PUReSmart

PolyUrethane Recycling Towards
a Smart Circular Economy

Deliverable

D5.6 Future scenarios for PU industry to be used for social analysis

WP5 – System innovation, Sustainability assessment & Business

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PUReSmart

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Table of content

Publishable Summary

This deliverable is aimed at defining, understanding and describing the scenario for the future PUReSmart system, meant as the technologies developed within the project for the sorting, chemical recycling and production of new mattresses embedded in the surrounding environment and ecosystem of stakeholders' relations in which it will operate. Building upon the narrative of the DPSIR (drivers, pressures, state, impact and response) framework for describing the interactions between society and the environment, the context consists of environmental, social cultural, commercial, technological and policy-driven driving forces that might affect and be affected by the development and introduction into the market of PUReSmart technologies. The scenario will then be used in task 5.2 and 5.3 for the social and sustainability assessment, respectively.

The following factors characterizing the scenario for the social LCA and the sustainability assessment have been defined:

- Two technological scopes, which serve different purposes:
  - PUReSmart as integrated system for producing and recycling mattresses, compared to current solutions
  - PUReSmart EoL technologies (sorting and chemical recycling) for managing EoL mattresses, compared to current solutions

  For both scopes, two types of scenarios are defined:

  - the Baseline scenario: it describes how EoL of mattresses will be dealt with in 2030 without PUReSmart technologies.
  - the PUReSmart scenario, which considers the availability of the sorting and chemical recycling technologies developed in the PUReSmart project, in 2030.

- Technology mix for EoL treatments have been set in both scenarios, including a mix of chemical recycling, mechanical and pyrolysis. Regarding the chemical recycling, it will consist of two technologies: the conventional one, and the chemolysis developed in PUReSmart, with high recovery efficiency and purity, making this recycling process more efficient and favourable than conventional chemical and mechanical recycling. In the PUReSmart scenario, a reduced share is sent to mechanical recycling in favour of the chemolysis.
- Policy context: there is a growing trend towards ensuring greater product sustainability through the adoption of measures aiming to avoid single-use and, at the same time, to increase repair, re-use, remanufacturing, recycling and uptake of recycled content. These measures, in turn, can be linked to the following social and sustainability topics: Product design; Product health and safety; Product durability; Product quality; Information for consumer; Right to repair; Operational health and safety.
- Key stakeholders' categories have been identified, which will be considered for evaluating potential detrimental and beneficial social performances as outcomes of the interactions between the stakeholders and the PUReSmart system.

Executive summary

1 Description of the deliverable objective and content

This deliverable is aimed at defining, understanding and describing the scenario for the future PUReSmart system, meant as the technologies developed within the project for the sorting, chemical recycling and production of new mattresses embedded in the surrounding environment and ecosystem of stakeholders' relations in which it will operate. Building upon the narrative of the DPSIR (drivers, pressures, state, impact and response) framework for describing the interactions between society and the environment, the context consists of environmental, social cultural, commercial, technological and policy-driven driving forces that might affect and be affected by the development and introduction into the market of PUReSmart technologies. The scenario will then be used in task 5.2 and 5.3 for the social and sustainability assessment, respectively.

2 Brief description of the state of the art

Not applicable to this deliverable.

3 Deviation from objectives and corrective actions

The deliverable has been postponed by 6 months, due to the COVID pandemic and also to allow including the outcomes of the activities on Social LCA related to the mapping of stakeholders. However, this does not affect the delivery of the final outcomes of task 5.2 and 5.3, planned for month 48.

4 Innovation brought and technological progress

The scenario definition will provide the reference for setting the social and sustainability assessment. By means of an in-depth investigation of the main drivers that might affect positively or negatively the introduction of PUreSmart into the market, the assessments will have a more robust basis. Scenarios are uncertain by definition, even if the time frame is not far into the future (2030): however, a mix of techniques have been used, building upon expert knowledge form the sector, and conservative assumptions have ben made.

Scenario analysis is common in LCA, even if seldom structured and usually related to the technological system only, while in Social LCA and in Life cycle Sustainability Assessment there is not enough evidence of its use. In this regard, the proposed approach can serve as basis and inspiration for future studies and can support also a better interpretation of the results through the lenses of the context analysis.

5 Impact of the results

Not applicable, as the scenario definition is functional to the social and sustainability assessment.

