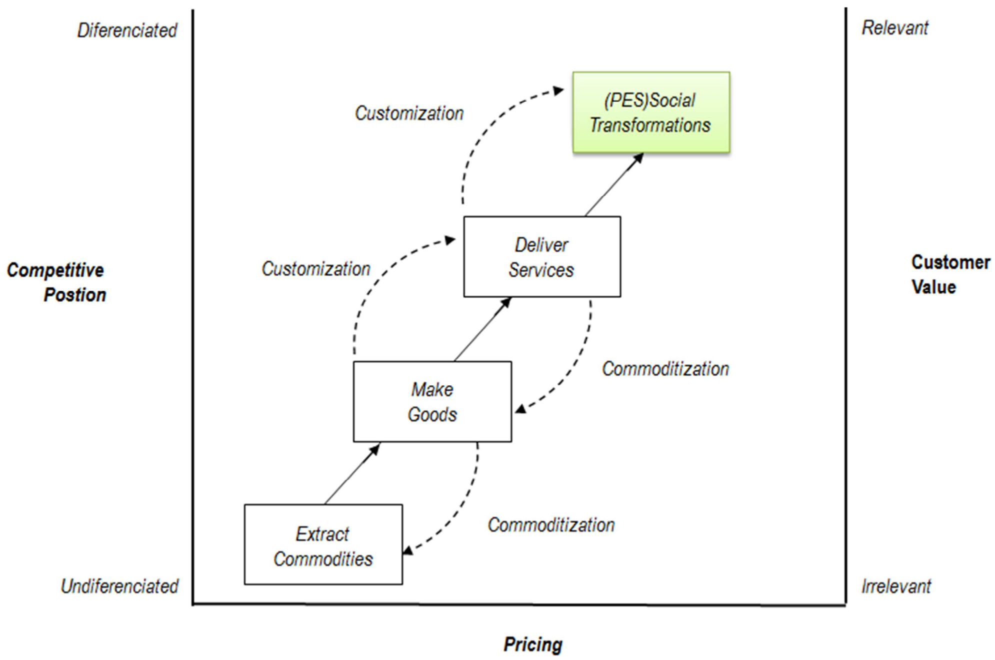


Figure 19. Shifting up the progression of Economic Value (based on [19])

But service provision is not the end of the progression of the companies, accordingly to B. Joseph and J. H. Gilmore [19] both goods and services shift up the progression of economic value when they are customized (Figure 19). Then, businesses that wish to prevent commoditization should enter in a new type of economy where they customize their goods and services and combine them together with other stakeholders to provoke social transformations.

Moreover, it is important to address that not all product service systems (PSS) result in the reduction of material consumption, they are more widely being recognized as an important part of a firm's environmental strategy. In fact, some researchers have redefined *PSS as necessarily including improved environmental improvement*. For example, Mont (in [20]) defines PSS as a "***a system of products, services, supporting networks, and infrastructure that is designed to be competitive, satisfy customers' needs, and have a lower environmental impact than traditional business models***" Mont elaborates her definition as follows: A PSS has also been defined as a "self-learning" system, one of whose goals is continual improvement.

On the other side, the business model concept has recently been adopted in the discourse on sustainable services (Halme et al., 2007) and is also routinely utilised in studies on product-service systems (PSS***). A PSS is a business model that has tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific customer needs*** (Tukker, 2004).

We can conclude, that for the purpose of ProSEco research, ***PSS is defined as a new business strategy based on a combination of tangible product(s) and (in)tangible service(s) that fulfil the user needs and satisfaction, taken into account the reduction of the environmental impact together with the competitiveness of the company and stakeholders; provoking a shift of behavior from consumption (selling product) to use (selling function).***

4 Lean based eco-Innovation Methodology

4.1 The concept

The need to transition to a more sustainable economy is one of the key beliefs in ProSEco and one of the most significant challenges society is facing nowadays. Despite the evidence that adopting a more sustainable approach is linked to more stable profits, this transformation is not easy at all for conventional manufactories that do not know where to begin with.

Moreover, in this global market, it is not enough to adopt a more sustainable approach; the key factor of success will be to be able to differentiate oneself from the competition based on successful innovations and to provide convincing customer value.

Many companies fail to provide their customers with true uniqueness and convincing differentiation based on innovation and sustainability. Therefore, *the aim of this methodology is to provide a new framework to facilitate the generation of **innovative PES** (product extension services) together with the business strategy (business model) based on a combination of the physical product(s) and (in)tangible services(s) that fulfill the user needs and satisfaction, taking into account the reduction of the environmental impact together with the competitiveness of the company and stakeholders; provoking a shift of behavior from consumption (selling product) to use (selling function).*

A conventional business model refers to a traditional manufacturing model based mainly on sales of goods or products, while in ProSEco we seek a transformation from product-oriented business models to service-oriented business models, also called Product Service Systems (or PSS business models)

A **sustainable business model** can be defined [21] as a new business paradigm that generates profit by providing customers with integrated solutions of products and services that directly or indirectly reduce the environmental load while generating profits equal to or greater than those of a conventional business models. Based on [22] [23] [24].

This methodology will be performed by stakeholders involved in the development of new products or businesses (CEO, designer, environmental expert, material expert, IT developer, manufacturing engineer, economist, sales representative, etc.) and therefore the collaboration tools of ProSEco will be used during the different stages of the process.

The following Figure 20 presents the workflow of the **lean-based eco-innovation methodology** and the following subsections will explain the guidelines for each of the process stages, putting special emphasis in those aspects related with the implementation of the eco and lean principles and the integration with the ProSEco tools developed by other RTD partners.

