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Sustainability Strategies by Oil and Gas Companies, Contribution to the SDGs and Local Innovation Ecosystems

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Abstract: Oil and gas (O&G) companies are facing increasing pressure to transform their businesses in order to contribute effectively to the transition from an economy based on fossil fuels to one driven by clean energy technologies. Understanding how O&G companies can define actions to comply with the United Nations' Sustainable Development Goals (SDGs) and, specifically, how they can generate a positive impact in terms of sustainability through technology innovation becomes relevant in order to guarantee the success of such transformation. To explore this issue, this article analyzes, using a case study research methodology, the sustainability strategy of an O&G company in the Basque Country region (Spain) that is undergoing a profound transformation of its overall business strategy. In particular, the analysis focuses on how the company's innovation and research and development (R&D) activities and projects related to clean technologies contribute to fulfilling the energy- and non-energy-related SDGs. The main result of the analysis is the identification and characterization of an emerging complex public–private multi-stakeholder business and innovation ecosystem surrounding the O&G company under scrutiny with a clear focus on low-carbon technologies. This ecosystem channels knowledge and innovation synergies and spillovers at the local and regional levels, encouraging green industrial growth in different value chains, and provides insights about how O&G companies can contribute effectively to the SDGs and, at the same time, increase the sustainability of their businesses.

Keywords: oil and gas; energy transition; decarbonization; corporate sustainability; innovation; sustainable development goals; industrial clusters

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1. Introduction

Oil and gas (O&G) companies face increasing pressure to adopt sustainability strategies that lead to effective, steep reductions in their greenhouse gas (GHG) emissions and environmental footprint and to economically and socially sensible business outcomes.

Given the environmental, economic and social implications of the current macroeconomic, energy and geopolitical scenario, O&G companies appear to be right in the middle of the global transition towards a sustainable society. This transformation process has relevant connotations for just, sustainable development [1,2], as global energy production and consumption forecasts strongly suggest that petroleum and natural gas will play a leading role in the future energy landscape, driven by the needs of a growing population and the urbanization trends in emerging economies [3,4].

This implies that the overall energy transition cannot be realized without relying on a parallel transition within the O&G industry, which is progressively adopting a multi-energy focus [5] and shifting the scope of its activities.

The pertinence of this issue is reflected in the growing academic and grey literature which addresses the investments of O&G companies in low-carbon energies in recent years. Although O&G companies are deploying a wide range of investment strategies in renewable energy and low-carbon technologies [6–8], they have been relatively slow in adapting their business strategies [9–11]. Mounting pressure to augment the sustainability of their activities is leading many of them to expand their investments in clean energies [12] and pay more attention to climate change issues and their transit towards sustainability [13]. Additionally, recent research has focused on how the Sustainable Development Goals (SDGs) are addressed by the O&G and other industries, such as the automotive industry [14] or the digital market platforms sector [15]. In the case of the O&G sector, attention has been paid to how the SDGs are incorporated into reporting strategies [16], to mapping specific sustainability activities and projects to the different SDGs [17] and to proposing indicators to assess the overall sustainability of O&G companies [18].

However, these studies have not assessed O&G sustainability approaches from the point of view of technology and innovation. This article sheds new light on this topic by explicitly including the technologies involved in sustainability actions into the analysis.

Understanding how O&G companies may contribute to the SDGs through their technology and innovation strategies is relevant on several counts. Firstly, it is widely assumed that no transition towards a sustainable global economy can occur without a transition by the O&G sector [19]. Secondly, it may help to identify the most effective and least-cost paths towards decarbonization, which will require significant amounts of investment in developing clean technology solutions in the coming decades [20,21] and will also be critical for key capital-intensive clean energy technologies (e.g., carbon capture, storage and utilization, green hydrogen, biofuels, etc.) to develop and reach maturity [5]. Thirdly, the O&G industry's long-term success will critically depend on enhancing its innovation potential to contribute to sustainability [22]. Additionally, O&G companies are usually large enterprises that generate significant amounts of added value in multiple value chains, fostering innovation and the creation of new business fabric and employment, with a sizeable economic and social impact at the local level [23].

Following the suggestions for further research proposed by [13], the aim of this article is to contribute to the academic literature on sustainability strategies in the O&G industry by specifically analyzing the role of large O&G players in fostering sustainability through their business and innovation strategies and generating economic and social value locally by leading the development of complex innovation, technological, resource and knowledge ecosystems that induce effective sustainable transformations. Specifically, this article addresses the following research question: "How can O&G companies generate a positive impact at the local and regional level in terms of sustainability and economic and social outcomes through their technology innovation activities?"

We answer this research question by following a qualitative case study methodology. First, we characterize the sustainability strategy of a specific O&G company under scrutiny in our case study by thoroughly reviewing its official corporate documents in order to identify key sustainability actions and projects and the technologies involved therein. We then applied an analytical framework developed by [24] to characterize how the firm is contributing to the energy- and non-energy-related SDGs via technological innovation and through interactions with multiple stakeholders within its surrounding business and institutional ecosystem. This framework, which is based on the work by relevant international organizations—namely, the United Nations Development Programme (UNDP) and the International Energy Agency (IEA)—provides a comprehensive and holistic view about the company's sustainability strategy and its implications. Analyzing the ecosystem around the company under study is relevant because developing and adopting effective low-carbon technologies and solutions requires significant innovation efforts and, thus, collaboration across companies and value chains, particularly in the hard-to-decarbonize transportation and industrial sectors.

The main contribution of this article is the identification and characterization of an emerging complex public–private multi-stakeholder innovation ecosystem surrounding the O&G company under study with a clear focus on low-carbon technologies. This multi-stakeholder network acts as a catalyst for technological spillovers and synergies involving low-carbon technologies across interrelated value chains and as a means for generating economic and social value, and can be considered another significant result of the company's overall sustainability strategy. Additionally, the proposed approach to analyzing the implications of the technological and innovation efforts of O&G companies may be especially useful due to its practical applicability.

The article is structured as follows. Section 2 describes the methodology and data used in the analysis. Section 3 presents the results of assessing the case study company's technological and non-technological approach to advancing towards the fulfillment of the SDGs and a discussion of its implications. Section 4 then draws the main conclusions and points to further research avenues related to the sustainable transformation of the O&G industry.

2. Methodology and Data

The analysis of the case company's sustainability strategy is conducted in two stages. The first stage is based on research in [24] (Section 2.1.1), while the second one extends the approach in [24] (Section 2.1.2). Overall, the analysis is based on qualitative case study research methods (Section 2.2).

2.1. A Tool for Assessing Sustainability Strategies of O&G Companies

Arguably the most relevant contribution in the grey literature regarding how O&G companies may contribute to the SDGs can be found in a report by the UNDP et al. [25], which presents a list of actions that contribute to each SDG. This allows O&G businesses to map their activities to the UN 2030 Agenda SDGs and, thus, better understand their position in terms of sustainability.

The framework in [25] is useful to O&G companies in several ways. Firstly, companies may use it to improve their self-assessments regarding sustainability and their reporting on how their activities are aligned with the most relevant SDGs for each particular company. Secondly, it may help to identify additional activities that can potentially be carried out by the company with a significant impact in terms of their contribution to the SDGs. Additionally, it may foster new ways to engage with relevant stakeholders, particularly governments, in areas such as decarbonization or sustainability policies, and foster new avenues for collaboration related to the SDGs of common interest.

From the point of view of academic research, the UNDP report is interesting because it facilitates the replication of sustainability analyses at the company, sectoral or even territorial level, thus opening the door to studying a new range of topics. However, the UNDP framework is not suited for comparing the different paths of contribution to the SDGs by O&G companies and, thus, prioritizing innovation activities and low-carbon technologies.