6 Related IPR

Not applicable.

7 Publishable information

The deliverable is public.

8 Conclusion

The following factors characterizing the scenario for the social LCA and the sustainability assessment have been defined:

- Two technological scopes, which serve different purposes:
  - PUReSmart as integrated system for producing and recycling mattresses, compared to current solutions.
  - PUReSmart EoL technologies (sorting and chemical recycling) for managing EoL mattresses, compared to current solutions

  For both scopes, two types of scenarios are defined:

  - the Baseline scenario: it describes how EoL of mattresses will be dealt with in 2030 without PUReSmart technologies.
  - the PUReSmart scenario, which considers the availability of the sorting and chemical recycling technologies developed in the PUReSmart project, in 2030.

  Current focus of this report is on the 2nd technological scope, i.e., the treatment of mattresses at the end of life.

- Technology mix for EoL treatments have been set in both scenarios, including a mix of chemical recycling, mechanical recycling and pyrolysis. Regarding the chemical recycling, it will consist of two technologies: the conventional one, and the chemolysis developed in PUReSmart, with high recovery efficiency and purity, making this recycling process more efficient and favourable than conventional chemical and mechanical recycling. In the PUReSmart scenario, a reduced share is sent to mechanical recycling in favour of the chemolysis.
  In both scenarios, landfill is not considered, thus going beyond the targets set by EC regulation in 2030 (max 10% landfill).

- Policy context: there is a growing trend towards ensuring greater product sustainability through the adoption of measures aiming to avoid single-use and, at the same time, to increase repair, re-use, remanufacturing, recycling and uptake of recycled content. These measures, in turn, can be linked to the following social and sustainability topics:
  - Product design
  - Product health and safety
  - Product durability
  - Product quality
  - Information for consumer
  - Right to repair
  - Operational health and safety.

These aspects will be included as input of the materiality assessment, under development in the project also with the engagement of the stakeholders in the value chain of mattresses.

- Key stakeholders have been identified, which will be considered for evaluating potential detrimental and beneficial social performances as outcomes of the interactions between the stakeholders and the PUReSmart system.

Deliverable report

1 Deliverable objective and content

This deliverable is aimed at defining, understanding and describing the scenario for the future PUReSmart system, meant as the technologies developed within the project for the sorting, chemical recycling and production of new mattresses embedded in the surrounding environment and ecosystem of stakeholders' relations in which it will operate. Building upon the narrative of the DPSIR (drivers, pressures, state, impact and response) framework for describing the interactions between society and the environment, the context consists of environmental, social cultural, commercial, technological and policy-driven driving forces that might affect and be affected by the development and introduction into the market of PUReSmart technologies.

This scenario will be used for the environmental social and also sustainability assessment of the PUreSmart systema, carried out in task 5.1, task 5.2 and task 5.3, respectively.

Scenario definition is aimed at supporting the assessment, and it is particular useful and needed when the system at hand is uncertain, due to either its complexity, or its lack of maturity at the time of the study (because it is not industrialized yet) or both. Overall, the evaluation of a technological system such as the one in PureSmart is challenging, for three main reasons. Firstly, PUReSmart technologies will deliver polyols and isocyanates, which are not end products but can be applied to a quite broad range of (unforeseen) applications, according to both a closed-loop and an open-loop value chain model. Secondly, PUReSmart is under development to achieve the TRL7 within the project, while the industrial upscale will be carried out beyond the boundaries of PUReSmart. This implies that data availability and scale up effects are open questions which strongly affect the assessment. Finally, rebound effects may occur, when the increased benefit/efficiency gained by the new technology is partly spoilt or turned into a loss. Overall, technologies in a broad sense behave like complex systems, characterized by non-linear relationships, feedback loops, emergent phenomena, and tangled connections among the parts (Barberio et al., 2021).

The definition of a robust and reliable scenario is key for performing the analysis of the social innovation induced by new technologies, and of the overall sustainability assessment. In fact, "*technology is neither good nor bad; nor is it neutral: technology's interaction with the social world is such that technical developments frequently have environmental, social and human consequences that go far beyond the immediate purposes of the technical devices themselves, and the same technology has quite different results when introduced into different contexts or under different circumstances*" (Kranzberger, 1997). The effects of a technology depend also on the way in which the technology is used and how it interacts with technological systems, physical context and on the behaviour or organizations.