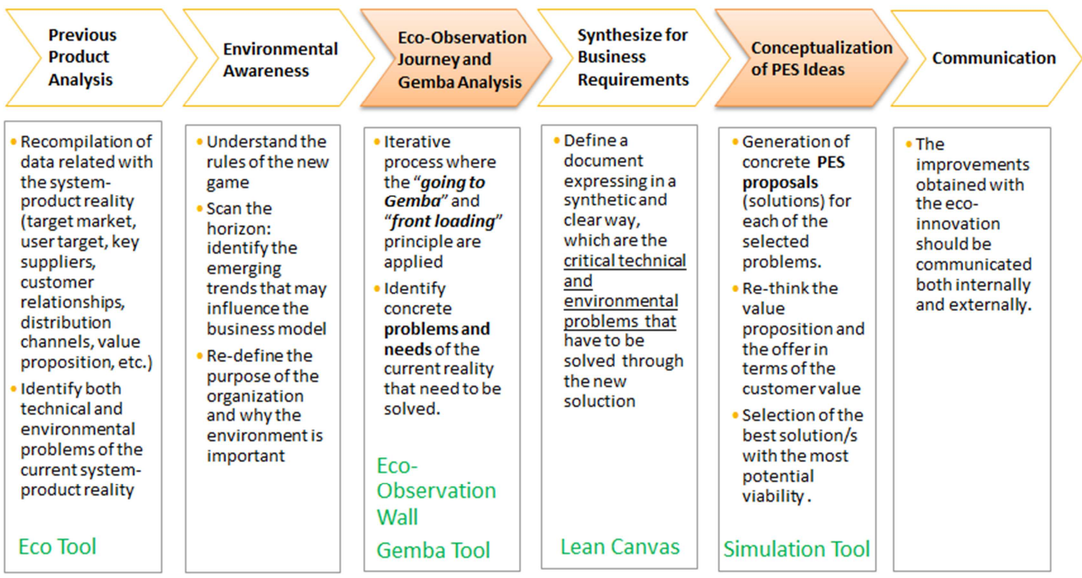


Figure 20. Lean-based eco-innovation methodology process

4.2 The Methodology

4.2.1 Previous Product Analysis

This first analysis implies to move our attention from the product itself to the system around the product. The eco-innovation methodology doesn't design just a product as an isolated reality, but the product together with all the aspects which allow the product to fulfil its function, taking into account the whole life-cycle: selected raw materials, production, commercialization, use, consume and waste disposal. (*See 3.2.2. System-Product Concept*)

The objective of this analysis is to have a full understanding of the system around the product in terms of two important aspects: the business and the environment.

For the **environmental analysis** a full life cycle assessment will be performed (*See section 5.1.1)* taking into account some selected indicators (limited availability of indicators) an evaluation of the energy and material consumption over the whole life cycle of the product (limited focus of analysis).This analysis will identify the ***environmental critical points*** to be improved and the stages of the product life cycle where these critical points are concentrated.

For the ***business analysis*** a recompilation of data related with the current business model, taken into account all the aspects around it, like: *target market, user target, key suppliers, customer relationships, distribution channels, value proposition, etc*. will be collected. The **Osterwalder Canvas Tool** together with a collaborative methodology based on the interaction and collective intelligence to combine the knowledge around a product and create a shared knowledge will be applied. (*See 5. ProSEco Tools Required*).

The deepness of this analysis will depend on the human, economic and technological resources the company wants to dedicate to this process and also the previous experience of the company in this kind of processes.

The first version of this business model canvas, shown in Figure *18*, will be developed in a workshop involving people from different departments (CEO, designer, environmental expert, material expert, IT developer, manufacturing engineer, economist, sales representative, etc.). Once this workshop is finished, the outcome of this workshop is saved in the ProSEco Collaborative Platform to be accessible by all actors involved.

4.2.2 Environmental Awareness

Companies most often decide to redesign their business model to reduce costs and improve customer experience, but this methodology goes further as we want to redesign the business model to identify environmental and social benefits for the company, the customers and the society.

Therefore the aim of this phase is to build a ***common understanding of the sustainability***, eco-innovation and life-cycle concepts, in order to understand that eco-innovation methodology is not simply about reducing input of resources into a single product, but about an overall better use of resources used to deliver certain utility or service.

> *"eco-innovation is the introduction of any new or significantly improved product (good or service), process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life-cycle* [13]*".*

Another important part of this phase is to ***identify the emerging trends*** that may influence the business model or inspire new business ideas.

Once the company understands the sustainability concept, it is time to find implications of those key aspects at the company level.

To perform this analysis, the company has to answer some key questions that should help to identify the ***motivation for change***:

1. *What is the purpose of the organization?*

2. *Why does it exist?*
3. *Why the environment is important for the organization?*
4. *Why the environment is important for the customers and for society?*

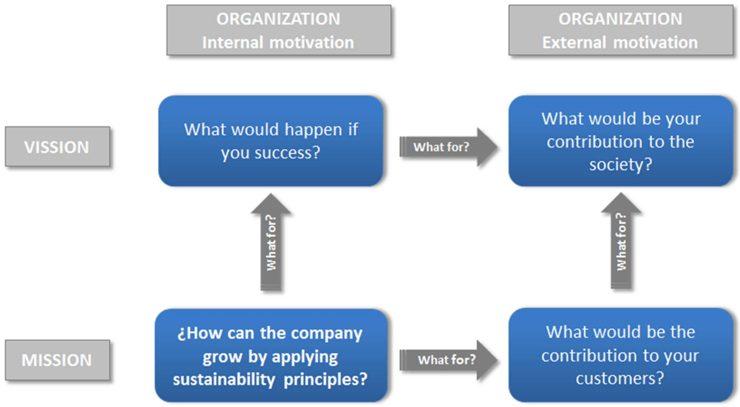


Figure 21 Reflecting on Company's Leading thoughts

The objective of this analysis Figure 21 is to re-define the purpose of the organization and why the environment could be important for them.

4.2.3 Eco-Observation Journey and Gemba Analysis

This phase of the methodology requires an iterative and deep process where the "***going to Gemba***" principle is applied. This principle is about going to the place where the "truth can be found", to understand what happens in real life of the customers by experiencing it by ourselves before saying which are the key needs or problems and how they should be solved (key features of the solution).

This principle, however, will not be successfully applied without understanding the "***front loading"*** principle. The application of this principle implies what we called in this methodology an ***Observation Journey.*** *Observation* is the active acquisition of information from a primary source. In living beings, observation employs all the senses. In science, observation can also involve the collection of ***data*** via the use of different instruments during the scientific activity.

Depending on the use case we will need to capture the knowledge from different sources, but in general this process can be divided in the following sources:

- Final users
- Customers
- Domain Experts
- Technological Experts
- Environmental Experts

The data alone cannot be humanly relevant information. Only when a data set is examined together taking into account one approach, an *hypothesis or theory*, it can be seen the information contained in the data. The *appropriate groupings structured* and *interpreted data* are considered to be the basis of humanly relevant information that can be used in decision-making.

During this process, all the *data* is captured and placed into the ***Eco-Observation Wall.*** This tool is more than just a container of data; it is a thinking tool that allows us to explore different approaches of the product taking into account the life-cycle perspective, the sustainable principles and the eco-innovation strategies to finally identify concrete **problems and needs of the current reality that need to be solved**. (See also section 4.2.3.1 and 4.2.3.2)

The section 5.1.2 explains the rationale behind the Eco-Observation Backboard Tool and the explanation of each of the steps of this observation journey together with some illustrated examples.

Moreover, in this phase the **Gemba Analysis** will also be performed. This activity includes observation the use of the product-service in the real place (gemba). The Gemba Analysis method will be elaborated

within ProSeco project on the basis of such existing methods like Value Stream Mapping [25], Consumption Stream Mapping [6], Go-See-Act and A3 Reports [26]. The general structure of Gemba Analysis is depicted in the Figure 22 (for industrial goods) and Figure 23(for consumer products).