This limitation is overcome in [24] by complementing the UNDP tool with information from an interactive database on low-carbon technologies developed by the IEA [26], known as the "Energy Technology Perspectives Clean Energy Technology Guide" (ETP-CET Guide). This database includes information on the level of maturity of more than 430 clean technology solutions (referred to as "key technologies" in this article) that are applicable in different segments of the energy system and that are thought to play a role in achieving the global objective of net-zero emissions in 2070 in the IEA's Sustainable Development Scenario. Individual technologies are ranked in terms of their Technology Readiness Level (TRL) and their "importance for net-zero emissions" (as assessed by the IEA). One of the limitations of the ETP-CET Guide is that it focuses exclusively on technologies that can be related to a short list of SDGs—specifically, goals 3 (good health and well-being), 7 (affordable and clean energy) and 13 (climate action).

The resulting combination can be viewed as a standardized analysis framework that helps to assess in a comprehensive and replicable way the sustainability strategy of any O&G company. The methodology for analyzing the company's sustainability strategy involves two phases and five steps (Figure 1).

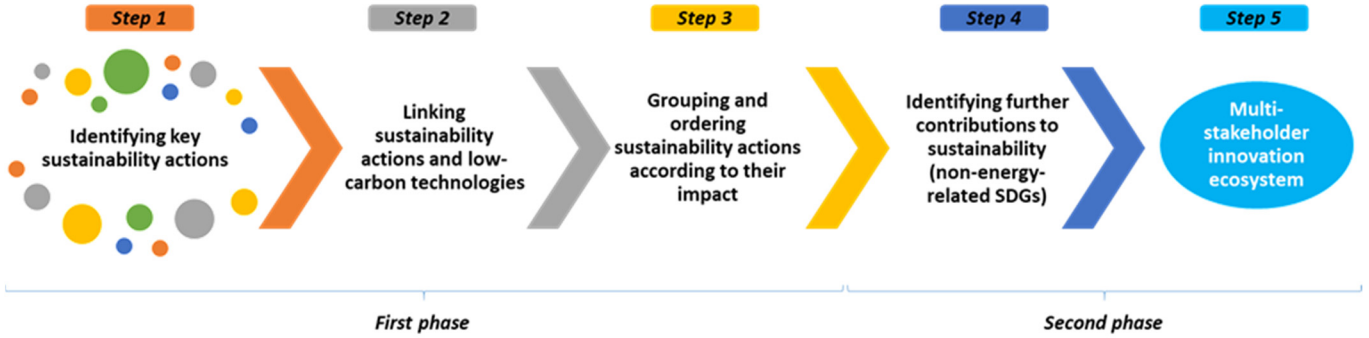

Figure 1. Summary of the methodology for assessing the technological contribution to SDGs by an O&G company.

2.1.1. First Phase

The first step in the assessment is to identify the unit of analysis. We focus on the specific individual activities (for instance, projects, investments, etc.) mentioned in the company's sustainability plans. The activities in the sustainability plans are then mapped to each of the SDGs, according to the classification proposed by [25], and classified into general "areas of contribution to sustainability".

The second step of the analysis involves linking sustainability actions and low-carbon, innovative technologies. Identified sustainability actions are associated with specific low-carbon technologies in the IEA's ETP-CET Guide, which, due to its focus on energy, covers only SDGs 3, 7 and 13.

In step 3, the sustainability actions are ordered according to (a) the technologies involved and (b) their matureness and relevance in the company's overall strategy. To do so, they are first assigned to technology groups (i.e., groups of sustainability actions involving the same or similar technologies), based on the identified common linkages to specific technologies in the ETP-CET Guide. These technology-related groups are then grouped into larger "macro-groups" according to their TRL scores and their role and relevance in the business strategy of the company.

The proposed triangulation approach to analyzing the company's strategy, from a triple business–sustainability–technology perspective, facilitates obtaining a fuller picture of the complex environment surrounding the company (Figure 2). The use of triangulation methods is justified as the case of an O&G company developing a sustainability strategy in the context of energy transition is sufficiently fairly complex along several dimensions [27–29]. This way, the company's value creation goal ("business level" in Figure 2) can be analyzed through the lens of two relevant and independent references ("international level" in Figure 2) which focus on the need to achieve sustainable development and global net-zero emissions simultaneously, thus working as a double sustainability benchmark. In particular, adding the technological dimension through the IEA ETP-CET Guide provides insights about the extent to which the innovation capacities of the O&G companies are aligned with the types of research and development (R&D) and innovation required for achieving net-zero emissions in the energy sector.

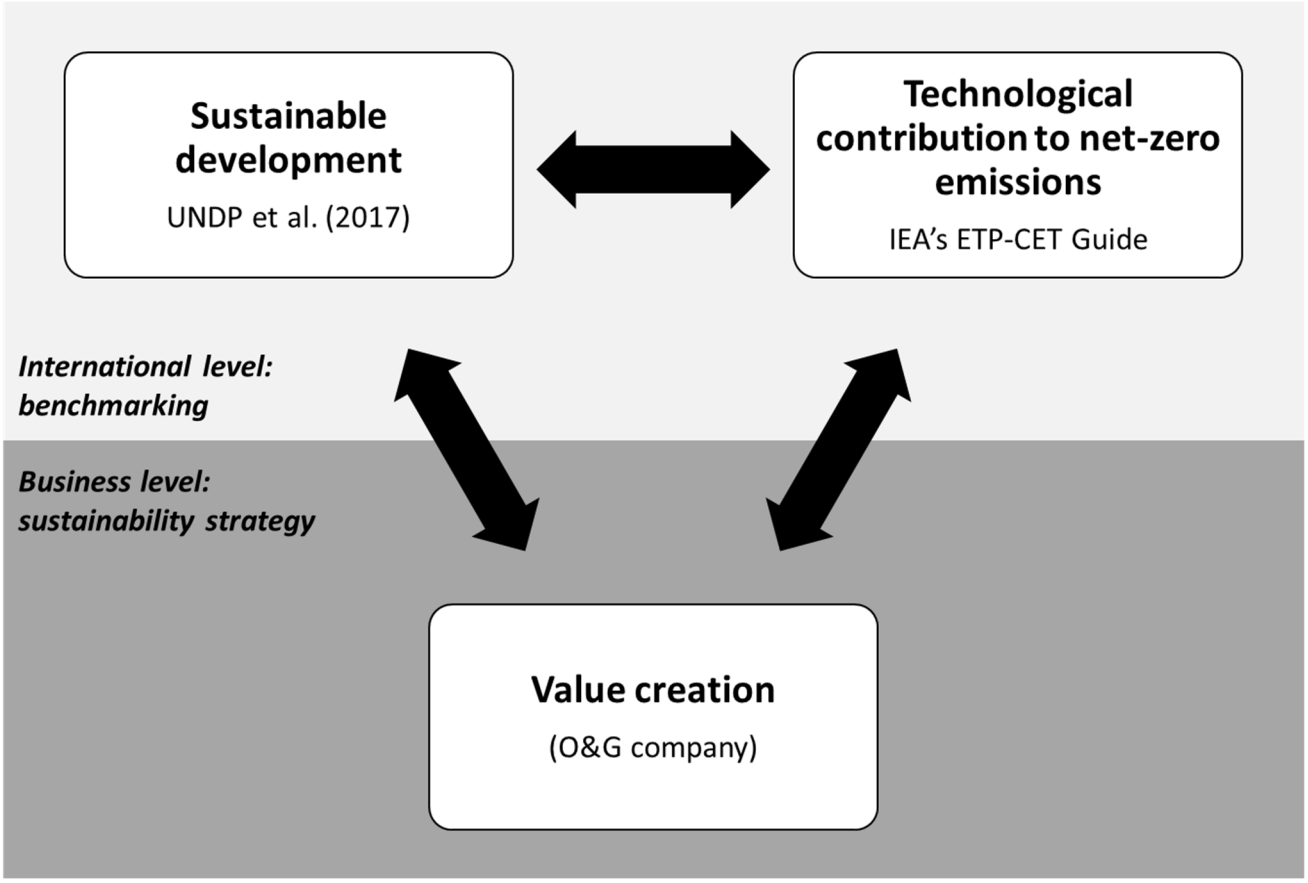

Figure 2. Analysis based on triangulation of an O&G company's approach to sustainability.

