Best practices to mitigate CO_2 operational emissions: A case study of the Basque Country energy ecosystem[*]

This work reviews the best practices to reduce CO_2 emissions in energy intensive organizations and energy value-chains by highlighting the synergy that can be built with like-minded organizations via collaborations; taking the Basque Country as a case study. An academic review covers how corporate strategies are attempting to curtail emissions in a systematic manner. The study is then complimented by findings obtained from interviews of key stakeholders in the Basque Country responsible for playing an important role in implementing a green agenda. The interviews allow us to highlight flagship projects and assess the collaborative framework strengths and challenges. Results indicate that organizations are well underway in implementing and researching low carbon solutions, but issues surrounding governance, strategy, and regulatory challenges can slow progress of goals.

Este trabajo resume las mejores prácticas en reducción de CO_2 en organizaciones con una gran huella de carbono y su respectiva cadena de valor al resaltar la sinergia que se puede dar a través de colaboraciones; utilizando como caso de estudio al País Vasco. El resumen detalla estrategias corporativas para reducir emisiones de una forma sistemática. El trabajo es complementado resaltando las perspectivas obtenidas por medio de entrevistas con actores clave en el País Vasco responsables de implementar una agenda verde. Las entrevistas mencionan proyectos primordiales y enfatizan las fortalezas y retos del trabajo en colaboración. Los resultados indican que las organizaciones están avanzando en implementar sus iniciativas, pero aspectos de gestión, estrategia y regulación pueden dificultar el lograr objetivos.

Lan honek laburbiltzen ditu karbono-aztarna handia uzten duten erakundeetan CO2 murrizteko egin beharreko jardunbide onenak eta euren balio-katea, lankidetzaren bidez eman daitekeen sinergia nabarmentzen baitu; eta Euskal Autonomia Erkidegoa azterketa-kasu gisa erabiltzen da. Laburpenak isurketak sistematikoki murrizteko estrategia korporatiboak zehazten ditu. Lana osatzeko, agenda berde bat ezartzeko ardura duten Euskal Autonomia Erkidegoko funtsezko aktoreekin egindako elkarrizketen bidez lortutako perspektibak nabarmendu behar dira. Elkarrizketetan funtsezko proiektuak aipatzen dira eta elkarlanaren indarguneak eta erronkak nabarmentzen dira. Emaitzen arabera, erakundeak aurrera egiten ari dira beren ekimenak ezartzen, baina kudeaketa-, estrategia- eta erregulazio-alderdiek helburuak lortzea zaildu dezakete.

* Spanish version available at https:/euskadi.eus/ekonomiaz.

Salvador Acha
Aitor Soler
Nilay Shah
Imperial College London

Table of contents

1. Introduction
2. Literature review in sustainability best practices
3. The Basque Country energy ecosystem case study
4. Results of the Basque Country case study
5. Conclusion

Appendix
References

Keywords: carbon mitigation, decarbonisation, environmental policy, low carbon technologies, sustainability best practice.

Palabras clave: descarbonización, mejores prácticas medioambientales, políticas medioambientales, reducción de carbono, tecnologías bajas en emisiones.

JEL codes: Q20, Q28, Q30

Entry date: 2020/11/19 Acceptance date: 2021/02/23

Acknowledgements: This research was supported by funds provided by Imperial College London. We would also like to acknowledge the time and support the following organizations offered during the research of this work: EVE, Spri Group, Diputación Foral de Bizkaia, Iberdrola, Petronor, Velatia-Ormazabal Group, Gestamp, Cluster de Energia, Ibil, Orkestra, and BC3.

