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Opportunities and incentives for Remanufacturing in the Basque Country

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Abstract

Remanufacturing is a business model that helps the development of the circular economy. There are numerous successful examples of remanufactured products in different industrial sectors of Europe and US. Obtaining the maximum benefit of remanufacturing is related to the client recognizing the value of his assets at the end of its life, and that the manufacturer makes products that have the functionality and durability required. These aspects, can be improved if the remanufactured products are converted into a product-service systems (PSS). The objective of this research is to identify the opportunities, challenges, drivers and barriers for the development of remanufacturing activities in the main industrial sectors of the Basque Country. The research team has analysed 890 industrial companies, of which 197 companies have been identified the potential to development their remanufacturing process. After that, in order to know the reality of the different industrial sectors of the Basque Country, the research team developed a questionnaire oriented to the companies with the highest remanufacturing potential. In addition, they interviewed the industrial managers and directors of innovation of the 18 leading industrial companies in the Basque Country. The research team estimated that the remanufacturing process in the Basque Country is an emerging activity with great potential for development for 2025. The initial sales estimate for the five priority sectors analysed in 2016 is 63.6 million euros, and for 2025 is 163 million. According to the interviews, the main motivations that companies have for remanufacturing are strategic advantage and differentiation, high product value and high durability of the product. The main barriers identified are access to products, the resulting quality and market valuation.

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1. Introduction

The industrial remanufacturing process consists on the restoration of a used product or component at a level of performance and quality equal or higher than that of a new product. Many products can be remanufactured and there are numerous successful examples [1,2] in different industrial sectors (e.g. aerospace, automotive, electronic & electrical equipment, machinery, etc.) of Europe and US. Due to the new economic scenario, characterized by the globalization of markets, and in order to stay competitive, companies must provide the greatest possible value to their clients.

Remanufacturing is a business model that helps in the

development of the circular economy. The Ellen MacArthur Foundation [3] defines the circular economy as a living system that creates value associated with the use of products, instead of with resources and energy consumption. In the circular economy, the durability of products and resources is one of the key factors. Obtaining the maximum benefit of remanufacturing is related to the client recognizing the value of his assets at the end of its life, and that the manufacturer makes products that have the functionality and durability required. These aspects, can be improved if the remanufactured products are converted into PSS. With this vision, you can even improve profit margins. Particularly if new services are included, that improve the performance of remanufactured products. In these

cases, remanufacturing has a new way of competing with products at similar prices [4]. Remanufacturing can be a key strategy to introduce new competitive products and PSSs that additionally reduce their environmental impact [5].

In the Basque Country, there is some evidence that there are companies that remanufacture their products [6], despite this, the development of remanufacturing activities, whether in the area of processes, or PSS, can be an important element in the development of the Basque Government's science and technology plan. Specifically, with the strategic priority of intelligent specialization in advanced manufacturing. This priority highlights the development of research activities on industrial sectors (especially transport, capital goods and metal), and supports the creation of new products and services, new materials, applications, and improvements in manufacturing processes. This is an opportunity for the competitiveness of Basque Country industrial companies, as well as for the accumulation of new scientific-technological resources [7]. The objective of this study is to provide an overview of the activities, services and markets of remanufactured goods of the Basque Country, in order to discover challenges, opportunities and barriers, which can influence the development of new activities and PSS related to remanufacturing. In addition, this report estimates and describes, the size and scope of remanufacturing in the Basque Country with a projection for the year 2030, including the main industrial sectors and employment levels.

2. Background

2.1 Remanufacturing

Today remanufacturing is a well-known concept. Born on World War II [8-10] when the war increased the need for natural resources that were scarce, manufacturing activity was reoriented to reconstruct the used pieces reworked from the original products. Ijomah [9] mentions that authors like Haynesworth and Lyon [11] date the first record of remanufacturing in the US in Boston in 1929. Other authors like Ramirez [12] consider that the investigation of the industrial process of remanufacturing begins officially in the US with the academic research of Robert Lund and William Hauser in 1984.