Indeed, this is related to technological change (TC), which represents the invention, innovation and diffusion of technology or processes [30]. While the theoretical aspects of TC have been largely studied since [31], the current urgency to decarbonize the economy requires a thorough understanding of innovation and the diffusion of new technologies in all economic sectors. This includes, therefore, addressing the transformation potential of the O&G industry from this technological perspective [32], as well as how the company's technological, organizational, and managerial processes affect TC and vice versa [33].

2.1.2. Second Phase: A Broader Scope

In the second phase of the analysis, the contribution by the company to non-energy-related SDGs is evaluated (step 4 in Figure 1); namely, goals 8 (decent work and economic growth), 9 (industry, innovation and infrastructure), 12 (responsible consumption and production) and 17 (partnerships for the goals).

This is followed by a characterization of the multi-stakeholder business and innovation ecosystem surrounding the company (step 5) through a multi-dimensional analysis. This complements the view on the company's sustainability strategy stemming from the review of specific sustainability actions (conducted in steps 1 through 4) with an analysis of the local innovation ecosystem that has grown around the activities conducted by the company and which is crystallizing as a network of institutions and businesses focusing on low-carbon technologies and innovative decarbonization solutions.

2.2. Case Study Methodology

The analysis in this article is based on case study research [34]. A case study approach allows analyzing in detail an example within a complex process such as the transformation of the O&G industry. However, one of the potential limitations of this method is that it may

prevent an easily generalization of results and the replication of the research. In this sense, the methodology proposed above aims to solve some of these issues. The most relevant point is to achieve a full understanding of the dynamics driving sustainability in a critical sector to energy transition as the O&G sector and, thus, analyzing a case study appears to be a necessary step in the assessment of the sector's transformation.

As one of the aims of this article is to extend the scope of the analysis in [24], it makes sense from a methodological point of view to choose the same case study on which the original research is based. Nevertheless, the primary data from the case study is updated in this article with the most recent available sources, as indicated in Figure 3.

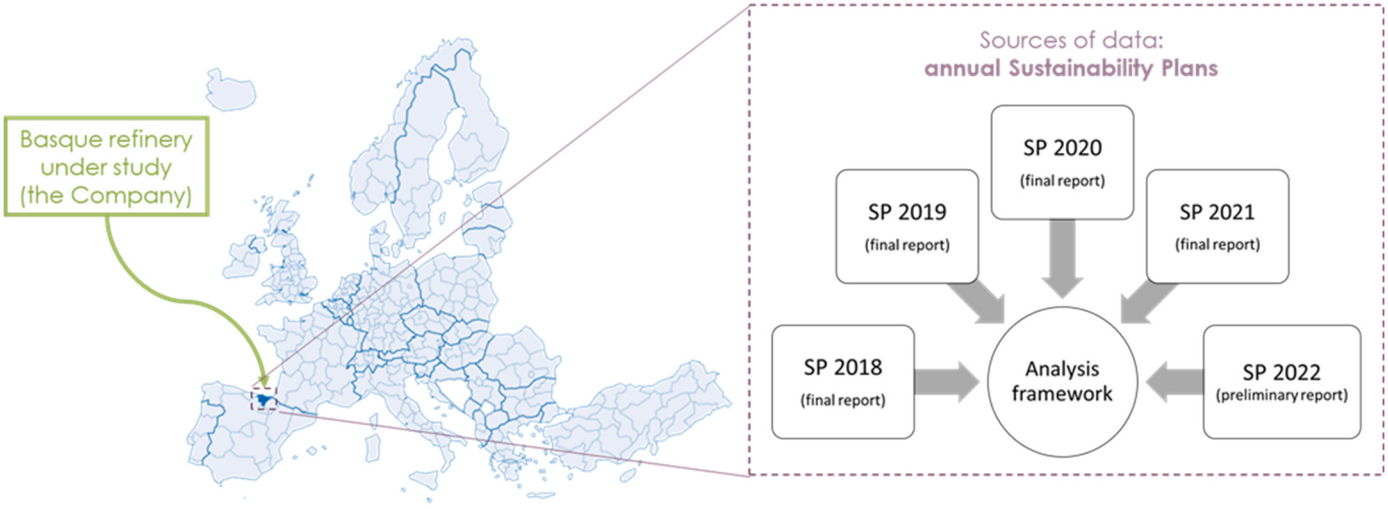

Figure 3. Primary sources of information used in this analysis and location of the Company under study.

The case study is based on the analysis of a company that owns and operates a refinery in the Basque Country region in Northern Spain (henceforth, referred to as "the Company"). The chosen case complies with the basic scientific requirements of case study methods [35–37], as the Company's situation can be considered to be of transparently observable interest and has enough importance and significance at the local level to be critical within the reality of the Basque Country. Further, the analysis of the Company's case under the lens of a standardized methodology may offer valuable insights for replicating the analysis for comparable companies.

The Company also lends its name in the Basque Country and other parts of Spain to a network of conventional fuel supply points (gas stations) for mobility, operated by the downstream business within its parent group. The refinery is one of the key infrastructures the O&G sector in the Basque Country; consequently, the Company plays a prominent role as an economic and business innovation actor in the region and, therefore, is a relevant driver of the Basque energy transition.

Additionally, although the Company has its own corporate identity (e.g., name, trademark, website, etc.), its main shareholder is a Spanish international oil company (IOC), which holds more than an 80% stake of the Company's shares. This means that the Company is fully integrated into the downstream business of the IOC, so the former's strategy and operations are affected by the latter's global corporate dynamics and strategy and are subject, therefore, to the implications of energy transition for the global O&G sector.

In recent years, the Company's strategy has focused on increasing the efficiency of its core refinery operations and on extending its activities and operations into new segments in the energy industry, such as electric mobility, new electricity services (for instance, based on the deployment of distributed energy resources, the development of energy communities, energy management and optimization services, etc.) and a wide array of activities related to the nascent green hydrogen value chain and services related to the deployment and

adoption of low-carbon technologies and decarbonization solutions [38]. An ultimate goal of the Company, as stated in its strategic plans (and those of its parent company) is to become a multi-energy business [39].

The Company states in its publicly available sustainability plans that its business places its sustainability focus on two groups of SDGs: (a) a primary set including goals 7 (affordable and clean energy), 8 (decent work and economic growth) and 13 (climate action); (b) a secondary set, including goals 6 (clean water and sanitation), 9 (industry, innovation and infrastructure) and 12 (responsible consumption and production). Additionally, it focuses on SDG 17 (partnerships for the goals).