1. INTRODUCTION

Carbon intensive organizations have the imperative need to decarbonise and implement best practices in their day to day operations. The United Nations Framework Convention on Climate Change (UNFCCC) in 2015 managed to agree a landmark climate pledge to combat global warming. 195 countries signed the Paris Climate Agreement at COP21, aiming to limit global temperature increase to 2 °C, relative to pre-industrial temperatures (United Nations Climate Change, 2016). This legally binding global climate change accord aiming to strengthen countries' ability to deal with the impacts of climate change and support them in their efforts is creating shockwaves across carbon management concepts and strategies for both profit and non-profit organizations (Zhou, 2020). COP21 has accelerated the transition to a low-carbon economy, across all sectors, but particularly within energy intensive organisations who are becoming more transparent and meticulous in their greenhouse gas (GHG) emissions reporting as exemplified in the Carbon Disclosure Project (CDP) initiative (CDP, 2020).

Meanwhile, almost 500 companies have already committed to implementing science-based targets, this initiative supports organisations in counteracting political short-termism by setting a glidepath towards long-term emissions reduction. Science based targets are in line with the level of decarbonisation set by climate science while future-proofing growth, as described in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) (Science Based Targets, 2017). Furthermore, a handful of countries have showed leadership and set a net-zero target by law (*e.g.* Denmark, France, New Zealand, Sweden, and the UK); making these nations climate targets fully aligned to COP21.

The advantages of setting ambitious environmental targets is that leading companies and governments will collaborate in developing innovation in sustainable energy generation and supply solutions while also evaluating policies that support their implementation (Rissman *et al.*, 2020). Solutions from the supply-side can range from low-carbon electrification, bioenergy, synthetic fuels, carbon capture, and zero-carbon hydrogen. Alternatively, important demand-side mitigation options include championing energy efficiency, on-site energy generation, the replacement of high-carbon materials for low-carbon materials and circular economy practices. A combination of all these solutions should ensure the competitiveness of key industries in a future where governmental policies will most likely set carbon pricing and energy efficiency standards, while achieving net zero emissions in the required timeframe set by the Paris agreement without sacrificing human and economic development (Hickel, 2020).

Although organizations have environmental targets, they all have their own business models and have the desire to be financially viable well into the future. Therefore, increasing profitability or reducing operational costs are key objectives in any organization. This financial goal consequently needs to be aligned with carbon management business drivers, such as innovation, stakeholder value, and future-proofing supply-chain risks. This combination of factors should create a virtuous cycle in the organization proactively seeking cost-effective ways to reduce carbon emissions and in turn defeat short-termism and uncertainty avoidance that results in sustainability inaction (Slawinski *et al.*, 2017).

Although nations are slowly enacting climate legislation for-profit organizations are moving faster to adapt and change their business practices in which sustainability is at the core of their decision-making. For instance, «big brand» carbon intensive organizations such as Amazon (Amazon, 2020), Microsoft (Microsoft, 2020), Repsol

(Repsol, 2020a), among many others are making pledges to become net zero in operations in the coming decades by 2050. As organisations from all economic sectors make zero carbon pledges, their corporate energy policies will face substantial challenges in undertaking cost-effective investments that both align in delivering value to shareholders but keep them on-track to meet their sustainability targets (Finnerty *et al.*, 2018).

Developing comprehensive tools to devise optimal investment strategies to mitigate GHG emissions is not straightforward and requires abundant knowledge of the activities and systems that originate the carbon and the technologies or measures that can address them (Ayoub *et al.*, 2020). However, unless organizations have specific expertise and extensive financial resources, most will lack in-house expertise for adequate decision-making to make informed decisions on how best to address their sustainability challenges (Campbell-Árvai *et al.*, 2019). The power of partnerships and collaboration is key to drive innovation and accelerate the transition towards a low carbon economy.

Implementing the solutions for a cost-effective transition towards a low carbon economy is not straightforward and this paper attempts to summarise and portray the best practices in decarbonisation and sustainability initiatives to help us become net zero. Emphasis is given to corporate carbon strategies and decarbonisation pathways. These best practices are then complimented by depicting the collaborative approach and initiatives a progressive ecosystem of organisations in the Basque Country are taking to mitigate carbon emissions. This paper allows key stakeholders to become aware on a range of sustainability best practices but also allows them to gain clarity on productive collaborative frameworks as they undertake tangible actions towards sustainable operations. The questions this paper is trying to answer is identifying the best practices being applied in the Basque Country in terms of solutions and collaborative vehicles, highlighting the strengths and challenges.