After the definition of the methodology for scenario definition in section 2, then the different factors of the scenario are defined in terms of technology development (3.1), policy context (3.29 and stakeholders (3.3). Conclusions on the setting of the scenario are drawn in section 4.

2 Methodology

A scenario is defined as “a description of a possible future situation relevant for specific applications, based on specific assumptions about the future and, when relevant, a description of a path from the present to the future” (Rebitzer and Ekvall, 2004).

The scenario has been defined adopting three main methods:

- *Participatory methods*, gaining insights and opinions of experts, represented by project partners who cover the mattresses value chain, on describing the possible future scenario. This technique has been used for defining the technology mix of EoL of mattresses into the future.
- *Extrapolation of historical and current trends into the future*. This technique has been used for defining the targets for mattresses collection and recycling.
- *Normative methods*, which consist of stating the desired future and then move backward in time to identify the necessary steps for reaching the goal, typically using qualitative descriptions. This technique has been used for supporting the definition of the technology mix for EoL mattresses, together with the participatory approach, and identifying the potential opportunities and constraints given by strategies and policy initiatives in Europe.

The following factors have been identified as affecting the scope of the future scenario for social and sustainability assessment:

- The speed of development of the relevant markets and technologies
- The environmental and social relevance of these developments for the conclusions of the social and sustainability assessment
- Expectations about radical or atypical developments
- The time horizon of the study. The selected time horizon is 2030, which represents the year in which the PUReSmart technology will likely be up and running into the market.
- The position of the specific processes developed in PUReSmart in the value chain.

All these aspects are analysed in Section 3 in the sub-chapters dedicated to technology development, policy context and stakeholders. All the information regarding the above factors has been elaborated based on desk research and on exchanges with the partners of PUReSmart, as technical experts of the sector.

3 Scenario definition

3.1. Technology development

Two technological scopes of PUReSmart are considered, depending on the goal of the assessment:

1) From the mattresses production up to the recycling at the end of life, and related recovery of materials.
2) From the European PU collection up to the preprocessing and recycling of mattresses, and related recovery of materials.

The first scope allows accounting for all the innovations implemented in PUReSmart, i.e., sorting, chemical recycling and also smart design, with the production of CAPU monomers for PU production. The second scope considers the main function of PUReSmart of managing the

EoL of mattresses with the combined sorting and chemical recycling, and the production of recycled materials that can be used either back into the mattresses production or into other value chains. For both scopes, two types of scenarios are defined:

- the *Baseline scenario*: it describes how EoL of mattresses will be dealt with in 2030 without PUReSmart technologies.
- the *PUReSmart scenario*, which considers the availability of the sorting and chemical recycling technologies developed in the PUReSmart project, in 2030.

Current focus of this report is on the 2nd technological scope, i.e., the treatment of mattresses at the end of life, whose scenario is defined in the following sections.

Baseline scenario

In the baseline scenario, the PUReSmart technologies will not be in place; thus, the EoL of mattresses will be dealt with according to current scenario[1], duly adapted considering the normative evolution for representing the situation in 2030[2].

The 2nd technology scope starts with the collection step, which includes the transport of mattresses at end-of-life to the pre-processing site and considers the inefficiency due to the illegal disposal of the mattresses. The pre-processing includes all preparatory activities needed to take all other valuable materials (e.g., textiles) out of the waste mattresses flow.

The logistics of the system, as well as the targets of both the collection and the recovery, are based on the Extended Producer Responsibility (EPR) scheme of two European countries, i.e., France and Belgium, which represent the worst and best case, respectively.

The EPR scheme is indeed the main policy driver to turn waste mattresses into resources and to favour a circular economy-based approach. Such scheme is expected to be implemented largely in Europe in the next years. France is considered for the baseline scenario as the French EPR is currently the only one running since more than 5 years and data are available, both related to targets and achieved results. The Belgium EPR is considered because, although it is a new-born scheme, a long-time perspective and targets have been set, until 2030.