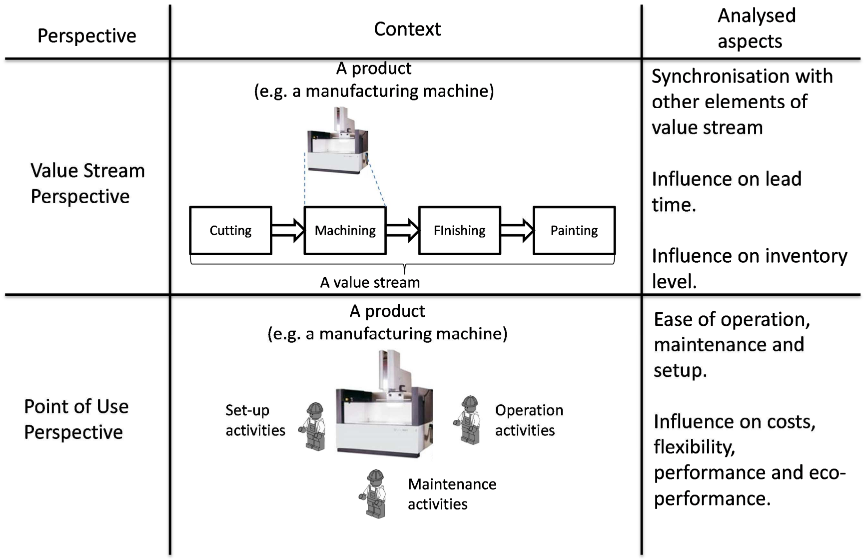


Figure 22. Gemba Analysis for industrial goods.

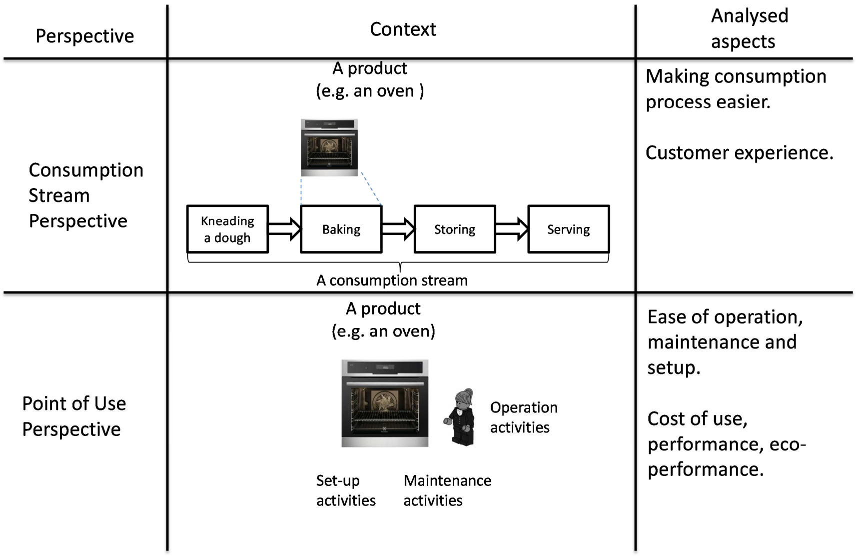


Figure 23. Gemba Analysis for consumer products.

Gemba Analysis will enable to identify how to solve a customer problem completely by providing a new meta-product or improve the existing one. This kind of analysis gives additional and in many cases key information, facts and detailed data in comparison to other approaches based on high level analysis and aggregated data. The ecological aspects will be also integrated in the analysis methods to identify opportunities to improve eco-performance of developed meta-products.

The output of Gemba Analysis and the Observation Journey will become the input for the Lean Canvas (see section 4.2.4. Synthesize for Business-Requirements).

4.2.3.1 Eco-Innovation strategies

Eco-Innovation strategies are generic business strategies corresponding to each life cycle stage of a product and/or service in order to help to create a **new sustainable business model**.

To simplify the selection of eco-innovation strategies, these are grouped in blocks according to life cycle stage on which mainly affect. Following Figure 24 lists the eco-innovation observatory (*see* [15])developed guidelines with some improvement considerations to help the generation of new business ideas.

<u>A guideline improvement procedure for new business ideas</u>

Life-cycle stage	Environmental consideration	Business case
Resource extraction	• Reduce environmental pressures and impacts by limiting extraction of virgin resources and by limiting "unused" extraction	• Consider renewable and secondary resources (circular economy) • Reduce cost by improving efficiency of extraction • Comply with and anticipate new regulations • Improve your reputation CSR (Corporate Social Responsibility)
Manufacture	• Use fewer resources, including energy • Use materials with less environmental impacts (substitutes) • Produce less pollution and waste	• Reduce production costs by improving material and energy productivity and by material substitution • Build resilience to changes in commodity prices and resource supply • Increase your turnover and profits from sales of resource-efficient products and services • Comply with and anticipate new regulations (including eco-design)

Distribution	• Reduce impacts, for example through:
	  • Better packaging design, reuse, recycling
	  • Fuel and energy use reduction in transportation and storage
		• Cost reduction
		• Regulatory compliance

Use	• Use less resources, including materials, energy, land and water • Cause less pollution and waste	• Shift to selling services from products (i.e. functional sales, including product leasing and sharing) • Improve your reputation and customer relations • Comply with and anticipate new regulations
End of life	• Reduce impacts of waste disposal by decreasing the volume of waste or by improving the quality of waste	• Develop and sell novel products and materials from waste • Reduce costs by reusing, recovering or recycling resources from your own or external waste streams (e.g. industrial ecology, C2C (Cradle to Cradle)) • Comply with and anticipate new regulations

Figure 24. Eco-innovation Strategies (based on [15])

Adopting a variety of business strategies using life cycle approaches, generally increases opportunities for companies to create environmental, economic and social benefits because <u>*planning and implementing business strategies*</u> is meant to achieve the company's business mission, such us *reducing resource consumption, minimizing waste, managing financial risk, and maximizing earning*.

4.2.3.2 Eco-Design Strategies

The eco-design strategies are <u>improvement proposals</u> to reduce resource consumption (raw materials, water, energy, soil, etc.) and/or minimize waste generation (emissions to the air, water, or soil) associated with the life cycle of the product / service to generate **new product ideas**.

To simplify the selection of eco-design strategies, these are grouped in blocks according to life cycle stage on which mainly affect.

<u>A guideline improvement procedure for new product development</u>

1. <u>Development of new concepts</u>
   - o *Dematerialization*: Reduce as far as possible the amount of material resources used to perform the function of the product.
   - o *Shared use of the product*: Maximize the utilization of a product by promoting a shared use of the product. This strategy allows reduction of environmental impacts associated with each use of the product.

- *Multifunction*: Integrate various functions on a product to prevent the need to produce other products.

2. Reduction of consumption and diversity of materials
   - *Minimization*: Minimize those components or parts of the product that do not have an essential function, or do not increase quality, or aesthetic value.
   - *Optimization*: Optimize the thickness of the walls and density of the materials thus achieving a reduction of material consumption and cost savings (material, transport ...)
   - *Reuse*: The high durability components of the product or those not subject to wear can be reused for new products.