This paper is structured as follows. Section 2 provides a literature review covering sustainability best practices that organizations need to consider driving effective environmental change. Section 3 gives context to the Basque Country innovation ecosystem and explains the interview approach undertaken to inform the case study. Section 4 presents the results obtained from the interviews and discusses them against the findings from the literature review. Lastly, Section 5, offers concluding remarks from this work.

2. LITERATURE REVIEW IN SUSTAINABILITY BEST PRACTICES

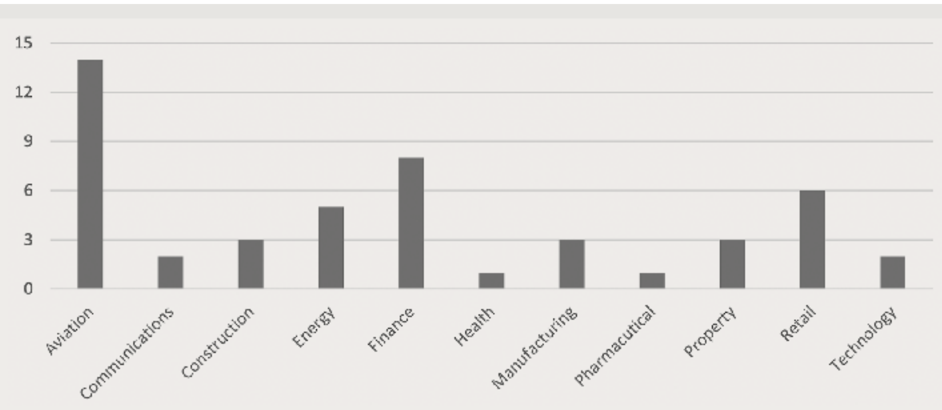
The process consisted in identifying key literature from 2016 onwards, after the Paris Climate Agreement had been signed to list the progress and innovation that has occurred in the last few years. Peer reviewed literature on corporate energy strategies to achieve carbon emissions reductions is not abundant, especially depicting holistic long-term approaches. In a similar fashion a literature review of technology solutions that are supporting the transition towards a low carbon economy was investigated. Thus, the literature review focused on summarising progress in the following areas regarding «carbon strategies in organizations”:

- Net zero pledges;
- Governance;
- Mitigation approaches;
- Energy management;
- Energy policy post Covid-19;
- Fostering R&D;
- Decarbonization solutions.

2.1. **Net zero pledges**

Net zero refers to achieving a balance between the amount of greenhouse gas emissions produced and the amount removed from the atmosphere. There are two different routes to achieving net zero, which work in tandem: a) reducing existing emissions and b) actively removing greenhouse gases (Institute for Government, 2020). Targets are indeed ambitious and due to the intrinsic differences of the economic sectors companies operate in, the solutions will vary for each organization, however tangible progress is mandatory, and it must also stand up to scrutiny. The journey of how a company gets to net zero is just as important as simply getting there. As of May 2020, a diverse group of 50 companies have officially announced their net zero ambitions by 2050 (at the latest) and have started to align their strategy and brand accordingly.