The worst case is based on France EPR 2015, thus representing a conservative scenario in which in 2030 EU countries are considered to have in place their EPR schemes running just since a couple of years. This assumption takes into account that the EPR implementation will not occur simultaneously in all the EU countries, some will start earlier, and others might not have any system in place by 2030. Adopting the France EPR 2015 as worst case means that data related to efficiency of collection, pre-processing and recycling of mattresses in France in 2015 are applied to all EU countries. Where needed (due, for example, to data gaps) data are complemented or adjusted with the information available related to the closest reference

[1] Currently mattresses are mechanically recycled only to a limited extent (33%) while most of it goes to landfill (45%), and part to incineration (22%) (European environmental bureau (2017) Circular economy opportunities in the furniture sector. Report-on-the-Circular-Economy-in-the-Furniture-Sector.pdf (kinstacdn.com) Accessed September 2021)

[2] The targets set by the EU are 55% reuse and recycling for municipal waste by 2025, including mattresses, and 10% max landfill by 2030 (Circular Economy Package)

period, namely 2017. The France EPR addresses the overall flow of furniture and as a consequence the pre-processing includes also a “sorting” step, which consists of separating the different furniture types. At this step, in the sorting site, mattresses are sorted out from the waste furniture flow and sent to the dismantling site.

The best case is based on Belgium EPR for mattresses and considers collection and recycling target set for 2030. The Belgian EPR only addresses the mattresses and as a such it benefits of higher efficiency in the first step, where there is no need to sort the mattresses out of the furniture flow.

Such scenario is considered an optimistic one, in which all EU countries will have implemented their EPR for more than 8 years.

The Baseline Scenario starts with the collection phase. The collection is assumed to be performed with lorries collecting furniture and mattresses from the various disposal sites. The logistic assumptions and information of all the end-of-life management are based on the French end-of-life management of furniture. The *collection rates* of the worst case and best cases are 15% and 85%, respectively.

In the best case, the collected mattresses are transported directly to the dismantling and preparation plants because no sorting is requested (only mattresses are collected). In the worst case, the collected furniture (including mattresses) is transported to the sorting plant, where the different flows are sorted, based on product types (like mattresses) or by materials (e.g., wood). The efficiency of the sorting phase for the mattresses is set to 55%.

In the dismantling and preparation phase, the PU-based mattresses are isolated and prepared to be sent to the recycling facilities. During this phase, several materials (such as iron, latex, wood, and others) are sent to different end-of-life management facilities, and the PU-based mattresses are sent to the recycling facility. The efficiency of dismantling is 93% and 75% for the worst case and best case, respectively. While the value of 93% is PU-specific and it is the outcome of a monitoring process, the value of 75% represents a generic target for the whole materials, which was considered applicable – as best case – to the PU too.

The last phase is the recycling of the material fractions in output from the dismantling. The current technologies to recycle PU-based material are chemical recycling, mechanical recycling, and pyrolysis.

In conventional chemical recycling, a low percentage of polyols are recovered, of low quality, and the recycling process produces a relevant amount of chemical waste. Through mechanical recycling, PU trim foams are obtained, which can be used for many different applications, ranging from production of insulation materials to carpets, just to mention some. From the pyrolysis, only energy outcomes are considered. This is a conservative assumption, as new pyrolysis processes are current under development[3], which are able to deliver materials in output, and not only energy. However, this material-to-material pyrolysis, compared to the material-to-energy one, is very much new, and neither data nor projections on its development are available. Considering that it will represent a fraction of the pyrolysis in 2030, as a

[3] See for example Polymer recycling - Versalis S.p.A. (eni.com)

conservative assumption only the material-to-energy type of pyrolysis is considered in the scenario.

As far as the quantification of the fraction of a PU-mattress that goes to recycling and incineration is concerned, the mattress composition reported in the background report of EU Ecolabel of the bed mattresses (Cordella et al., 2012) was considered, according to which the composition of a standard PU-based mattress consists of:

- PU – 79%
- Textile – 11%
- Padding – 10%

In the Baseline Scenario, textiles and puddings are assumed not recovered and sent to incineration. Thus, the material recycling through mechanical recycling technologies is considered applied only to PU.

PUReSmart scenario

In the PUReSmart scenario, the assumptions for the collection, sorting, dismantling, and preparation steps are the same as for the baseline scenario. The same assumptions are adopted also for the logistics, in terms of distances among facilities and transport means.

Compared to the baseline scenario, a Smart Sorting step is introduced, to separate the PU by main families, and ensuring thus the quality of the chemolysis process.