3. Selection of materials with low environmental impact
   - *Use of natural resources*
   - *Use of recycled materials*: the production with virgin material is avoided, it is possible the mixture of materials (recycling + virgin).
   - *Use of reused and / or reusable components*
   - *Elimination of hazardous substances*. Additives, finishes, toxic materials, etc.
   - Use *of recyclable materials*. Use of materials that have recycling known circuits.
   - *Materials with low energy intensity*: Use of materials that not require large amounts of energy for their manufacturing process.

4. Reduction of the impact of production processes
   - *Reducing the number of production stages*, with the aim of reducing the *consumption* of materials and energy.
   - *Internally recycle production waste*: Select materials and processes to internally recycle waste production (i.e. defective products, production testing…).
   - Choosing *cleaner production processes*. More efficient use of water and energy, low-energy, low-waste, use renewable energy, and do not alter the properties of the materials making them difficult to recycle waste.

5. Optimization of the distribution
   - Reduction *of the volume of the* product: Increase the amount of goods carried per transport unit.
   - *Reduce weight*: Reduce consumption of energy (especially fossil fuels) during transport.
   - *Minimize the use* of *containers*: Avoid the use of containers whenever it is possible, design reusable containers, reducing the amount of materials used or new features to the packaging.
   - *Optimize container volume*: Reduce the impact of the distribution.
   - *Use of* raw materials from local suppliers, with consequent minimization of transport.

6. Reduction of the impact during use
   - *Reduce the consumption of energy and materials per unit of* service provided by the product, increasing energy efficiency and integrating energy saving systems.
   - *Incorporate the use of renewable energy*
   - *Reduced consumption of resources* and emissions in maintenance.

7. Increase the lifetime of the product
   - *Eliminate weaknesses*. Remove components susceptible to breakage or need to be repaired or replaced frequently.
   - *Choose suitable materials*. Choose appropriate materials and thicknesses to give good resistance to your product before continued use.
   - *Facilitate* repair and maintenance. Favouring that the most vulnerable components can be easily removed and replaced.
   - *Design* the *product in modules*. To facilitate their adaptation over time.

8. Optimize final waste management
   - *Use recyclable or biodegradable materials*
   - *Use the minimum amount of material*, to facilitate recycling of the product
   - *Create mono-material products* that can be recycled together without the need for disassembly.
   - *Simplify the disassembly of the product*. To reduce the time required and the economic costs of separating the components of the product, and encourage recycling or reuse.
   - *Facilitate the identification of the type of materials used* (for example, by symbols).
   - *Reduce the volume of waste.* To facilitate the compaction of the product and to reduce the volume of the residue.

4.2.4 Synthesize for Business-Requirements

The objective of this phase is to identify at least one opportunity to innovate and create value for real market. To do so a refinement work is needed to synthesize all the information and emotions collected from final users, operators, designers, machines, etc. that have been identified in the previous phase.

A document is created to express in a synthetic and clear way, the new concrete business requirements to be addressed by the new Meta Product conceptualization.

Therefore, the outcome of this analysis will be summarized in a document that will express the **key important features** (*functionalities*) the solution should address to solve the identified customers' problem. Lean Canvas tool is an adaptation of the Business Model Canvas of Osterwalder, which can be used to express the above information in a graphical way.

To fulfill the **Lean Canvas**, firstly we add into the tool the 3 key problems the customer segment needs to solve (selected from the previous phase). Once this is done we think about how early adopters[1] address these problems today and how our company could address them in order to establish the ***3 most important features of our solution***, trying to clarify why our solutions is better, that is our unfair advantage. Finally, we establish the set of indicators, which will help us to make decision regarding this solution.

Figure 25. Lean Canvas

[1] *Early* adopters *generally rely on their own intuition and vision and choose carefully. For any new product or service to be successful, it must attract innovators and early adopters, so that its acceptance or 'diffusion' moves on to early majority, late majority, and then on to laggards*

***Problem**: Identify 3 key problems your customers face (related to your business)*

***Solution**: Establish the 3 most important features of your solution (product or service oriented) that will help to solve customers' problems*

***Unfair Advantage/Unique Value Proposition:** Clarify what makes you special and how you will help your customers solve their problems*

***Key Metrics**: establish the set of indicators which help us to make decisions*

4.2.5 CONCEPTUALIZATION & VALIDATION

The conceptualization means to generate concrete solutions (business ideas), that is, the transformation from generally formulated *eco-innovation strategies* into product or service related measures.

This stage of the process requires experience and creativity as well as methodological support.

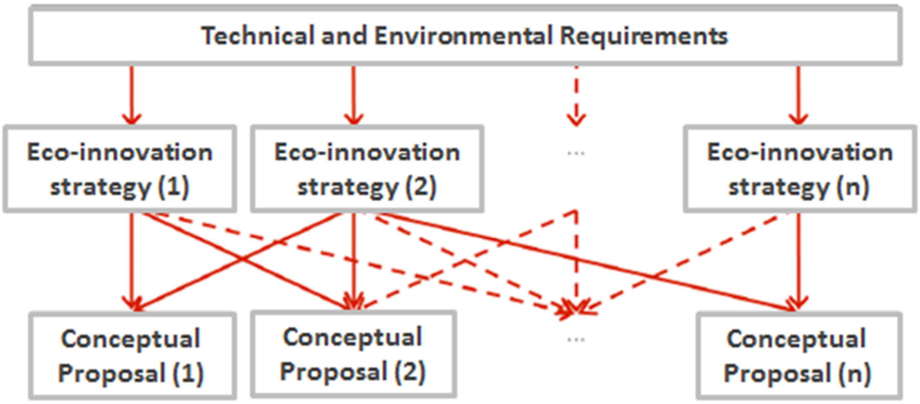


Figure 26 Process of generating concrete solutions

Along this conceptualization phase, *different PES ideas (conceptual proposals)* associated to the technical,environmental and bussness requirements are proposed through the domain conceptualization of the previously selected strategies.

These solutions are generated via creative workshops involving people with different expertise and knowledge of the different life cycle of the product (marketing and sales, design, technical, etc.) Therefore collaboration of the different agents involved in the design process and knowledge management will be crucial to perform this stage of the methodology.

But not all business strategies that generate environmental benefits create profit or social benefits and vice versa. For example, a business strategy can encourage more consumers to choose the rental service rather than buy the product, thus producing a positive return, creating positive economic effects sufficient to offset the negative effects in the use and maintenance stages.