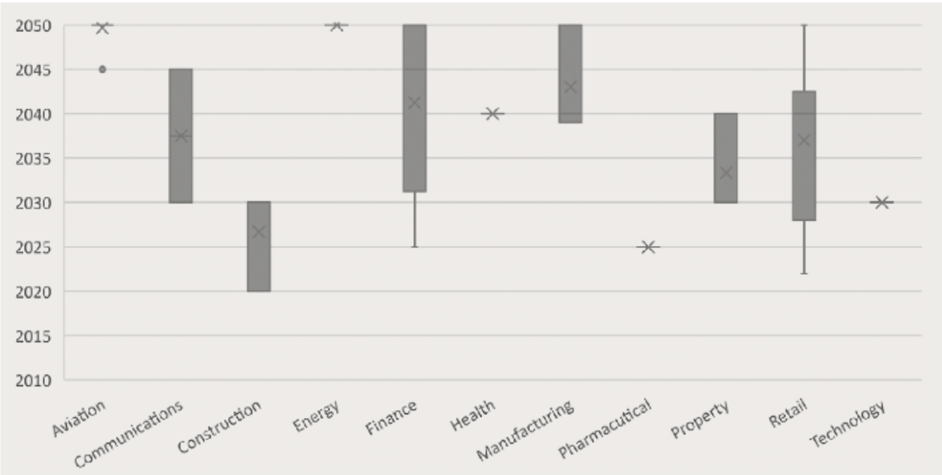
Figure 1. **NUMBER OF NET ZERO PLEDGES FROM COMPANIES BY ECONOMIC SECTOR**



Source: Carbon Intelligence, 2020.

However, there is a race to reach net zero as quickly as possible and some organizations are showing a great degree of ambition, see Figures 1 and 2 illustrating how net zero pledges vary by economic sector (Carbon Intelligence, 2020). Mace, a construction company stands out as committing to net zero by 2020 via energy efficiency and by offsetting all outstanding emissions (Mace, 2020). Also, it is worth highlighting some organizations such as Microsoft and AstraZeneca have gone a step further and committed to become carbon negative. Whichever target is established, setting a net zero target implies a business needs to do exhaustive work across its business units to develop a clear roadmap and governance structure that produces a credible and cost-effective pathway to reduce its GHG emissions. As Figure 2 indicates companies are taking an ambitious and proactive approach to the challenge and most of them are hoping to meet their environmental targets well before 2050.

Figure 2. **NET ZERO TARGET YEAR SET BY COMPANIES IN VARIOUS ECONOMIC SECTORS**



Source: Carbon Intelligence, 2020.

2.2. **Governance**

Carbon governance refers to an organization's managerial capabilities of dealing with risks and opportunities related to climate change mitigation and resulting governance mechanisms. Carbon governance can be broken down into various corporate activities that need to be championed by institutions; however, the following are deemed the most important to convert wishful thinking into reality (Caritte *et al.*, 2015):

- Organizational involvement: A company can assign roles and responsibilities for climate change issues to staff at different organizational levels, shifting the culture to raise awareness about climate change and to promote climate-friendly behaviour, offer monetary and non-monetary incentives and engage employees in innovation processes for emission reductions (Damert & Baumgartner, 2017);

- Alignment of incentives: Despite increasing pressure to deal with climate change, firms are usually slow to respond with effective action because of excessive short-termism and avoidance of risk or uncertainty due to corporate culture and regulatory inadequacy. In the short run, such decisions are generally not consistent with executive incentives and generally regarded as not maximizing profits. Therefore, firms need to incentivise boards, directors, and managers so they align their sustainability strategy to increase the long-term value of the companies they lead (Aggarwal & Dow, 2012).

2.3. **Carbon mitigation approaches**

There are two elements to a net zero pathway: a reductions pathway and a removals pathway. Organizations should not become complacent and try to implement both approaches in parallel, but the priority should be on the reduction pathway. The carbon mitigation approaches can be grouped into four categories (Carbon Intelligence, 2020):

- Decarbonization: Reducing emissions on an absolute basis through efficiency improvements or via low carbon solutions (*e.g.* converting to renewables) with regards to the sourcing, management, and disposal of resources;
- Removals: Balancing remaining emissions by sequestering carbon through activities that happen within the value-chain of the company;
- Carbon credits: Balancing emissions with carbon credits from carbon removal projects or carbon avoidance projects;
- Avoided emissions: Balancing emissions with emissions avoided by selling products or services.