After the sorting, the collected PU material is sent to the Smart Chemolysis phase, assumed to occur in the same facility. The Chemolysis allows a high recovery of high-quality polyols and other compounds (such as TDI and MDI), which can be used as raw materials for new PU-based mattresses production.

In this scenario, the mechanical recycling and the pyrolysis are still present but with the following changes:

- The chemical recycling will consist of two technologies: the conventional one, considered also in the baseline scenario, and the chemolysis developed in PUReSmart, with high recovery efficiency and purity, making this recycling process more efficient and favorable than conventional chemical and mechanical recycling.
- A reduced share sent to mechanical recycling in favour of the chemolysis.

3.2. Policy context

The policy context is represented by the strategies, policies and legal frameworks at the European Union level regarding the mattresses and their end-of-life management and expected to have considerable impacts on the sectors targeted by the PUReSmart technologies. In this regard, given that the recovered polyols from the chemolysis process can be used for many diverse applications, the reference sector here considered is the furniture one, narrowing down the scope of the recovered materials into closed-loop system, i.e., from mattresses to mattresses.

In the policy arena, a key role is played by the recent European Green Deal, “a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy (…)” (COM (2019) 640 final, p.2). It foresees the adoption of a circular economy action plan including a “‘sustainable products’ policy” aiming to

support the circular design of products and, at the same time, to reduce waste production (COM (2019) 640, p. 7).

The new Circular Economy Action Plan has already been adopted by the European Commission. It "aims at accelerating the transformational change required by the European Green Deal (…)" (COM (2020) 98 final, pp. 2-3), providing a sustainable product policy framework and the related key actions. In particular, within the planned legislative proposal on the policy for sustainable products, the Commission plans to establish principles and ways to regulate, among others, the aspects related to the "*durability*, *reusability*, *upgradability* and *reparability*" of products; *remanufacturing and high-quality recycling*; prohibition of the destruction of unsold durable goods; the reduction of single-use and "premature obsolescence, the presence of hazardous chemicals in products, the *recycled content in products*, while ensuring their performance and safety; the" encouragement of *product-as-a-service* or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle" (COM(2020) 98 final, p. 4). **Plastics**, **chemicals** and **furniture** are some of the products and sectors identified as a priority to act on. Moreover, the new Circular Economy Action Plan foresees a proposal for the "*revision of EU consumer law to ensure that consumers receive trustworthy and relevant information on products at the point of sale, including on their lifespan and on the availability of repair services, spare parts and repair manuals*" (COM (2020) 98 final, p. 5). In addition, the provision of greater consumer protection in case of premature obsolescence and the introduction of a new right to repair are expected (COM (2020) 98 final, p. 5).

Finally, the plan envisages a series of actions from 2021 for an "Enhanced waste policy in support of waste prevention and circularity" (COM (2020) 98 final, Section 4.1).

The cornerstone of EU waste policy (European Commission 2010, p. 4) is the Waste Framework Directive, which provides a waste hierarchy to "apply as a priority order in waste prevention and management legislation and policy" consisting of "prevention", "preparing for re-use", "recycling", "other recovery" and "disposal" (art. 1). Moreover, the Waste Framework Directive introduced the Extended producer responsibility (EPR), considered "one of the means to support the design and production of goods which take into full account and facilitate the efficient use of resources during their whole life-cycle including their repair, re-use, disassembly and recycling without compromising the free circulation of goods on the internal market" (Recital 27).

The EPR is "is a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products. Assigning such responsibility could in principle provide incentives to prevent wastes at the source, promote product design for the environment and support the achievement of public recycling and materials management goals" (OECD 2011, p.164). The Waste Framework Directive establishes general requirements for the Extended producer responsibility (art. 8 e 8-bis), while specific provisions are established for packaging and packaging waste, end-of-life vehicles, batteries and accumulators and their waste and waste electrical and electronic equipment (WEEE). The EU legislation provides a general framework, while the implementation of EPR is a responsibility of the Member States, which can also adopt EPR regarding products different from those object of the specific aforementioned directives (Monier et al., 2014). Therefore, the EPR schemes adopted by the Member States are very heterogeneous.