The main sources of data are the Company's sustainability plans, complemented with additional corporate documents including strategy plans, financial reports and other corporate and business publicly available presentations and other documents. The oldest sustainability plan considered in the analysis corresponds to the year 2018, as this was the first one in the history of the Company that targeted specific SDGs in its sustainability actions, while the last available one was published in 2022 (Figure 3).

3. Results and discussion

3.1. The Company's Technological Contribution to SDGs 7 and 13

The methodology described above facilitates the identification of different avenues that the Company chooses (or creates) to make technological contributions to SDGs 7 (affordable and clean energy) and 13 (climate action), based on its own technological and industrial resources and its current research and innovation projects. According to the methodology, SDG 3 (good health and wellbeing) would also be included in the first phase of analysis, but it was not covered by the assessment due to a lack of specific data.

The aim of the analytical tool, when applied to assess an O&G company's sustainability strategy, is to eventually classify sustainability actions into major (macro) groups based on the company's technology choices in a straightforward way, facilitating the discussion and conceptualization of the company's approach to sustainability. Previous research on the link between O&G sustainability strategies and the SDGs centered on mapping sustainability actions to specific SDGs [17] and on stressing the relevance of the SDGs in the reporting strategies regarding sustainability [16]. However, none of the published articles delve into the specific clean technologies used in the various sustainability projects and actions. Developing and adopting new clean technologies requires collaboration between different agents and value chains. By investigating in more detail the actors involved in all these projects, we can derive the picture of the business and innovation ecosystem surrounding the Company.

The focus on the technological maturity of the technologies linked to each of the Company's sustainability actions leads to a relevance order, among them based on the criterion that the higher the TRL is for a specific technology group, the less time it will take for it (hence, for the associated sustainability action) to contribute to the targeted SDGs and, therefore, a higher relevance order should be placed in the assessment of its value in terms of sustainability. In the case of groups with the same TRL, their "importance for net-zero emissions" (as assessed by the IEA) is used to rank them. This way, the groups of sustainability actions are ordered hierarchically from the highest to lowest relevance in terms of their (technological) contribution to sustainability.

Table 1 shows the main results of applying the analytical framework to the Company, considering the information in the annual sustainability plans from 2018 to 2022. The technology groups in this table indicate how a general approach to achieving net-zero emissions characterizes the strategy of the Company and, thus, how the Company seeks a close alignment to SDG 13. While most of the technologies can also be considered as a support to clean energy development (SDG 7), innovations such as energy community or microgrids, and even electric mobility technologies, can contribute to improving the access to clean and affordable energy by citizens, deepening the implementation of the seventh SDG. On the other hand, it is important to note that some decarbonization solutions will

still imply GHG emissions at different stages of the value chain and may require different forms of carbon capture. Although this does not mean direct full decarbonization in line with SDG 13, carbon capture is backed by the IEA's ETP-CET Guide as an additional tool to reach zero net emissions. At the same time, as indicated in the methodology, the view adopted here takes the IEA's Sustainable Development Scenario as a reference, which implies accomplishing SDGs 7 and 13 and, more generally, contributing from the energy sphere to the overall concept of sustainable development as it is internationally understood.

Table 1. Main technological contributions to SDGs 7 and 13 by the Company.

Relevance Order	Main Technology Groups, TRLs and "Importance for Net-Zero Emissions"	Major Groups of Technologies
1	Hydrogenated vegetable oil (HVO) (TRL 9–10; M)	Cutting Edge
2–3	Electrolysis (TRL 9; VH)	
2–3	Electric mobility (TRL 9; VH)	
4–5–6	Hydrogen supply for transportation (TRL 9; M)	
4–5–6	Carbon capture with mineralization (TRL 9; M)	
4–5–6	Biogas production by pyrolysis treatment (TRL 9; M)	
7	Hydrogen production from biogas (TRL 8–9; H)	
8	Energy communities (TRL 8; VH)	Electricity Value Chain
9–10	Power aggregation and demand response (TRL 7; H)	
9–10	Microgrids (TRL 7; H)	
11	Collaboration with natural gas DSO (TRL 6–7; M)	Alternative Fuels for Transportation
12	Synthetic fuels production (TRL 5–7; VH)	
13	Refinery's CO_2 emissions reduction (TRL 5; M)	Advanced Refinery Processes
14	Refinery's internal waste reduction (TRL 3–5; M)	
15	Refinery's hydrogen production optimization (TRL 3–4; M)	

Note: "Importance for net-zero emissions" is marked with "M" (moderate), "H" (high) and "VH" (very high), according to [26].

The technology groups of sustainability actions identified in Table 1 (second column) can be further grouped into four "macro-groups": Cutting Edge, Electricity Value Chain, Alternative Fuels for Transportation and Advanced Refinery Processes. This supports a pyramidal view of the Company's sustainability strategy, as suggested in [24].

According to this view, an O&G company materializes technological contributions to sustainability by supporting low-carbon solutions with low or high TRLs. High TRL low-carbon technologies should be the focus of the O&G company's business development and R&D efforts, as they represent the path with the highest potential to achieving positive impacts in the shortest term (i.e., a company's "Cutting Edge" macro-group of sustainability actions in Table 1).

In the case of the Company under study, the "Cutting Edge" technologies encompass the critical technologies for transformation in the medium and long run of the company into a sustainable business, including, especially, electric mobility (as an alternative to conventional mobility, based on internal combustion engines), green hydrogen (as an avenue to decarbonizing industrial activities where electrification is not viable or may not be the most efficient option), carbon capture (as a way to reduce GHG emissions) and biogas as either an input or output that can contribute to more sustainable energy production and consumption processes.

A second macro-group of low-carbon technologies can be associated with sustainability actions by the Company in areas related to the power system (i.e., the "Electricity Value Chain" in Table 1). The Company's aim to become part of a multi-energy business implies extending its activities into electricity supply, which has evident synergies with the current conventional fossil fuel supply downstream business. To do so, the Company has been devoting capital resources to the development of innovative services (which include the

provision of energy assets and infrastructure) in areas such as energy communities, power aggregation services or the deployment of microgrids.

Additionally, R&D efforts by the Company focus on complementing the high-TRL technologies in the "Cutting Edge" and "Electricity Value Chain" macro-groups with the development of additional technologies with lower TRLs, classified into the other two macro-groups in Table 1 ("Alternative Fuels for Transportation" and "Advanced Refinery Processes"), which also provide returns in terms of sustainability and GHG emissions reductions and are synergetic with the core, critical activities of the Company and with its transformation strategy.

An example of this may be achieving higher efficiency and improving competitiveness in the traditional refinery business through technological advancements such as the deployment of a state-of-the-art "digital twin" to optimize the refinery operations [40]. This may also be the basis for the interest in technologies oriented to producing alternative fuels for transportation (i.e., synthetic fuels production), which provide a viable and short-term way to reduce emissions in the transport sector, and the development of alternative technological capacities may indirectly support the activities in the "Cutting Edge" macro-group, even if their TRLs and their "importance for net-zero emissions" are lower.

The full set of innovation projects in Table 1 shows an interrelation among the technological capabilities of the Company with a shared direction towards achieving sustainability benefits (increased efficiency, reduced GHG emissions, cleaner energy, technologies and fuels) and strongly suggests that the sustainability strategy of an O&G company should be studied as a whole rather than by looking at isolated pieces or individual technologies.

High TRL, potentially disrupting low-carbon solutions, can be seen as the "tip of the pyramid" of the Company's innovation potential, whose materialization relies on both the historical technological and industrial capacities of the company and collaboration with a diversity of agents and companies in different value chains.