The carbon mitigation approach championed by organizations needs to be transformational. This principle implies that the approach followed by a company to reach net zero emissions should inform long-term strategies and investments while also providing certainty to investors, and other stakeholders, that the business model of the company will continue to be viable in a net zero carbon economy. This means companies need to build a strategy and pipeline of projects to inform their investment programme for carbon reduction or removal. To meet this pressing requirement novel modelling frameworks are being proposed by the research community; providing a blueprint to enable organizations to develop their bespoke low carbon roadmap strategies. Ayoub *et al.* (2020) presents a reductions pathway modelling framework to develop cost-effective decarbonisation investment programs that address electricity and heat carbon emissions in organisations with multiple properties by 2050. Similarly, Hart *et al.* introduces a data-driven modelling framework for optimal investment strategies supporting the food retail industry to transition from hydrofluorocarbon (HFC) refrigeration systems to lower GWP systems by 2030, in line with EU legislation (Hart *et al.*, 2020). Works such as these offer valuable insights into some of the complexities and techno-economic attributes low carbon roadmaps require to meet the scrutiny of key decision-makers.

2.4. **Energy management practices**

Implementing best energy management practices is pivotal in the global agenda to improve energy performance and GHG reduction in organizations. Organizational processes and actions in energy and environmental management can be comprised of two key areas that improve business competitiveness: strategy and operations (ISO, 2020).

Naturally, there are barriers that even the most proactive and engaged organizations need to face and overcome to implement effective energy management practices. Researchers have published extensively in this field and their reviews suggest the following barriers are the most common in industry (Finnerty *et al.*, 2018):

- Low availability of capital: Due to a lack of vision or a different order of priorities organizations do not allocate sufficient resources to energy related investments as they might deem them too risky or with a low return on investment;
- Risk of disruption in production or trading activities: The threat of a loss in revenues from implementing an energy related project can derail promising initiatives;
- Lack of support: A lack support from regulation to incentivise consumers via policy mechanisms to champion energy efficiency and reduce GHG emissions can slow down innovation.

2.5. **Energy policy post Covid-19**

Naturally, companies do not act in a vacuum and require the support from governments via progressive policies to enable them to implement carbon mitigation solutions. In May 2020 over 150 global companies aligned to Science Based Targets urged world leaders for a net-zero recovery from Covid-19 (Science Based Targets, 2020). Ignacio Galán, Chairman & CEO, Iberdrola, said: «The world must be united to tackle the current health crisis. And, as we emerge from this crisis, we must focus economic recovery on activities aligned with key priorities, such as the fight against climate change, and reactivating economic activity and employment quickly and sustainably. Pursuing environmental sustainability will be essential for long-term economic recovery.» The statement comes as governments around the world are preparing financial stimulus packages to help economies recover from the impacts of the Covid-19 pandemic, and as they prepare to submit enhanced national climate plans under the Paris Agreement.

The IEA recently stated: «Covid-19 does not change the elements of the net-zero emissions innovation policy package, but some of the elements deserve immediate attention as governments prepare policies to repair, stimulate and recover economic activity. The central role of government in supporting energy innovation is well established, especially in relation to the public good nature of R&D and tackling the greenhouse gas externality is widely agreed to need strong government action over the coming decades. Energy innovation offers an opportunity to boost economic activity damaged by the Covid-19 pandemic and at the same time to help with the transition to net-zero emissions.» In other words, a lack of investment in energy innovation and sustainable transitions would have grave consequences and complicate meeting the Paris Climate Agreement (IEA, 2020). Table 1 depicts the IEA recommendations to foster both short-term and long-term investment in sustainable solutions across the developed and developing countries.