Currently, there only two EPR schemes in Europe related to mattresses: one in Belgium, which came into force since January the 1st, 2021, and dedicated to mattresses; one in France, since 2015, on furniture including mattresses ("La filière des Déchets d'Éléments d'Ameublement

(DEA)") (Figure 1 and Figure 2) . The adopted scheme is a collective one: the chain is managed by the eco-organisations Éco-mobilier for household waste and Valdelia for professional waste. Éco-mobilier and Valdelia coordinate the collection, by using selected service providers. The partners in the collection are "Distributeurs", "Acteurs de l'ESS" (for both household and professional waste), the "Collectivities locales/décheteries" (for household waste) and the "Détenteurs professionels" (for professional waste). "Les structures de l'Economie Sociale et Solidaire (ESS)" direct part of the material collected towards "réemploi" and carry out also a "réutilisation" activity. The "réemploi" is the operation whereby a product is donated or sold by its original owner to a third party who will give it a second life, if possible. In this case the product retains its status, without ever acquiring the status of waste. Instead, the "reutilisation" is applied when the person who intends to dispose of the detained good does so without going to a structure whose purpose is the "réemploi". In this case, the good loses its product status and acquires waste status. It then undergoes a treatment operation, which enables it to regain its product status.

Once collected, the DEA are sent to sorting and treatment facilities, contractually linked to the eco-organisations. Schematically, four processing modes can be distinguished: "réutilisation" (carried out by the "Acteurs de l'ESS"), recycling, energy recovery and landfill.

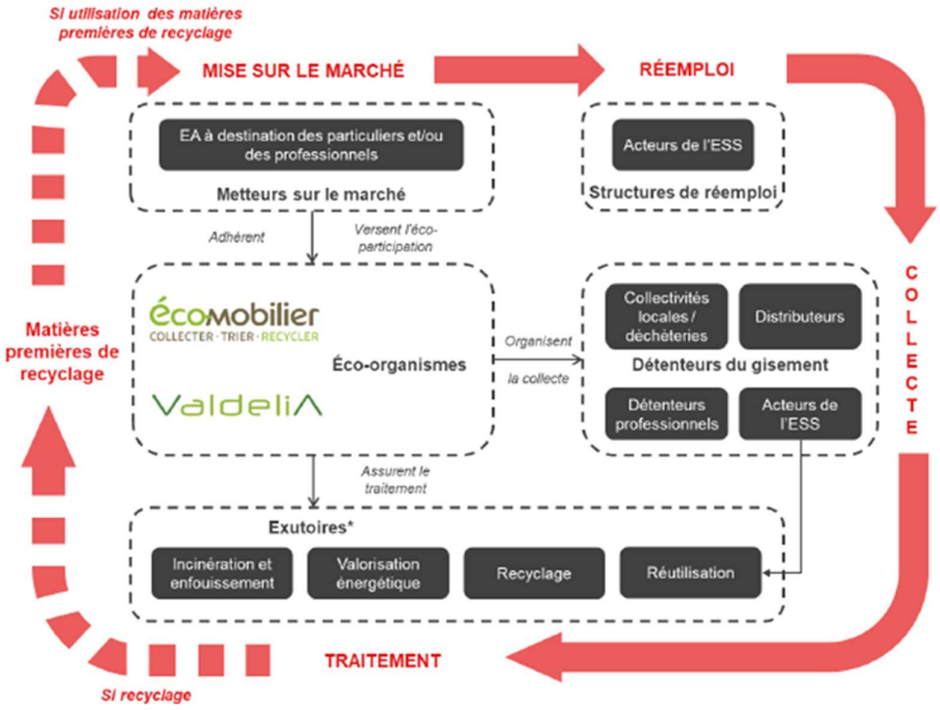

Figure 1 "La filière des Déchets d'Éléments d'Ameublement (DEA)". (Source : ADEME 2019, p. 11)

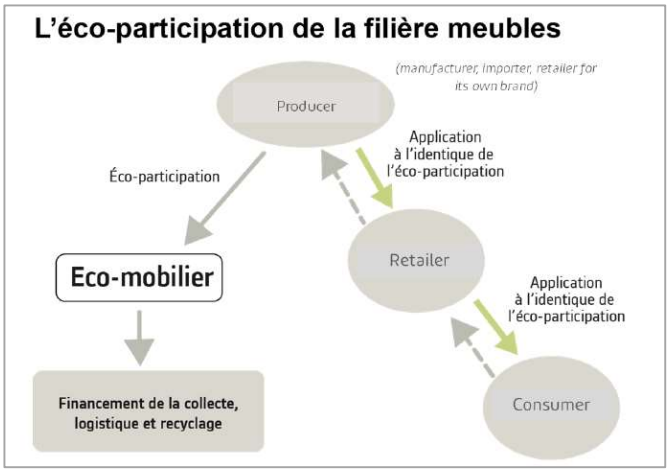

Figure 2 Structure of the Éco-partecipation (Source: Des Abbayes 2014, p. 8)