According to Hauser and Lund [13], remanufacturing allows recovering between 85% and 95% of the materials and energy consumed in the original product. In the same way, remanufacturing takes advantage of and maximizes the knowledge incorporated in the product during its design and manufacture. Haynesworth and Lyons [11] and Lund [14] among others claim that remanufacturing reduces production costs so that products are provided to customers at much lower prices compared to conventionally manufactured alternatives. There are different definitions of the term remanufacturing. For example, Seaver [15], Lund [16], Ijomah [9] and Sundin [17] define remanufacturing as an industrial process that returns a product to its original conditions with a guarantee that it is equivalent or better than the product manufactured initially, through inspection, disassembly, cleaning, reprocessing, assembly and testing. The original components are replaced by new components in order to reuse the product or sell it at a lower price than a new product, but always keeping the same guarantee. The aforementioned definition is clear and

restrictive. However, in some cases of incipient products (cores), it is convenient to consider that obtaining a remanufactured product at a lower price with similar or superior characteristics to the original product is not feasible due to technological limitations. Therefore, we can also consider these products as remanufactured products.

2.2 Characteristics of products to remanufacture

The characteristics of remanufactured products refer to economic and market characteristics, technological characteristics, legislative characteristics and the attributes of the product itself. The following tables (Table 1, Table 2, Table 3, and Table 4) show in more detail the bibliographic review regarding each characteristics.

Table 1. Economic and market characteristics

Contributions of authors	Authors
Capacity to collect products or components	[18-20]
Existence of a first and / or second life market	[18-20]
Long useful life	[7,12,21-24]
Product or component with added value	[12,19,21,23]
High recoverable value	[25]
Low product cost compared to the added value	[16,20,23]
Low demand for new product	[22]
Business model focused on service	[22,26]
Quantitative criteria (quantity of recoverable products, regional availability, etc.)	[21]
Criteria related to interference with new manufacturing (competition or cooperation with OEM, etc.)	[21]

Table 2. Technological characteristics

Contributions of authors	Authors
Low rate of technological change in the product or component	[7,16,19,20,22,25,27]
Stable process technology	[25]
Product with high technological content	[12]
There is technology to remanufacture	[20,28]

Table 3. The legislative characteristics

Contributions of authors	Authors
Product composed of standard interchangeable parts	[16,20]
Legislation for remanufacturing product	[22]
End of life criteria	[21,26]

Table 4. Characteristics of the product design

Contributions of authors	Authors
Stable design	[23,25]
Possibility of improving the product	[20,21,26,29]
Easy disassembly identification	[20,21,24,26]
Good separation of the materials of the product	[7]
Ease of classification of the components	[20,30]
Ease of cleaning and simple methods of tests	[20,21,30]
Ease of assembly	[20,24,30]
Modular architecture	[7,27,30]
High integration level. Number of components	[27]

2.3 Characteristics of remanufacturing companies

Remanufacturing of products or components can be executed by different types of companies, [17,31-33] classify them as follows:

First, OEMs (Original Equipment Manufacturers) that remanufacture their own products collected from different centres such as stores, dealers, etc. These OEMs have all the necessary information about the design of the product and they have spare parts and knowledge about the services provided. Second, companies contracted by the OEMs that remanufacture products and offer their customers those products at a lower price. This way, OEMs put less capital at stake (workers, machines, etc.) and take less risk.

Third, Independent Remanufactures (IR) that remanufacture products with little contact with the OEM and need to buy or collect cores (used parts) for their processes.

From a profitability point of view, Guide [34] indicate that companies with more opportunities to remanufacture are the OEMs.

3. Remanufacturing in the Basque Country

In order to identify the remanufacturing potential of the Basque Country, First, the research team has analyzed the most relevant industrial companies. After that, they have interviewed the industrial managers and directors of innovation, of the leading industrial companies in the Basque Country. The interviews refer to: (i) sales and employment, (ii) barriers, motivations and challenges in remanufacturing.