Table 1. **POLICY ACTIONS FOR A SUSTAINABLE ENERGY RECOVERY POST COVID-19**

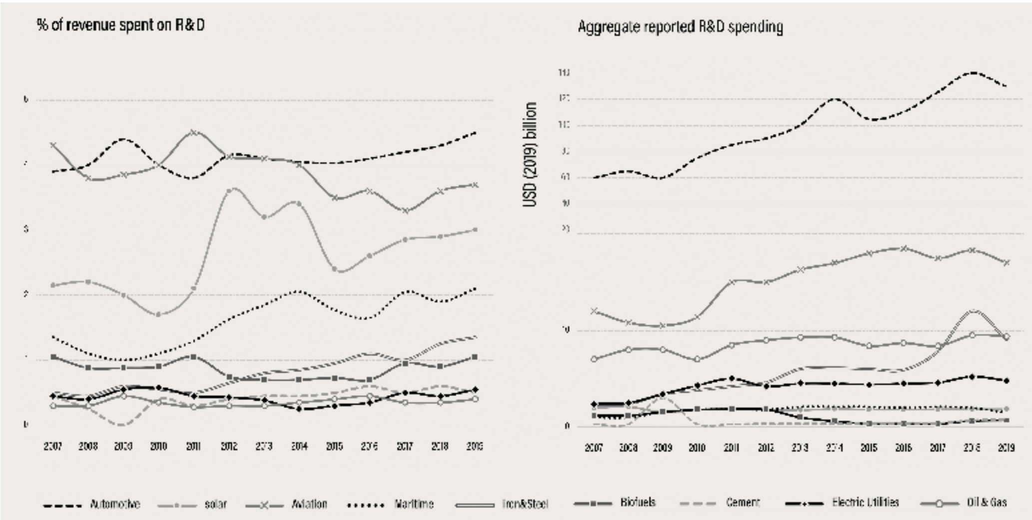
Sector	Measure
Buildings	– Implement large-scale retrofit programmes for public buildings, provide subsidised financing for private retrofits. – Implement appliance turnover schemes to replace inefficient appliances, install heat pumps and renewable energy systems that use solar water heaters and biomass boilers. – Support clean cooking access by offering modern stoves, and developing advanced biomass and liquefied petroleum gases delivery systems.
Transport	– Implement vehicle turnover schemes to accelerate efficient car and electric vehicle adoption. – Boost high-speed rail and incentivise the purchase of new efficient trucks, airplanes and ships. – Accelerate deployment of recharging networks for electric vehicles, upgrade public transport, and improve walking and cycling infrastructure.
Industry	– Incentivise industrial energy efficiency, especially light-industry electric motor and process heat pumps upgrades. – Improve waste collection and recyclable material recovery rates, especially where waste collection processes are informal. – Upgrade to efficient agricultural pumps.
Electricity	– Invest in electricity network upgrades, particularly distribution system strengthening and modernisation. – De-risk and fast-track new wind and solar PV deployment. – Extend lifetimes for nuclear plants near their end of life and repower existing hydropower facilities.
Fuels	– Support for biofuel industries if they meet appropriate sustainability criteria. – Implement methane leak detection programmes to address fugitive methane from upstream oil and gas operations. – Reform inefficient fossil fuel subsidies without increasing end-use prices.

Source: IEA, 2020.

2.6. **Fostering R&D**

Companies active in renewable energy technologies have increased their R&D spending faster than other energy technology sector companies: they increased their expenditure on R&D by 74% between 2010 and 2019, adding over USD 2.5 billion to efforts to improve their technologies. Companies have continued to increase their spending in recent years, with government policies and competitive pressures leading them to focus more on energy efficiency and electric vehicles, as illustrated in Figure 3 by the analysis made by the IEA depicting R&D spending in key energy sectors. Other sectors – notably cement, biofuels, electric utilities, and iron and steel – invest much less in R&D as a proportion of their revenue. Electric utilities and heavy industrial companies are generally consumers of technology, typically engaging in technology development via partnerships with suppliers.

Figure 3. **GLOBAL CORPORATE R&D SPENDING BY SECTOR FROM 2007 TO 2019**



Source: IEA, 2020.