The EPR is one among several policy tools addressing sustainability of products. Other relevant in the scope of PUReSmart system are the following:

- the EU Ecolabel, a voluntary tool that, on the one hand, stimulates enterprises to make products with a lower environmental impact throughout their life cycle and, on the other, supports consumers in making more conscious and responsible purchasing choices. Specific Ecolabel criteria have been developed for bed mattresses. Some of them (i.e., Criteria no. 12 - Technical performance (including quality, durability and warranty), 13 - Design for disassembly and recovery of materials, 14 - Information appearing on the EU Ecolabel, 15 - Additional information to consumers) are in line with trends in EU initiatives to promote reparability, facilitate recycling, provide consumers with comprehensive information on the product and its use and disposal.
- The legislative background of the mattress includes also the CLP Regulation (Classification, Labelling and Packaging of Substances and Mixtures) and the REACH Regulation (Registration, Evaluation, Authorisation and Restriction of Chemicals) (Cordella and Wolf, 2010).
- The Sustainable Product Initiative[4], which will revise the Ecodesign Directive and propose additional legislative measures, aiming at making products placed on the EU market more sustainable. Among the sectors in the scope of the initiative, also the furniture one will be targeted. The overarching goal is the reduction of the overall life-cycle environmental footprint and also social footprint (where appropriate) of the products placed on the EU market, achieving longer product lifetimes (with more durable and reparable products), increasing circularity and reducing waste. The objectives of the Circular Economy Action Plan, brought forward by the SPI initiatives, are the keywords for this context analysis, around which social and sustainability topics of concern will be identified: improving product durability and reparability, addressing hazardous chemicals and premature obsolescence, increasing recycling and recycled

[4] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en

content, setting incentives to reward products and products-as-a-service based on their sustainability performance

The analysis of the policy initiatives showed a marked trend towards ensuring greater product sustainability through the adoption of measures aiming to avoid single-use and, at the same time, to increase repair, re-use, remanufacturing, recycling and uptake of recycled content.

The trend is somewhat confirmed by a recent judgement of the Court of Justice of the European Union[5], who ruled that the art 16(e) of Consumer Directive[6] "must be interpreted as meaning that goods such as a mattress, from which the protective film has been removed by the consumer after delivery, do not come within the scope of the concept of 'sealed goods which are not suitable for return due to health protection or hygiene reasons and which have been unsealed by the consumer after delivery' within the meaning of that provision". Moreover, "such an equation between those two categories of goods — namely garments and mattresses — may, as the Advocate General notes in point 34 of his Opinion, be envisaged, in so far as, even in the case of direct contact of those goods with the human body, it may be presumed that the trader is in a position to make those goods, after they have been returned by the consumer, by means of a treatment such as cleaning or disinfection, suitable for new use by a third party and, accordingly, for a new sale, without prejudice to the requirements of health protection or hygiene" (paragraph 46)[7] .

However, several social issues can be identified in connection with this trend. The mattress's lifespan from a technical point of view varies from 7 to 10 years, but it ranges from less than 10 years to 20-35 years, depending more on consumer choice than on mattress design (Cordella and Wolf, 2013). Increasing the already long lifespan may prove problematic due to regulatory changes regarding the Safety and usability of specific components (EUROPUR 2016). Indeed, the longer is the lifespan of the mattress, the greater is the possibility that the materials used have meanwhile been banned (EUROPUR 2016).

In any case, options such as repair, re-use, remanufacturing, and recycling require accurate and complete information to consumers on the product, maintenance, and disposal.

Finally, the Covid-19 pandemic might affect the reference context by e.g., limiting possibilities for reuse.