The Company's current sustainability plan shows a strong bet on technologies linked to the production of low-carbon hydrogen (including electrolysis and production from biogas) and carbon capture. These technologies were not present in sustainability reports prior to 2021, indicating that the scope of the company's business development and innovation has shifted its focus towards developing a more ample portfolio of low-carbon technologies within which green hydrogen clearly stands out but which, at the core, reflects an implicit approach to making sustainable mobility a pillar of the strategic shift and integral transformation of the Company's current business.

Figure 4 summarizes the "pyramidal view" of the Company's approach to technological innovation and sustainability.

3.2. Contribution to SDGs 8, 9, 12 and 17

The analysis of the Company's sustainability strategy is extended here to include an analysis of how it is aiming to achieve SDGs 8 (decent work and economic growth), 9 (industry, innovation and infrastructure), 12 (responsible consumption and production) and 17 (partnerships for the goals).

Table 2 maps a number of activities presented and described in the Company's sustainability plans to the general areas of contribution to SDGs 8, 9, 12 and 17 as presented in [25]. This represents an extension of the analysis of the technological contribution to SDGs 7 and 13 in Section 3.1, resulting from applying the analysis framework that combines the UNDP tool and the IEA's ETP-CET Guide database described in the preceding sections.

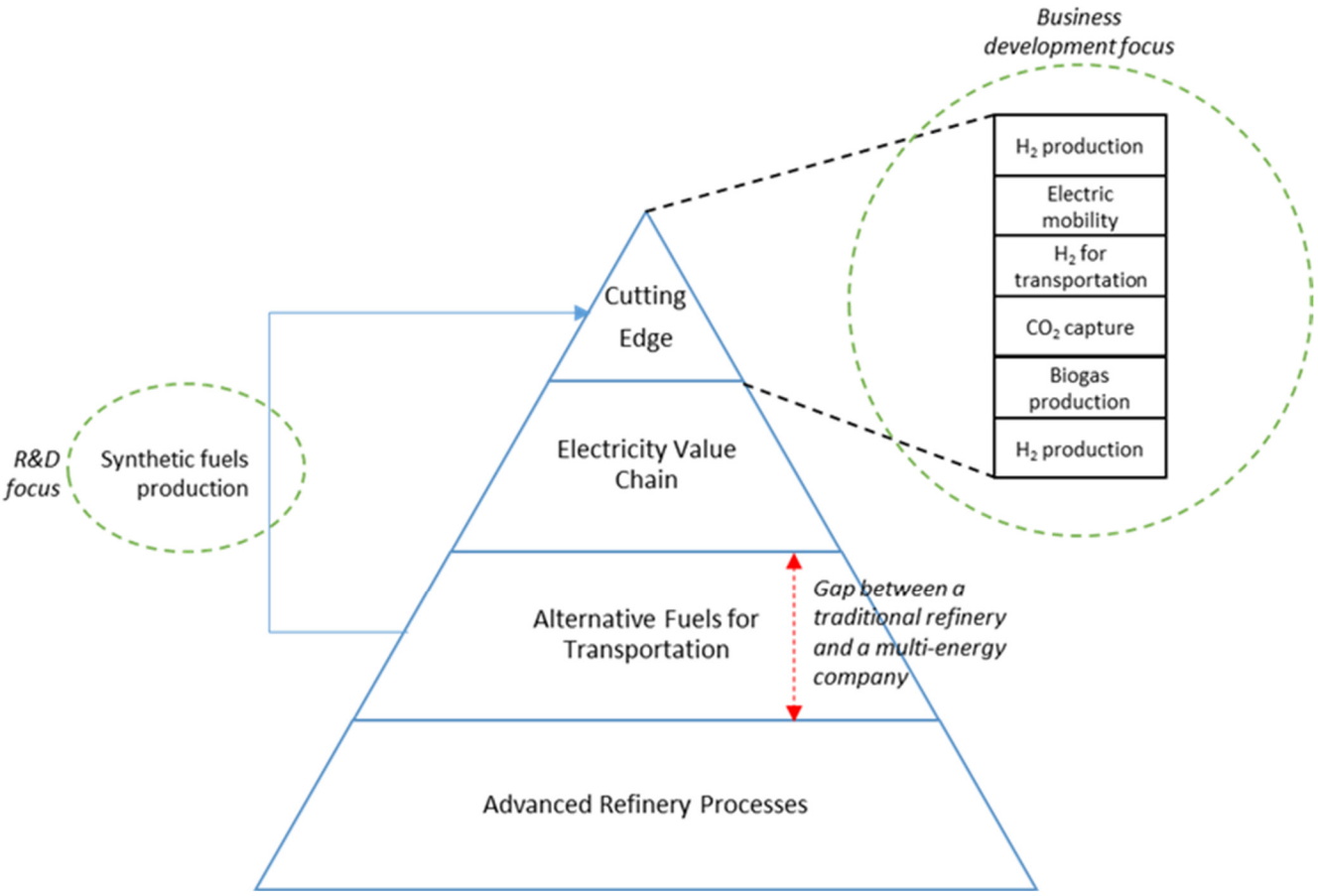

Figure 4. The "pyramid" view of the Company's technology innovation approach towards sustainability (regarding SDGs 7 and 13). Source: based on [24].

Table 2. Contribution to SDGs 8, 9, 12 and 17 by the Company.

Areas of Contribution in UNDP et al. (2017) [25]	Sustainability Activities Conducted by the Company
SDG 8. Decent work and economic growth	
Conduct skills assessment and communicate reasonable expectations	N/A
Foster full and productive local employment and workforce development	- The Basque H_2 Valley supports the development of a master's degree in collaboration with Spanish universities.
Encourage local procurement and supplier development	- Manufacturing electrolyzers for hydrogen production in local facilities built in collaboration with a Basque multinational engineering company. - The development of capacities in electric mobility and energy storage is made in collaboration with Basque companies. - The digitalization of refinery processes relying on Basque companies.
Support economic diversification to achieve higher levels of economic productivity	- The diversification of the company's business is aligned with the Basque energy transition (general contribution).
Multi-stakeholder dialogue to promote development orientated policies	- Dialogue with the Basque Energy Agency and the Basque Energy Cluster Association in order to develop a variety of low-carbon projects (general contribution).

Table 2. *Cont.*

Areas of Contribution in UNDP et al. (2017) [25]	Sustainability Activities Conducted by the Company
SDG 9. Industry, innovation and infrastructure	
Upgrade infrastructure and technology to make them sustainable	- The digitalization of refinery processes. - The development of capacities in energy storage. - Biogas production and major projects regarding synthetic fuels. - CCUS of the refinery's GHG emissions.
Evaluate potential opportunities for shared use infrastructure	- The Port of Bilbao as main location for major projects related to biogas production and synthetic fuels production. Contributes to create an innovation hub focused on renewable energy and decarbonization at the regional port. - The Energy Intelligence Center knowledge hub as a strategic business and research institution supported by public–private collaboration.
Enhance technological capabilities and knowledge transfer	- A Memorandum of Understanding between the parent company (IOC) and a foreign national oil company (NOC) regarding the technology development related to multiple O&G activities. - Collaboration with an EV charging company.
Expand off-grid energy access	- Work on microgrids development. - The creation of a subsidiary company for distributed renewable generation and creation of energy communities in the Basque region.
SDG 12. Responsible consumption and production	
Integrate product stewardship approach	- The integration of second-life batteries in electric vehicle charging points.
Introduce environmentally sound and efficient chemical and waste management	- Biogas production by pyrolysis treatment of urban waste to substitute part of the refinery's natural gas consumption or to produce hydrogen.
Improve supply chain sustainability	- Collaboration with the agri-food industry to use biological waste as raw material.
Coordinate approaches to sustainability	- Collaboration with Basque cluster associations within the Basque Hydrogen Sectorial Forum. - Collaboration with Basque cluster associations and with a power utility within the Basque Net Zero Industrial Super Cluster project.
SDG 17. Partnerships for the goals	
Build government capacity	N/A
Develop and disseminate sustainable energy technologies	- The business diversification of the company is aligned with the Basque energy transition (general contribution). - Collaboration with companies operating in the Basque industrial, energy and mobility value chains.
Participate in dialogue	- Dialogue with the Basque Energy Agency and the Basque Energy Cluster Association in order to develop a variety of low-carbon projects (general contribution).
Strengthen coordination between initiatives	- Collaboration with Basque cluster associations within the Basque Hydrogen Sectorial Forum. - Collaboration with Basque cluster associations and with a power utility within the Basque Net Zero Industrial Super Cluster. - Connection of the Basque H2 Valley with other H2 valleys in North and Northeastern Spain. - Coordination between the Company (regional approach) and the parent company (Spanish and international approaches) in defining the Company's role in the development of low-carbon technologies.
Incorporate SDGs into policies	N/A
Apply SDG indicators	N/A