2.7. **Decarbonization solutions**

A variety of low carbon technologies, product design choices, and operational approaches can rapidly and cost-effectively reduce energy consumption and GHG emissions across a broad range of industries (Kramer & Haigh, 2009). Furthermore, all these technologies and interventions can be enhanced by integrated systems design. So very large reductions in industrial GHG emissions are possible by focusing on a limited set of product and process improvements. This section presents a brief overview of the solutions and developments that are expected to enable viable solutions by 2050; both on the supply side and on the demand side – outlined in Table 2. These solutions need to be supported by strategic, well-designed policies that accelerate innovation and provide incentives for technology deployment (Griffin & Hammond, 2019). High-value policies include carbon pricing with border adjustments or other price signals; robust government support for research, development, and deployment; and energy efficiency or emissions standards (Rissman *et al.*, 2020). Technologies will likely be deployed in waves, with demand-side interventions and already commercialized efficiency technologies dominating through 2035, structural shifts becoming more pronounced from 2030–2050, and nascent technologies such as hydrogen becoming important thereafter.

Table 2. **SOLUTIONS FOR CARBON MITIGATION EXPECTED BY 2050**

Theme	Key solutions for carbon mitigation
Supply-side: Materials and carbon capture	– Reduce process emissions from cement. – Reduce thermal fuel-related emissions from cement. – Reduce carbon emissions from steel production. – New chemical production technologies avoiding fossil fuels. – Use of biomass feedstocks and recycled chemicals. – Biomass and hydrogen value-chains. – Reuse of CO2 for chemicals production. – Chemical separations. – Carbon capture and storage (CCS/CCU) to address residual CO2. – Retrofit of buildings to passive house level.
Supply-side: Energy	– Renewable energy generation via wind, solar, tidal, and geothermal power. – Energy generation from waste resources (AD), biogas, biomass, and biomethane. – Efficient steam and heat recovery processes. – Electrification of key services such as heating and transport. – Integrated distributed energy systems for local energy districts supporting heating, cooling, and transport. – Zero carbon hydrogen production and use. – Sustainable production of ammonia, methane, and methanol.
Demand-side: Interventions	– Improvements in energy efficiency for heating, cooling, and other services in industry, commercial and domestic buildings. – Implementing advanced control strategies to shift demand using dynamic energy prices and weather forecasts. – Machine learning applications for energy efficiency and controls. – Replacement of fossil fuel transportation systems. – Additive manufacturing for industry 4.0 (3D Printing). – Low embodied carbon materials. – Circular economy practices: longevity, transfer, refurbish, recycle.

Sources: (Acha, 2013), (Acha, 2013), (Delangle *et al.*, 2017), (Efstratiadi *et al.*, 2019), (Chakrabarti *et al.*, 2019), x (Bustos *et al.*, 2014), (Bustos *et al.*, 2015), (Bustos *et al.*, 2016), (Langshaw *et al.*, 2020), (Acha *et al.*, 2016), (Gonzato *et al.*, 2019), (Cedillos *et al.*, 2016), (Mariaud *et al.*, 2017), (Acha *et al.*, 2018), (O'Dwyer *et al.*, 2019), (Olympios *et al.*, 2020), (Rissman *et al.*, 2020), (Sunny *et al.*, 2020), (Tapia *et al.*, 2019), (Sarabia *et al.*, 2019), (Maouris *et al.*, 2019), (Acha *et al.*, 2020).

3. THE BASQUE COUNTRY ENERGY ECOSYSTEM CASE STUDY

This section depicts the different players and collaboration vehicles that have made the Basque Country a leading industrial European hub and explains the interview approach undertaken to implement carbon mitigation initiatives and their collaborative framework.