Overall, the key aspects that emerged from the policy context can be summarised with the following keywords:

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[5] Court of Justice of the European Union, Sixth Chamber, Judgement of 27 March 2019, C 681/17, ECLI:EU:C:2019:255

[6] Directive 2011/83/EU of the European Parliament and of the Council of 25 October 2011 on consumer rights, amending Council Directive 93/13/EEC and Directive 1999/44/EC of the European Parliament and of the Council and repealing Council Directive 85/577/EEC and Directive 97/7/EC of the European Parliament and of the Council.
Art. 16 (e) consider an exception from the right to withdrawal "the supply of sealed goods which are not suitable for return due to health protection or hygiene reasons and were unsealed after delivery".

[7] The Court also stated that in this case, "in accordance with Article 14(2) of Directive 2011/83, read in the light of recital 47 thereof, the consumer is liable for any diminished value of goods resulting from handling other than that necessary in order to establish the nature, characteristics and functioning of the goods, without the consumer thereby being deprived of his right of withdrawal (…)" (paragraph 47).

- Repair
- Reuse
- Remanufacturing
- Recycling

These in turns can be linked to the following social and sustainability topics:

- Product design
- Product health and safety
- Product durability
- Product quality
- Information for consumer
- Right to repair
- Operational health and safety.

3.3. Stakeholders

A stakeholder is defined as an Individual or group that has an interest in any activities or decisions of an organization. (ISO 26000, 2008). Their identification in the framework of a scenario analysis is key because they are those that might affect and will be affected by the introduction of the PUReSmart system into the market. In the framework of the social analysis, carried out in task 5.2, stakeholders are those towards which social performances[8] will be evaluated. More broadly:

- The needs of stakeholders are taken into account, when defining the breadth and depth of both the social analysis and the life cycle sustainability assessment
- Stakeholder' view is key for defining the materiality of the PUReSmart system
- The communication of the results of the sustainability assessment of PURESmart system needs to consider the stakeholders affected (positively or negatively) by it.

Stakeholders have been mapped through the desk analysis on the context, considering either the technological system (for both technological scopes) and the policy context. Their selection will be validated, during the project, through an engagement process with stakeholders, by the end of 2021.

4 Conclusions

The analysis carried out on scenario definition led to the identification of the following factors characterizing the scenario for the social LCA and the sustainability assessment:

- Two technological scopes, which serve different purposes:

[8] Social performance are principles, practices, and outcomes of businesses' relationships with people, organizations, institutions, communities, and societies in terms of the deliberate actions of businesses toward these stakeholders as well as the unintended externalities of business activity measured against a known standard (Wood, 2016)

- PUReSmart as integrated system for producing and recycling mattresses, compared to current solutions
- PUReSmart EoL technologies (sorting and chemical recycling) for managing EoL mattresses, compared to current solutions

For both scopes, two types of scenarios are defined:

- the Baseline scenario: it describes how EoL of mattresses will be dealt with in 2030 without PUReSmart technologies.
- the PUReSmart scenario, which considers the availability of the sorting and chemical recycling technologies developed in the PUReSmart project, in 2030.

Current focus of this report is on the 2nd technological scope, i.e., the treatment of mattresses at the end of life.

- Technology mix for EoL treatments have been set in both scenarios, including a mix of chemical recycling, mechanical and pyrolysis. Regarding the chemical recycling, it will consist of two technologies: the conventional one, and the chemolysis developed in PUReSmart, with high recovery efficiency and purity, making this recycling process more efficient and favourable than conventional chemical and mechanical recycling. In the PUReSmart scenario, a reduced share is sent to mechanical recycling in favour of the chemolysis.
  In both scenarios, landfill is not considered, thus going beyond the targets set by EC regulation in 2030 (max 10% landfill).

- Policy context: there is a growing trend towards ensuring greater product sustainability through the adoption of measures aiming to avoid single-use and, at the same time, to increase repair, re-use, remanufacturing, recycling and uptake of recycled content. These measures, in turn, can be linked to the following social and sustainability topics:
  - Product design
  - Product health and safety
  - Product durability
  - Product quality
  - Information for consumer
  - Right to repair
  - Operational health and safety.

  These aspects will be included as input of the materiality assessment, under development in the project also with the engagement of the stakeholders in the value chain of mattresses.

- Key stakeholders have been identified, which are those that will be considered in the social analysis – after their validation during the engagement process – for evaluating potential detrimental and beneficial social performances as outcomes of the interactions between the stakeholders and the PUReSmart system.

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Milestone achievement

There is not a milestone linked to this deliverable.