The Company's activities aim to contribute to these SDGs in both a technological and non-technological way. SDG 8, for instance, focuses on strengthening the quality

of human capital and on fostering the generation of economic value, especially at the local level. The Company's leadership in the development of the so-called "Basque H2 Valley" [41] or the government-led "Basque Net-Zero Industrial Super Cluster" project [42], for instance, materializes in a wide array of technological and non-technological innovation activities, including sponsoring specialized, technical education programs with local and other Spanish universities.

A large number of R&D projects within these two strategic initiatives are engaging local businesses in several value chains, including those focused on hydrogen production, renewable energy, smart energy grids and advanced grid equipment, new digital solutions, energy storage, green gases, EV charging infrastructure and the like. Basque companies involved in the development of a local low-carbon hydrogen cluster and a local industrial decarbonization hub include not only the assemblers and distributors of advanced equipment and infrastructure, but also the manufacturers of (infrastructure and equipment) components and services providers in the areas of engineering, eco-design or ICT solutions [43]. Coordination, dialogue and cooperation with key local (Basque) institutions such as the Basque Government's Energy Agency and the Basque Energy Cluster (the main association in the energy sector) to foster the implementation of the Basque energy and climate change, industrial and innovation strategies is also the focus of a large number of activities that can be linked to the general sustainability strategy of the Company.

The industrial and innovation capacities of the Company, along with its existing (and planned) assets and infrastructures in the Basque Country strategically position it to contribute to SDG 9. Key activities and developments in this respect include, as shown in Table 2, (a) the digitalization of refinery processes; (b) innovation projects in critical low-carbon technologies for the Company (biogas, synthetic fuels, carbon capture, energy storage, microgrids, etc.), the Company's project to convert its portfolio of infrastructure and energy assets in the Port of Bilbao into a low-carbon innovation and decarbonization hub (involving wind energy, CO_2 capture, production of green hydrogen, biogas and synthetic fuels and the deployment of large capacity electrolyzers, [44]); (c) the creation of a knowledge and innovation center (Energy Intelligence Center) as a strategic business and research institution fostering public–private collaboration in strategic areas for the Company (green hydrogen, O&G transformation, electric mobility, etc.); (d) the development of strategic ties and technological cooperation agreements (e.g., the Memorandum of Understanding between the parent company and a world leader, foreign national oil company or NOC); (e) financing new technology-based businesses and creating subsidiaries in areas such as EV charging technologies, distributed renewable generation and energy communities or decarbonization solutions for the industry and the commercial and residential sectors.

The Company's contribution to SDG 12 is materializing in circular economy activities in areas such as recycling and boosting the second life of (car) batteries or the valorization of urban waste by using it to produce biogas (via pyrolysis) which can be utilized as a feedstock in refinery processes.

Collaboration at the local level with multiple actors and within several relevant initiatives is also a key pillar of the Company's sustainability strategy. For instance, the (Basque) Hydrogen Sectorial Forum, which is coordinated by the Company, drives the cooperation efforts around hydrogen activities with eight different sectoral associations in the Basque Country. This is conducted under the umbrella of the Basque Energy Cluster, the energy sector association that has been active in the last three decades in helping to implement innovation strategies and in fostering the modernization and specialization of the Basque energy value chains (in renewable energies, smart grids, power electronics or energy storage, to name a few).

The Basque Net Zero Industrial Super Cluster initiative, which aims to achieve the full decarbonization of the energy-intensive industries in the Basque Country, is based on a three-headed partnership involving the Company, an international power utility that has its headquarters and global smart grids innovation center located in the city of Bilbao (close

to the Company's refinery) and the Basque Business Development Agency (part of the Basque Government). The three-armed collaboration extends to embrace up to 16 Basque sectoral associations that, as a whole, represent the companies responsible for 65% of the Basque industry's CO_2 emissions (mostly concentrated in the oil refining, iron and steel, foundry, cement and pulp and paper industries).

Both collaboration initiatives share, as a flagship initiative, the Basque Hydrogen Corridor (BH2C), also led by the Company. This is a public–private initiative supported by approximately 80 entities at the regional level (companies, R&D centers, universities and public institutions) with the aim of developing a complete, competitive hydrogen value chain in the Basque Country. The germ of such a long-term regional innovation and industrial development initiative can be found in some of the Company's key technological projects (see Tables 1 and 2). These projects are located in the geographical vicinity of the Company's refinery with a strong local approach, closely linked to the surrounding industry in the metropolitan area, to the nearby industrial port and to sources of urban waste resources, appearing to be setting the pillar of a new industrial decarbonization hub (Figure 5).

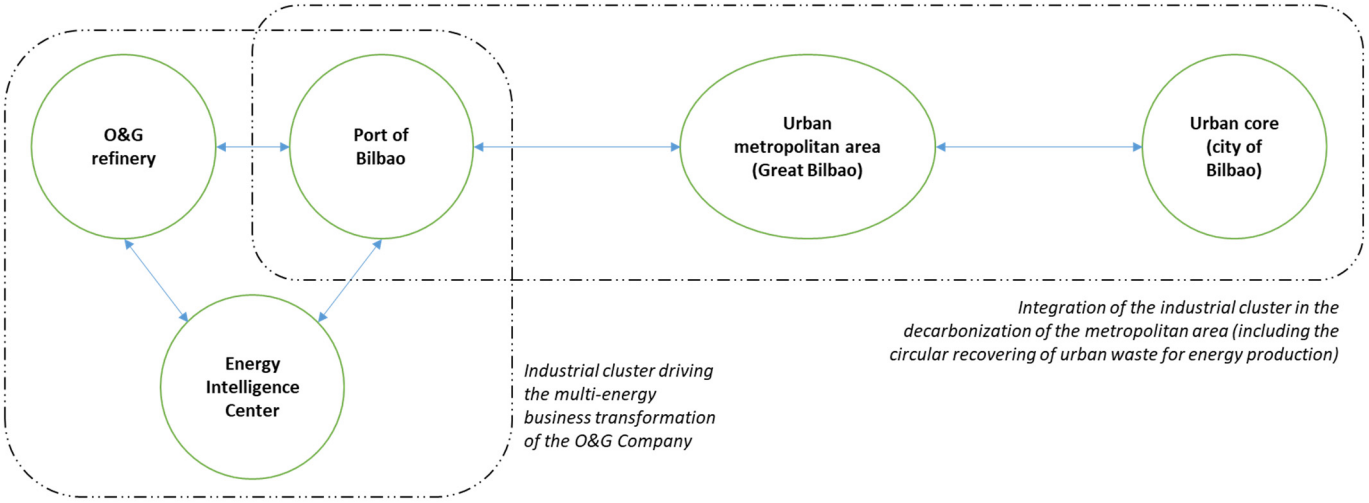

Figure 5. Relationship between the planned flagship decarbonization projects near the Company's refinery.