Therefore it is important to analyze the new PES ideas together with the new business models that may comprise many inter-related variables such as *suppliers, suppliers' suppliers, customers, customers' customers, distribution channels, prices policy, etc.*

As it been explained in D200.31, simulation models are well-suited to facilitating investigation of complex situations in the real world, such as international business scenarios or new local buissness scenarios, that is, Simulation modelling is particularly useful when prototyping or experimenting with a real world systems, as Simulation modelling facilitates the repeated formulation and testing of hypotheses about real world interventions**.**

Therefore the aim of this phase is to test behavioural patterns of new identified PES to validate them in terms of the customer value. To do so the Business Model Simulation Tool developed by VTT will be used. (See also section 5.1.5 Business Model Simulation Tool)

In this phase of the process key domain specific variables need to operationalize in detail within the simulation model through inclusion of relevant causal phenomena. The tool allows to set scores for customer expectations or new **PES** offering. The minimum requirement is that the meta-product being designed should be at least congruent with customer expectations. Not all criteria are equally important to potential customers; hence there is weighting of criteria to reflect their relative significance.

Once the Simulation tool has balance a The different conceptual alternatives are presented and the one with the greatest potential feasibility is selected. It can be just one or two of them or a new one composed by two or three alternative solutions.

4.2.6 COMMUNICATION

The multi-resolution simulation model together with the improvements obtained with the eco-innovation is used to explore the market potential of the new PES ideas.

The improvements should be communicated both internally and externally. External communication refers to customer demands, market trends, policy tools, and infrastructural support. Internal communication comprises human resources and other physical entities such as technology and facilities.

The communication strategy should be part of a business model of the new service or meta-product. This strategy should encompass target customer groups (customer segments), value propositions, communication channels and a content (see Table 1).

Table 1. An example of general definition of a communication strategy.

Communication content	Communication channels	Value proposition	Customer segments
Quote saved per month, calculator of savings	Facebook, www	Reduced costs of living	Young couples below 35
Quote saved per month, calculator of savings	www	Reduced monthly cost of fuel	Families
Reduced fuel consumption per particular car model	Individual meetings	Better cars' performance, more competitive offers	Car dealers

In ProSeco approach the communication stage will be integrated with the development process through business canvas methods (see in Figure 27). The guidelines will be provided how to derive communication strategy from the Lean canvas wall.

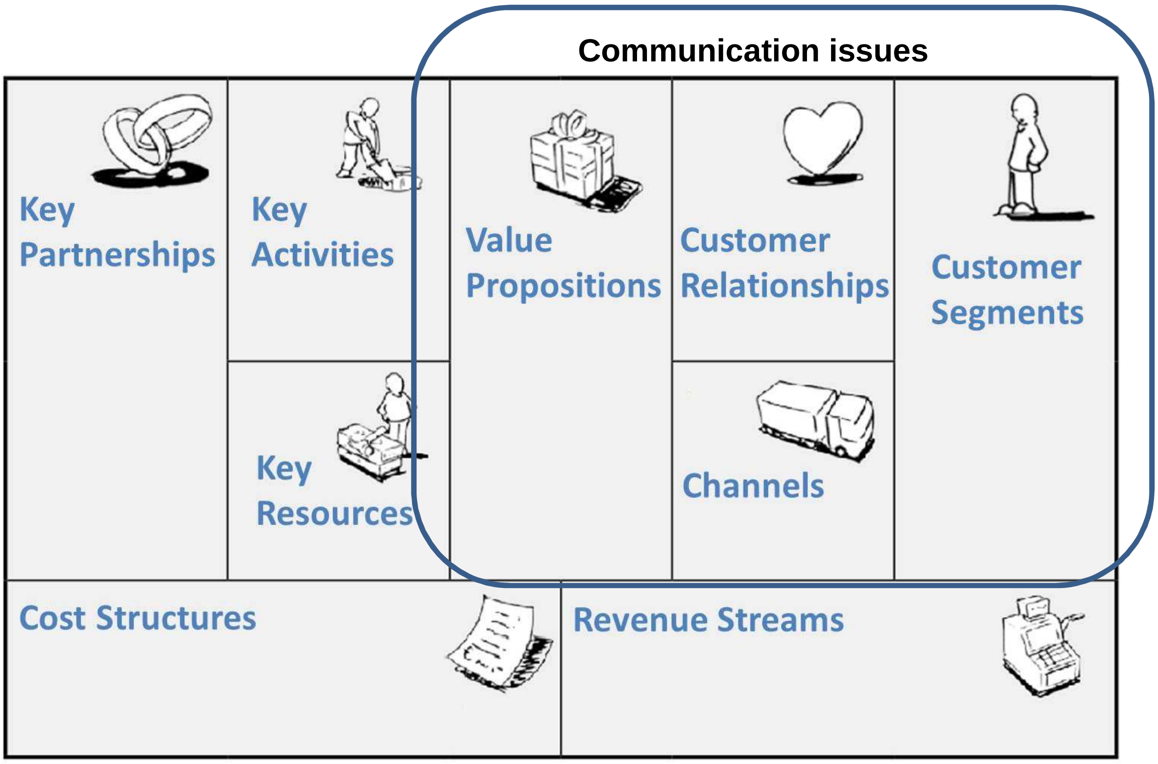


Figure 27. Communication issues within business canvas model.

It should be noticed that in business canvas approach the notion of customer could be understand in a broader perspective including several stakeholders like company owners, employees, business partners, society, local community, policy makers etc. Depending on character of improvements and/or innovation developed it might be important do define value proposition and communication strategy for some or all of these groups.

5 ProSEco Tools Required

The success of the eco-innovation methodology will depend on the tools and people that will support the eco-innovation process.

Because of that, ProSEco is developing a set of ICT tools for collaborative product design together with a collaboration methodology for eco product / services**.**

Therefore, in this section we state the **collaboration and configuration requirements for optimizing the eco-innovation process**, potential collaboration and configuration methods and tools that will comprise the ProSEco platform.

Afterwards, USAL will explore solutions for overcoming identified barriers during this process for collaboration (business cultures, conflicting objectives, technical system interoperability issues), accommodating different forms of collaboration (ad-hoc and planned; synchronous and asynchronous; distributed and co-located).

5.1.1 Environmental Assessment Tool

The environmental assessment tool, or Eco-tool, will be leveraged during the application of the initial phase of the lean-based eco-innovation methodology, that is to say, the *Previous Product System Analysis* (see chapter 4.2.1), where the technical and environmental issues of the current product system will be identified within the scope of the life cycle of the product / process / service (PSS) system. Figure 11 shows the different phases of a PSS life cycle.

Thus, following the *Previous Product System Analysis* step, the Eco-tool will support the modeling and parameterization of the product life cycle processes so as to enable the calculation of the environmental impacts that these processes entail. In this regard, impact analysis will be performed using life cycle assessment (LCA) techniques taking into account some selected eco-indicators and the evaluation of the resources consumption over the whole life cycle of the current product. This analysis will identify the ***environmental critical points or hot-spots*** and the processes and phases where these critical points are concentrated. Figure 28 shows the results of an impact analysis for an EDM[2] machine. It can be observed that the processes that entail the greatest environmental impacts are those associated with the EDM operation (use phase), followed by the processes involving the manufacturing of an EDM.