3.1 Relevant industrial companies for remanufacturing in the Basque Country

The Basque Country is one of the most important industrial concentrations in Spain. The regional gross domestic product (GDP) is at €68,897m [35], which is the highest in recent years, manufacturing industries represent 20.11%. The strongest industrial sectors of the Basque economy are aerospace, automotive, energy, machine tool/equipment goods and railways. Table 5 shows the distribution of the 890 most important companies in the sectors identified. For each sector, it show, the nº companies, nº the employees, the sales and the investment in R&D [36]

Table 5. Five priority industrial sectors in the Basque Country [36]

Priority industrial sector	No. Companies	No. Employees	Sales (millions €)	Investment in R & D (millions €)
Aerospace	65	12	1,585	266
Automotive	350	34,85	13,07	470
Energy	350	68	44	400
Machine tool and equipment goods	96	5,673	1,18	60
Railways	29	14,176	2,658	90
Total	890	134,699	62,493	1,286

The criteria to define the remanufacturing potential of companies based on the type of products they manufacture. The research team first, based on the bibliographic review of point 2.2, have identified four criteria; value added, manufactured quantity, useful life and technological cycle.

Table 6. Criteria's to estimate the potential for remanufacturing

Level	Criteria				Potencial Reman
	Value added	Manufactured quantity	Usefull life	Technological cycle	
1	High	High	High	High	HIGH
2	High	High	High	Low	HIGH
3	High	High	Low	Low	HIGH
4	High	Low	High	High	MEDIUM
5	High	High	Low	High	MEDIUM
6	High	Low	High	Low	MEDIUM
7	High	Low	Low	Low	MEDIUM
8	High	Low	Low	High	LOW
9	Low	High	High	High	LOW
10	Low	Low	High	High	LOW
11	Low	High	High	Low	LOW
12	Low	High	Low	Low	LOW
13	Low	High	Low	High	LOW
14	Low	Low	Low	High	LOW
15	Low	Low	High	Low	LOW
16	Low	Low	Low	Low	LOW

Subsequently, for each above criteria, two possible levels have been assigned (low and high).

Next, the levels of remanufacturing potential have been defined based on the combination of each criterion in its different levels. To this end, the techniques based on the design of experiments DOE, have been used. DOE is a systematic method to determine the relationship between factors affecting a process and the output of that process [37].

With all this, the 16 levels of remanufacturing potential that are shown in Table 6 have been identified. These levels have been classified into three potential levels, low, medium and high. The low level represents a low value added and a low quantitative manufacture. Medium level represents low quantitative but high value and high useful life. Moreover, high level represents, high value added and high quantitative manufacture. Level 1 corresponds to the highest potential and

level 16 corresponds to the lowest. Finally, the remanufacturing potential of each company has been defined based on the valuation of the products they manufacture with the levels identified in Table 6.

The results infer to be considered that it is necessary to focus on companies that manufacture products of high added value, in medium and large series, with long useful life and with a medium-high technological cycle.

Then, the team analysed 890 companies in order to identify those companies that have a medium or high level of remanufacturing. As a result, they identified 197 companies. Afterward we classified these 197 companies into three groups: Group 1: Companies that have a high potential and are currently remanufacturing.

Group 2: Companies that have a high potential but are not currently remanufacturing.

Group 3: Companies that have medium potential. In this group, we exclude companies that are not currently remanufacturing.

3.2 Results for each sector

The analysis performed by each sector is summarized below.

Aeronautics: The aeronautical industry is one of the strategic sectors of the Basque Country, both for the development high added value products and for the generation of qualified employment. This is due to companies' high experience in the sector, concentration of suppliers, as well as large technology plans and R&D projects and the level of internationalization and external relations [36]. From the 65 companies analysed, we identify 10 OEM1 companies, 2 with high potential (group 2) that are not remanufacturing today but have remanufacturing potential and 8 companies with medium potential (group 3).

Automotive: More than 45% of the production volume of the automobile industry in Spain is in the Basque Country. The Basque automotive sector is innovative, competitive and comprehensive. The high degree of effectiveness and efficiency make the management levels similar to those of the most advanced countries in the world [36]. From the 350 companies analysed, we identify 16 companies with remanufacturing potential (3 OEM-type companies, 12 OEM1-type companies 1 and 1 RI-type company). From those companies, 3 companies are remanufacturing today (group 1), 5 companies are not remanufacturing but have a high remanufacturing potential (group 2) and there are 8 companies with medium remanufacturing potential (group 3).