To sum up, the entire array of collaboration initiatives with business and institutional actors and with knowledge and research centers in the Basque Country and elsewhere serves as an example of how the Company is incorporating SDG 17 into its strategic approach to sustainability.

Overall, the set of sustainable activities listed in Tables 1 and 2 show how the Company's strategy to transform its business by readapting its core activities (to make them more sustainable) and by exploring new business areas related to clean energy and alternative forms of energy, in its quest to become a multi-energy company, is implemented via a large number of technological and non-technological projects that are simultaneously interrelated and oriented towards achieving the key SDGs for the Company.

3.3. Development of a Multi-Stakeholder Local Innovation Ecosystem

The UNDP framework for characterizing and assessing an O&G company's contribution to the SDGs refers repeatedly to a "multi-stakeholder" approach, claiming that dialogue and collaboration between O&G companies and relevant institutional and non-institutional actors both locally, nationally and globally are relevant to achieving the SDGs and effectively advancing in the sustainability of O&G activities and operations.

This collaborative approach appears to be the most effective way to reach the full potential to contribute to the achievement of the SDGs, particularly taking into account

that these goals are interrelated, and that multi-sectoral and multi-disciplinary approaches and partnerships will be needed to materialize the synergies between activities and critical technological and non-technological innovation and, thus, maximize the results in terms of sustainability. This call for a multi-stakeholder approach is therefore paramount to the definition of a sound sustainability business strategy in the O&G and other sectors.

The analysis in Sections 3.1 and 3.2, based on the information included in the Company's annual sustainability plans, can be completed and enriched by mapping the multi-stakeholder ecosystem that is developing and evolving around the Company's innovation activities. An attempt to synthesize the complex mesh of corporate, economic and institutional relationships related to both technological and non-technological developments that surround the Company is shown in Figure 6. The pursuit of new technological development, following the classification of macro-groups in Table 1 (differentiated by color in Figure 6), would act as a main driver of new partnerships between the Company and a variety of stakeholders. The linkages created by these partnerships are also indicated for each stakeholder in the figure.

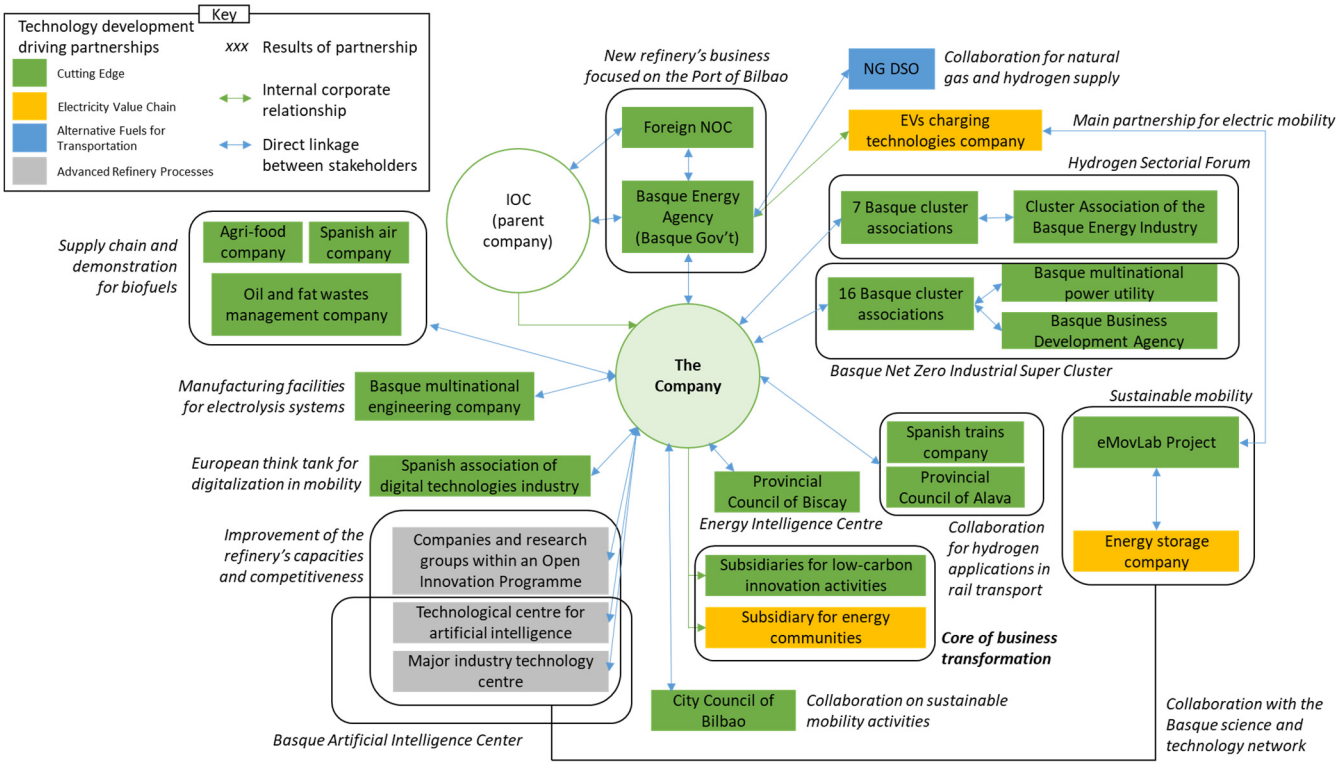

Figure 6. A multi-stakeholder innovation ecosystem evolving around the Company's sustainable activities. (This characterization of the Company's surrounding innovation ecosystem is corroborated by data and information published by the Basque Energy Cluster (www.clusterenergia.com/home) (accessed on 6 February 2023), the Basque Energy Agency (www.eve.eus/en) (accessed on 6 February 2023) and in the context of projects such as the Basque Hydrogen Corridor (https://h2v.eu/hydrogen-valleys/basque-hydrogen-corridor-bh2c) (accessed on 6 February 2023) or the Net-Zero Basque Industrial Super Cluster (https://www.spri.eus/en/support/net-zero-basque-industrial-super-cluster/) (accessed on 6 February 2023), to name a few. These represent or involve stakeholders that are external to the studied company and, thus, provide independent views and criteria for the verification of this article's outcomes.).

While the core activities of the Company led to the development of a network of companies (suppliers, services providers, etc.) and institutions (e.g., technology centers) engaging in various types of traditional collaboration and business relationships, the Company's new focus on low-carbon technologies and the increasing pressure to implement

an effective decarbonization strategy has caused the surrounding business and innovation ecosystem to evolve and incorporate new actors in different value chains (mobility, hydrogen, digital services, distributed energy resources, etc.), with which the Company is establishing new connections and relationships.

The innovation strategy of the company is deployed and implemented in several dimensions simultaneously, including strategic partnerships and agreements with key public institutions (e.g., the Basque Government, the Biscay provincial government or the City Council of Bilbao, to name a few), foreign actors (e.g., a leading NOC in the O&G sector), local technology centers and actors within the highly developed Basque Research and Technology Alliance (BRTA) and Basque Network of Science, Technology and Innovation and via collaborations and business relationships with local (and non-Basque) companies and associations in several value chains which are critical to the Company's business strategy. Strategic positions to the Company in key energy transition areas are also strengthened by the creation of specialized subsidiaries. Especially noteworthy are the collaboration initiatives aimed at creating new knowledge and skills related to the decarbonization of energy-intensive industries and the transformation of the O&G sector.