As a result, it can be concluded that the major environmental impacts may be reduced by means of the application of eco-innovation strategies focused on this use phase. In this regard, the application of the *Conceptualization & Eco-Innovation Strategies* step of the lean eco-innovation methodology will guide the process that will enable the generation of ideas to develop concrete and personalized product extension services (PES). These services will lead to the generation of novel, sustainable and high added value business models.

[2] Electrical Discharge Machine

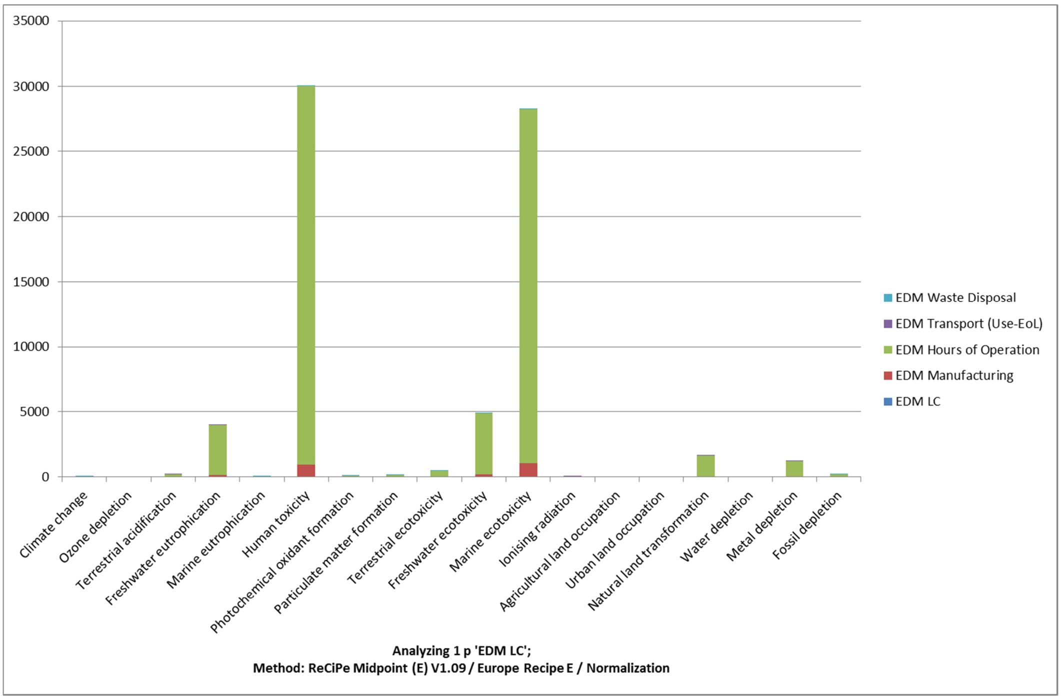


Figure 28. Hot spots identification

Therefore, the Eco-tool can be regarded as an engineering tool that contributes to find appropriate measures to improve the environmental properties of a PSS system.

5.1.2 Eco-Observation Wall

This tool will be used during the observation phase of the methodology (see section 4.2.3) and after having performed the *Environmental Awareness workshop.*

The objective of this tool is to know and understand the needs and problems of the user in context through a deep, empathetic and multidisciplinary journey following the steps showed in Figure 29.

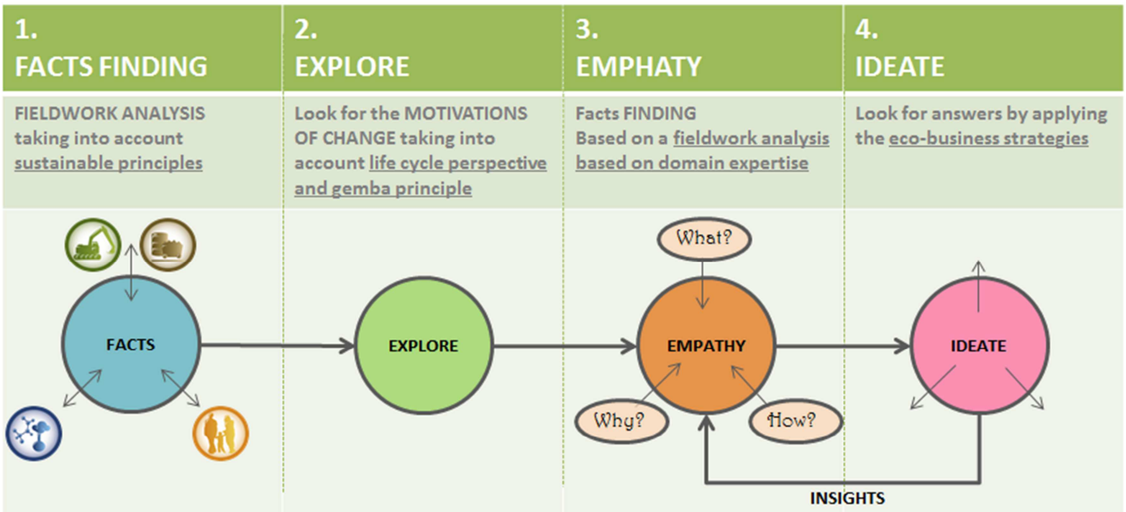


Figure 29. Eco-Observation Journey

5.1.2.1 Facts Finding.

The first step of the journey is based on a fieldwork analysis taking into account the 4 fundamental principles by Natural Step (see Figure 14)The collection of data is focused in these principles to identify the facts of the system that may affect these principles that are grouped in the following three blocks:

- The use of Natural resources. (including material, energy, water and land)
- The release of harmful substances. (including any kind of polluted emissions)
- The human/customer needs. (locally and worldwide)

The analysis has to be as objective as possible and not assume anything in this first part, to identify as much as possible facts around:

- Concrete needs and problems of the product
- Users fears and expectations
- Human/Customer needs

5.1.2.2 Explore Alternatives

The goal of this second step is to expand the analysis by exploring different alternatives taking into account the whole life cycle perspective together with the *How approach*.

This method consists of transform all the data in the form of a How question; therefore the eco-observation blackboard is transformed in the following Figure 30.

Moreover, as the environmental assessment has previously been performed, we can select the key questions that have to be answered in each specific case. And link this questions with the previous identify facts.

Figure 30. Exploration for ONA case

5.1.2.3 Empathy

The objective of this step is to understand the environment in context through deep, empathetic and multidisciplinary analysis observing needs, desires and emotions.

WHAT?	HOW?	WHY?
What is doing the person in a particular situation or in a particular photograph? Try to be objective and not assume anything in this first part.	How the person is doing what you observe? Does it require some effort? Do they seem rushed? Do they have any pain? Does it seem that the activity or situation is impacting their positive status or negative?	Why the person is doing what you are observing and why he/she is performing in that particular way?

The method to fulfill this observation is a fieldwork based on ethnographic techniques, performing immersion and observation of users in their natural context.