Energy: The energy sector analysed consists of the auxiliary suppliers such as windmills or turbines. It is also a strategic sector and has a strong dynamism throughout its value chain. For example, regarding the manufacturing of capital goods or services for the installation and maintenance of energy infrastructures [36]. From the 350 companies analysed, we identified 25 companies with remanufacturing potential. Three that are currently remanufacturing (group 1), 10 that do not remanufacture but have a high remanufacturing potential (group 2), and 12 that have a medium remanufacturing potential (group 3).

Machine tool and equipment goods: The Basque Country ranks third as the largest producer of machine tools in the European Union. Produces all types of components for companies of aeronautics, automotive, etc. More than 2,000 machine models are produced with a wide range of highly competitive products [36]. From the 165 companies analysed, we identify 63

companies with remanufacturing potential: 59 OEM-type companies and 4 OEM1-type companies. In total 13 are remanufacturing today (group 1), 1 company do not remanufacture but has a high remanufacturing potential (group 2) and 49 companies do not remanufacture but have a medium remanufacturing potential (group 3).

Railways: The Basque railways industry is able to produce solutions adapted to the specific needs of each operator all over the world [36]. From the 29 companies analysed, we identify 4 companies with remanufacturing potential. One company that is not remanufacturing but has high potential (group 1) and 3 companies with medium potential that are not remanufacturing today (group 2).

3.3 Interviews with representatives of companies

In order to know the reality of the different industrial sectors of the Basque Country, the research team developed a questionnaire oriented to the companies with the highest remanufacturing potential. The interviews were conducted, based on the questionnaire developed for the remanufacturing market study, which was carried out within the project funded by the ERN - European Remanufacturing Network [2]. The following are issues that were intended to be addressed mainly through the interviews. Current situations of refurbishing, and remanufacturing, trends of market, motivations, main customers products, situations of product services, effects of services, economic benefits, job creation effects.

Among other things, the research team conducted 18 interviews to identify the size of the remanufacturing market in Basque Country, the possible projection in the next future, and the barriers and limitations of the market. According to the interviewees, 60% of the companies indicate that they are currently remanufacturing and in contrary 40% indicate that they do not remanufacture. The equipment goods sectors is the sector with the highest percentage (80%) of companies that remanufacture, followed by machine tool (75%) and energy (50%). The companies from appliances and automotive sectors do not perform remanufacturing. Table 3 shows the sectors that remanufacture.

(i) Sales and employment

The estimated sales in remanufacturing for three of the five priority industrial sectors in Basque Country is 39.5 million euros and employs 196 people (Table 7).

Table 7. Three of the five priority industrial sectors in Basque Country [36]

Sector	Machinery	Equipment goods	Energy	Total
Interview	5	4	4	13
Reman Sales (millions €)	277.5	189.5	116	583
Sales (millions €)	14.2	6.5	18.8	39.5
(%)	5.64%	3%	16,2%	6,7%
Total Employment	1,030	702	765	2,497
Reman employment	99	27	70	196
(%)	10.92%	3.32%		

This represents the 5.64% in the machine tool sector and the

3% in the capital goods sector. In terms of employment, in the machine tool sector, the people employed in remanufacturing represent the 10.92% of the employment, while in the case of the equipment goods is the 3.32%.

(ii) Barriers, motivations and challenges.

According to the interviews, the motivations that companies have for remanufacturing are high durability of the product (9 companies), high value of the product (11 companies), products with low technological change rate (8 companies), customer loyalty (6 companies), strategic advantage and differentiation (12 companies), legislation (8 companies). In addition, 7 companies mention Services 4.0. Five companies indicate that the main barriers in remanufacturing are the access to the products, the resulting quality and the valuation of the market. Concerning the remanufacturing activity in the equipment and machinery sector, predominates the remanufacturing of the OEMs. In the case of the energy sector, the remanufacturing is under OEM contract. The technological challenges of the remanufacturing process are the development of the inspection, remanufacturing, verification and testing and calibration processes.