Areas of collaboration in R&D activities include, as seen in previous sections, key technologies for the adaptation of the current core business and the expansion of the Company's activities into other high-expected-growth areas of the energy value chain (hydrogen, sustainable mobility, distributed renewable energy and advanced services for prosumers, green gases, etc.) and other enabling technologies (such as digital operating tools and services, cybersecurity tools, etc.).

In many of these cases, the participation of the Company (either directly or through subsidiaries) as the main partner in a variety of collaboration projects acts as a lever in reinforcing and strengthening the local and regional business and innovation ecosystems and in engaging cluster associations in several sectors and value chains and, in general, the local and regional business, R&D, education, social and institutional ecosystems in the transition towards a more sustainable economy.

The development of innovative sustainable business models in partnership with local agents (for instance, related to the deployment and operation of "digital twins", new activities associated with the green hydrogen value chain or new value proposals involving distributed energy resources and energy communities) helps the Company to not only expand and diversify its business, but also to materialize new operating and technological approaches conducive to greater sustainability in a variety of ways, including improved energy and material efficiency, lower GHG emissions and circular economy solutions, to name a few. To sum up, the Company's technological contribution to the SDGs is supported by a multi-stakeholder innovation network, which acts as a catalyst for innovation spillovers and synergies across interrelated value chains and for the identification and materialization of business (and social) opportunities. This multi-stakeholder approach could then be considered another output of the Company's overall sustainability strategy, in that it aims at developing and achieving technological breakthroughs that will eventually have an impact on the decarbonization and the environmental footprint of the Company's activities, on the one hand, and generate positive economic and social impact, on the other hand.

4. Conclusions

The main objective of this article was to analyze how O&G companies may generate a positive impact at the local level through their technology innovation activities in terms of sustainability and economic and social outcomes.

We study this issue through the analysis of a case study focusing on a refinery in the Basque Country (Spain) that is undergoing a profound change in its overall business strategy. To do so, we apply a replicable methodology and analysis framework to characterize its sustainability strategy by mapping its sustainability activities (as described in the corporate sustainability reports) to energy- and non-energy-related SDGs and identifying the main low-carbon technologies involved in those activities and projects.

The analysis of the sustainability activities by the Company yields several interesting insights regarding how O&G companies may be responding to the need to change their business strategies in order to achieve net-zero emissions.

Firstly, the analysis in this article helps to identify a comprehensive sustainability and innovation approach by the Company that is coherent and complements its business strategy and its long-term transformation plan. Hydrogen production and sustainable mobility appear to be strategic fields that may allow the company to achieve positive impacts in terms of sustainability in the short term by focusing on relatively mature technologies, with high TRLs and with a significant potential for reducing GHG emissions. Devoting resources to potentially disruptive (from the point of view of the Company) technologies and activities, which may be viewed as the top of the Company's innovation strategy, is coupled by interconnected R&D activities and projects, both with a technological and non-technological focus, that help to strengthen the less visible or bottom part of it (i.e., the core business, which itself is undergoing profound changes in search of a lower environmental footprint).

Secondly, the shift in the Company's strategy, placing innovation and sustainability at the center of the transformation of its business and activities, leads to the development of a varied network of agents and institutions which partner and collaborate in multiple ways. This is due to the fact that developing and adopting effective low-carbon technologies and solutions requires significant innovation efforts and, thus, collaboration across companies and value chains, particularly in the hard-to-decarbonize transportation and industrial sectors. The focus of the Company on clean technologies and the associated business and innovation relationships and collaboration agreements and projects with all kinds of stakeholders at the local and regional level (local, national and foreign companies, R&D centers, universities, public institutions, etc.) gives way to the strengthening of the local business and innovation ecosystems and to new ways to create economic and social value. In short, the multi-stakeholder ecosystem generated through the technological and innovation activities of the Company will create new ways to increase the return of the company's sustainability efforts in economic, social and environmental terms.

The main contribution of this article is twofold. On the one hand, the use of a replicable methodology helps to characterize in a structured manner the sustainability strategy of an O&G company in the light of energy- and non-energy-related SDGs, specifically taking into account the technological and innovation dimensions, which had not been addressed in previous academic work. On the other hand, the analysis of the Company's sustainability strategy under this approach leads to the identification and characterization of a complex multi-stakeholder business and innovation ecosystem which acts as a catalyst for technological spillovers and synergies involving low-carbon technologies across interrelated value chains and as a means for generating economic and social value locally in areas such as (a) employment, skills and economic growth; (b) industrial innovation and the development of key infrastructures; (c) responsible consumption and production; and (d) increased collaboration in areas related to energy transition and the decarbonization of the economy. This should be considered another result of the company's overall sustainability strategy.

The analysis of the chosen case study also has interesting policy implications. For instance, the conventional policies oriented towards fostering local business and innovation ecosystems emerging as a result of the transformation of O&G companies (such as the one around green hydrogen in the Basque Country) could be strengthened by facilitating collaboration across key public and private stakeholders and within and across local firms and value chains, and by identifying effective channels to create value at the local level and generate incentives for business model innovations with tangible economic, social and environmental impacts.

The main limitation of the analysis is that it suffers from a lack of publicly available quantitative information on the Company's activities (i.e., investment volumes devoted to each project, achieved GHG emissions reductions, etc.). Such information would help to measure in economic terms the impact of the various sustainability actions by the company

and, therefore, to establish a relevance order or prioritization of actions, investments and projects in terms of GHG emissions abatement, generation of economic value and other social outcomes (for instance, the development of local skills and more sophisticated, better quality jobs, more awareness involvement of the local population in areas such as energy transition or sustainability at large, etc.). This could be partly overcome, for instance, by new research that focuses, explicitly, on valuing specific investments in clean technologies, infrastructure and expenses on innovation and R&D activities by O&G companies with a view to estimate the environmental and economic returns of sustainability strategies.

Further research may focus on applying the analysis framework and the "pyramidal view" concept to companies with different profiles or to compare the sustainability strategies across companies (and even across sectors), with the aim of identifying the factors of success and efficient ways to increase sustainability outcomes.

Further, understanding how local innovation ecosystems are created and evolve around O&G companies undergoing structural changes in their strategies may help to design more effective innovation and industrial policies and new channels and models of public–private and private–private collaboration conducive to improved environmental, economic and social outcomes. This could be done, for instance, by assessing the sustainability strategy of the Company under the prism of the creating shared value (CSV) theory [45], specifically seeking to assess, in the context of the local multi-stakeholder ecosystem, how markets, products and services are redefined, how productivity improves along value chains and how local clusters are fostered through innovation and R&D activities focusing on sustainability, for instance. The findings in this paper can be related to these three dimensions of CSV. According to the original proponents of CSV, this gives way to superseding corporate social responsibility (CSR) by broadening the connection between business and society, particularly in relation to the local population. While this article focuses on a case study in a developed country (Spain), applying a CSV perspective to evaluate the strategies of oil companies can have promising implications, particularly for integrated oil majors operating in emerging economies.

Additionally, analyzing in detail how new business models may be created and deployed in the context of the Company's sustainability activities under the light of sustainable business model archetypes (SBMAs) [46–48] could illustrate new ways to improve environmental, economic and social outcomes at the local level.

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