- Depth interviews (with noninvasive forms) that allow "active listening" to users and a dialogue that enhances empathy towards them.
- Analysis, synthesis and identification of needs.
- "Person Development" Work intensively with individuals representing specific segments or archetypes of users with similar needs. People to serve as "role models" for them from capture histories, values, fears and expectations that help strengthen the anthropocentric dimension of the project are being sought.

Based on this fieldwork, the tool will use different approaches to find connections and more information to work with

5.1.2.4 Ideation

The previously identified *How questions* should be answered in this step taking into account domain expert knowledge, through:

- Interviews with domain experts will be done. (environmental + industrial experts)
- Taking into account eco-innovation strategies (see 4.2.3.1)

This step will allow the research team to identify more ideas, identify patters between them and insights to go for a deeper analysis.

5.1.3 Lean Canvas

As we have explained in section 4.2.1, the initial stage of the eco-design methodology consists of the recompilation of data related with the system-product reality, taking into account all the aspects around the product, like: target market, user target, key suppliers, customer relationships, distribution channels, value proposition, target user, potential users, etc.

Osterwalder Canvas template together with a collaborative methodology based on the interaction and collective intelligence to combine the knowledge around a product can create a **product-system shared knowledge**. This canvas will be the first photo about the product to start with.

It can also be interesting to perform a specific workshop involving people from different departments of the company to explain Lean Canvas. During this initial session some questions related canvas' fields can help the participants to understand the tool.

Later on, in section 4.2.4 we use the Lean Canvas, as an adaptation of Business Model Canvas that Ash Maurya created to focus on four key aspects: *problem, solution, unfair advantage and Key metrics*. The main objective of Lean Canvas is to make it as actionable as possible.

Behind the Lean canvas tool are some of the Lean Startup principles as:

- ***Uncertainty*** : The lack of compete certainty, that is, the existence of more than one possibility
- ***Risk***: A state of uncertainty where some of the possibilities involve a loss, catastrophe, or other undesirable outcome

5.1.4 Gemba Analysis tool

Gemba Analysis tool will consist of excel worksheets and forms as well as guidelines to perform Gemba Analysis and provide results in the form of problem-solution definitions for Lean Canvas (to be used in the Collaborative Canvas Tool). The main elements of the tool are depicted in the *Figure 31*.

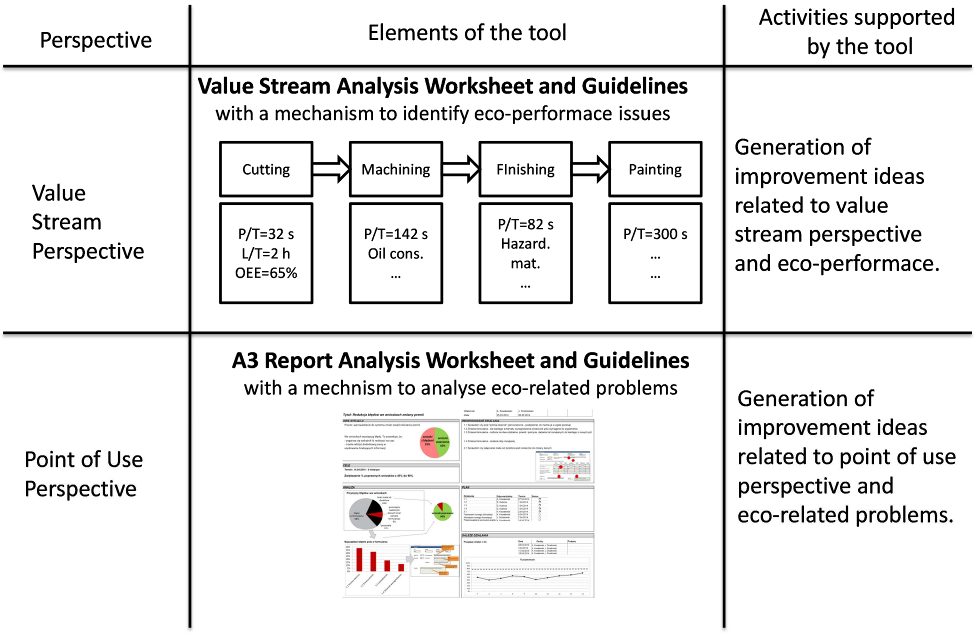


Figure 31. Gemba Analysis for consumer products.

5.1.5 Business Model Simulation Tool

The need to understand behavioural dynamic complexity is being increased by intensifying competition as more and more parts of the world develop the capabilities to enter international markets; as offerings incorporate physical and digital features; as markets become increasingly fragmented into smaller segments with shorter durations. Thus, the number of competitive variables increases, the number of potential inter-relationships between them increases, the unpredictability of the thoughts, emotions, and behaviours they can bring about at different locations increases. In particular, it is important to answer what and how questions about complex situations (i.e. description); to address why questions about complex situations (i.e. explanation), to set and achieve expectations about complex situations (i.e. prediction), to make effective intervention in complex situations (i.e. control); and/or to improve complex situations (i.e. change).

Increasingly, advancing the description, explanation, prediction, control, and/or change of complex phenomena involves the application of simulation modelling techniques – both in science and in practice. Furthermore, the strengths of different simulation modelling techniques are being combined, and their weaknesses are being addressed, through the application of multi-resolution simulation models. These enable, for example, the testing of hypotheses about long-term trends across regions with “low resolution” high level System Dynamics models: in conjunction with investigation of short-term patterns at particular locations within the same region using “high resolution” Agent-Based models.

Simulation models are well-suited to facilitating investigation of complex situations in the real world, such as international business scenarios. Simulation modelling is particularly useful when prototyping or experimenting with a real world system is extremely expensive and/or practically impossible. Simulation modelling facilitates the repeated formulation and testing of hypotheses about real world interventions. By doing so, simulation modelling can support the development of strategies for international business, ranging from global supply chain management to city-specific marketing campaigns. Modelling is an iterative process of abstraction, which involves mapping real world scenarios as a model. Simulation models involve rules that can be expressed as, for example, equations. The rules define how the system being modelled will change in the future, given its present state. Simulation is the process of model “execution” that takes the model through (discrete or continuous) state changes over time. Simulation modelling is especially useful for addressing complex scenarios where time dynamics are important.

There are different types of simulation models. Each has strengths and weaknesses. Accordingly, multi-resolution simulation models are being introduced. These models can be used to formulate and test behavioural hypotheses involving dynamic complex interactions among individuals and groups in diverse competitive markets. Multi-resolution model simulation involves using the different strengths of different modelling methodologies to investigate different aspects of dynamic complex interactions. For example,

hypotheses about long-term trends in whole regions may be tested with “low resolution” System Dynamics models. By contrast, short-term patterns at particular locations in the same region may be tested with “high resolution” Agent-Based models. The ProSEco multi-resolution simulation model deploys System Dynamics models and Agent-Based models.