4. Size of the current market and future potential market

Considering Vreeswijk and Advies’ [38] classification that shows in Table 8, the Basque Country would be at the lowest level (Level 1, Ad-hoc). However, the main sectors (energy, machine tools and capital goods) could be located at Level 2 (unstructured).

Table 8. Maturity levels of the remanufacturing, adapted [38]

Analyzed aspect	Maturity level			
	1	2	3	4
Remanufacturing	Ad-hoc	Unstructured	Structured	Optimized
Parts harvesting	Ad-hoc	Unstructured	Structured	Pro-active
Installed based management	-	Growing	Active	Pro-active
Sales channel	Via brokers	Ad doc	Organization	Sales support
Share of sales	< 3%	3-7 %	7-12 %	>12 %

Possible future growth scenarios are shown in Table 9.

Table 9. Growth scenarios for remanufacturing

Stage	2020	2030
Level 1	2 %	3 %
Level 2	3 %	5%
Level 3	5 %	7 %
Level 4	>12 %	-

When defining growth scenarios, it is important to consider that each sector has its own business model rules. OEMs are better positioned to remanufacture than other companies. Table 10 shows the estimated figures for the growth projection in the five priority sectors analysed. Ç

Table 10. Estimated growth for remanufacturing in Basque Country

Industrial Sector	Sales estimated in 2016	Reman estimated in 2016	(%) Reman in 2016	Reman estimated in 2020	(%) Reman in 2020	Reman estimated in 2025	(%) Reman in 2025
Aeronautics	94	0	0%	0	0	0	0
Automoción	365	5	1.3	7.3	2	10.9	3
Equipment goods	762.1	11.4	1.0	22.8	3	38.1	5
Machine tool	737.3	16.5	2.4	22.1	3	36.8	5
Energy	1.113	30.7	2,7	55.6	5	77.9	7
Total (millions €)	3,0719	63,6	2	107,8	3.4	163.7	5,2

Aeronautics: due to the type of the product, currently the remanufacturing takes place in the US and France under the control of the leading OEMs (BOEING and AIRBUS). Therefore, we consider that this sector will have zero growth.

Automotive: remanufacturing is already a reality in this sector (there are independent remanufacturers) and companies based in the Basque Country have already opened remanufacturing plants in Spain. However, from the interviews with representatives we consider that the growth of the remanufacturing in this sector will be weak, unless the OEMs start demanding it. Thus, we place the sector in Level 1.

Machine tool and equipment goods: remanufacturing is already a reality in this sector too and the interviews suggest that currently represents the 3.8% of the total volume of the remanufacturing companies. Industry 4.0 trend will push the growth in this area to provide better services. Thus, we place the sector in Level 2

Energy: Currently energy companies of the Basque Country remanufacture. On the one hand, there are large OEM companies, and on the other, OEM1 and IR. The energy efficiency improvements together with the renovation of facilities and the monitoring of products will make this sector grow to Level 3.

5. Conclusions

The remanufacturing process for 2025 has great potential for development in the Basque Country. The initial sales estimate for the five priority sectors analysed in 2016 is 63.6 million euros, and 163 million euros for 2025, which represents an increase of 253%..

Remanufacturing in the Basque Country is still emerging as has been pointed out previously, remanufacturing is taking place spontaneously. Numerous opportunities to develop the remanufacturing process that must be exploited, due to the fact, that there are some sectors and Basque companies, but are do not currently remanufacture products in fact done so in other countries. There are large Basque OEMs with a high remanufacturing potential that are not currently remanufacturing and those companies can generate a tractor effect in their respective sector.

Very few companies apply remanufacturing in their facilities in a strategic, planned and integrated way. In order to place

remanufacturing at the strategic level, Basque companies must invest efforts on new business models able to go beyond one-off payments for products [39]. Therefore, it is necessary to merge remanufacturing process with PSS strategies so that manufactures can stablish more profitable and regular revenue models resulting from their remanufacturing activities [30].

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