System Dynamics (SD) is a “top down” modelling technique that focuses more on aggregate flows around networks than on the individual behaviour of entities. Within SD, real world processes are represented in terms of stocks, flows between stocks, and information that determines the values of the flows. Within SD, real world scenarios involve interacting feedback loops which balance or reinforce. Mathematically, SD simulation models are based upon differential equations. SD simulations models enable exploration of the dynamics of mutual causation by updating all variables in small time increments, including positive and negative feedbacks. Several well-established software packages are available to support SD simulation modelling. Free software with limited functionality is available to enable new learners to practice SD modelling using the software’s graphic user interface. This enables the drag, drop, and connection of standard icons to build SD models.

Agent-Based modelling (ABM) involves “bottom up” computational techniques for simulating the actions and interactions of autonomous agents with each other and their environment. Agents in ABM include people in different roles. As an alternative to the simplistic conceptualizations of national culture, ABM can be used to simulate dynamic complex interplay between individuals’ self-categorization, collective identity, and social identity. Self-categorization involves an individual perceiving people, including themselves, as a group. Collective identity involves an individual’s cognitive and emotional connection with a group. Social identity involves an individual’s perceptions of status differences within a group, and the perceived ability to move from one group to another. Dynamic complex interplay between individuals’ self-categorization, collective identity, and social identity can lead to groups with their own micro-cultures forming, growing, shrinking, and dying. The formulation agent-based simulation models for investigating the complex interplay between individuals and groups can be informed by Social Cognitive Theory. Within this theory, an individual’s changing behaviour is affected by observations of others, expectation of own direct experience, and expectation of the outcome of own behaviour. Figure 32 below provides an overview of Simulation Tool variables for meta-product design.

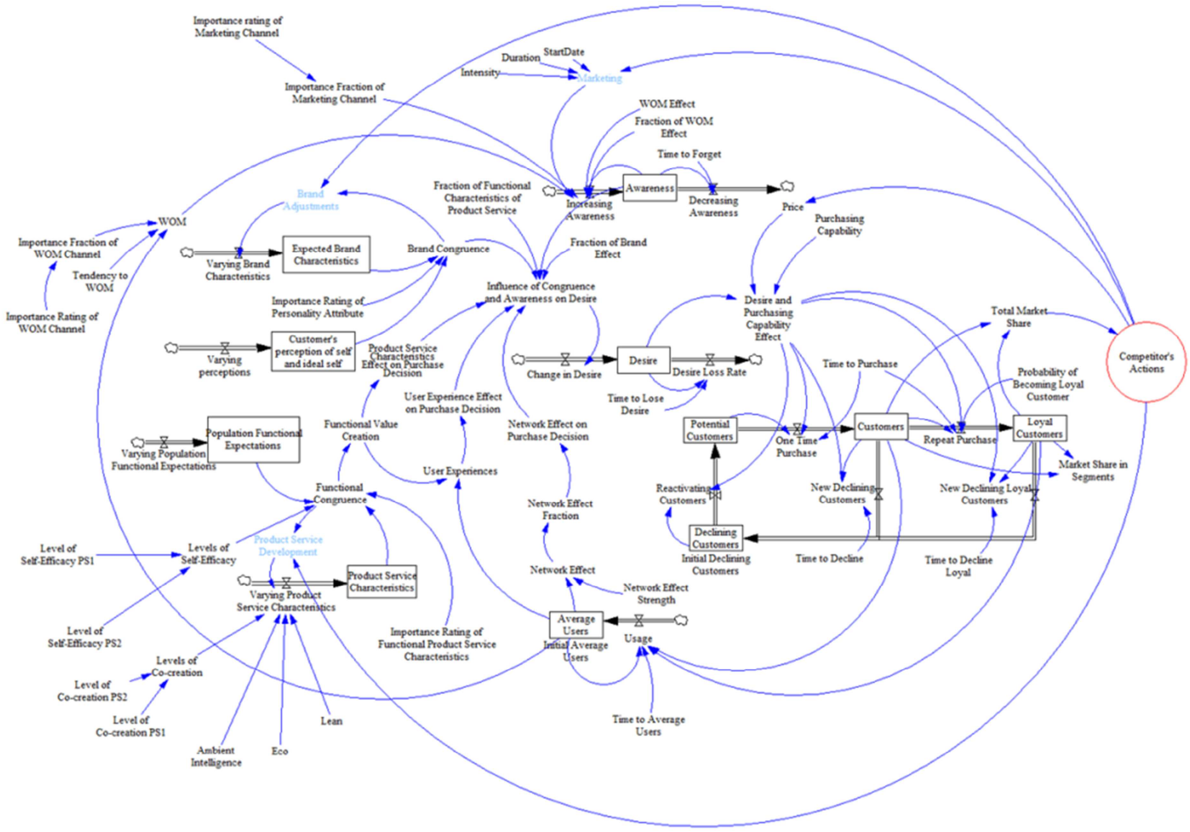


Figure 32 Overview of Simulation Tool variables for meta-product design

6 Conclusions

As stage in section 2, manufacturing industries account for a significant part of the world's consumption of resources and generation of waste. But at the same time, manufacturing industries have the potential to become a driving force for the creation of a sustainable society. As they can design and implement integrated sustainable practices and develop products and services that contribute to better environmental performance.

Analysing the business requirements at ProSEco we see industrial partners are facing different challenges and therefore the implementation of sustainable strategies and practices will be different and mainly dependent on their current market demands. But at the same time the implementation of the different strategies implies different improvements for the company but also different implications for the society as well as for their customer behaviour.

Therefore **eco-innovation methodology** implies not only the creation of new innovative product extension services (PES) but also a big sustainability concern of the company and changes of paradigm at the customers perspectives, which means the creation of new Business models that may imply new actors (3rd parties) and new market orientation of the companies.

Moreover, meta-products have global potential, due to the fact that much of the value of meta-products can reside in the Cloud and be accessed from any location via the World Wide Web. Hence, some of the new meta-product offerings could be international offerings. As a result, market behaviors will be hetero-geneous: diverse reflections of diverse markets in different parts of the world with different behaviors. Thus, as explained in deliverable D200.31 Specification of the Simulation, many sources of dynamic complexity are involved.

Because of that, it is so important in ProSEco to understand customer behaviour and foresee new behavioural changes that may affect the market orientation of the companies. Simulation models will support the development of new strategies for international business, ranging from global supply chain management to city-specific marketing campaigns.

Summarizing the aim of this methodology is to provide a new framework to facilitate the generation of *innovative PES* (product extension services) together with the business strategy (business model) based on a combination of the physical product(s) and (in)tangible services(s) that fulfil the user needs and satisfaction, taking into account the reduction of the environmental impact together with the competitiveness of the company and stakeholders; provoking a shift of behaviour from consumption (selling product) to use (selling function).

This deliverable provides the theoretical framework and guidelines to do so, but in the following months this methodology will be validated with some of ProSEco Industrial partners in order to see the suitability of this framework and obtain feedback that will allow as to modify it accordingly and to develop the final version.

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8 Annex(es)