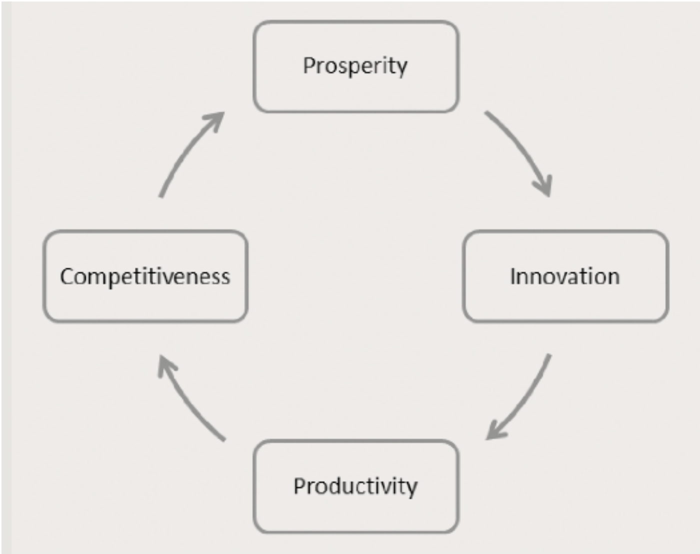
3.1. Basque Country entrepreneurial ecosystem

After a struggling economic period with high unemployment and low productivity in the 1970s and 1980s, due to an outdated manufacturing and industrial sector, the Basque Country reinvented itself in the 1990s by setting up technology clusters and industrial parks sparking innovation and knowledge creation that made the most of their strong engineering know-how (Grupo SPRI Taldea, 2020a). This refocus was derived from strategic technology planning devised by government, industry, and chamber of commerce experts. By frequently reviewing the technology plan, goals are closely aligned in their effort to maximise economic potential for the region, creating a win-win situation for business growth, employment, and societal well-being.

As depicted in Figure 4, the entrepreneurial ecosystem thrives on enhancing innovation capabilities to power productivity and competitiveness which results in prosperity. Competitiveness ultimately depends on improving the microeconomic capability of the economy and the sophistication of local competition (Pressman, 1991). This policy framework over the years has yielded economic growth and aided Basque companies' in becoming important players in key sectors such as energy (*e.g.* Iberdrola, Petronor, Velatia Ormazabal), telecommunications (*e.g.* Euskaltel), manufacturing (*e.g.* Gestamp, Siemens-Gamesa), and aeronautics (*e.g.* ITP). These strategic technology plans have been complimented by bespoke policy that supports their implementation and consist of the following elements:

- Basque Economic Agreement featuring autonomy in financing, taxation, and policy (Bizkaia Foru Aldundia Diputación Foral, 2020);
- Integrated and balanced structure;
- Adaptable to economic conditions;
- Strong support in spurring industry development;
- Industrial ecosystem with a focus on R&D, clusters, financing, and entrepreneurship;
- Long-standing policy support through tax incentives for business investment;
- Ongoing public-private collaboration.

Figure 4. **DETERMINANTS OF COMPETITIVE ADVANTAGE OF INDUSTRIES**



Source: Pressman (1991).

3.2. **Basque Country energy stakeholders**

The SPRI Group at the Development and Infrastructure Department of the Basque Government has been a key pillar in driving the technology plans and helping companies obtain access to resources so they can innovate and stay at the forefront in their sectors (Grupo SPRI Taldea, 2020b). The SPRI Group coordinates 22 clusters in the Basque Country, facilitating communication of their action plans with hundreds of profit and non-profit organizations. The evolution of these clusters has seen its actions oriented towards the gradual development of the pyramid of cooperation on their strategic areas of action. Its goal is to promote cooperation between its members in addressing the strategic challenges of each cluster with a preferred approach of strengthening SMEs. This cluster support across areas such as energy, advanced manufacturing, automotive, and aeronautics is pivotal in driving competitive advantage.

In particular, the Basque Energy Cluster is made up of the leading companies in the energy sector located in the Basque Country (*i.e.* energy operators, component and equipment manufacturers), agents of the Basque Science, Technology and Innovation Network and public administration bodies involved in the energy field (Cluster Energia, 2019). The Cluster is a non-profit organisation which was set up at the end of 1996 within the framework of the Basque Government's policy to foster the competitiveness of the industrial sector. It is currently made up of over 160 companies and entities active in the energy sector leveraging its ability to invigorate partnerships and promote the visibility of the sector both locally and internationally.

Members belong to five major groups:

- *Driver companies* defined as end-users and potential clients that steer solutions;
- *Large enterprises* are businesses of a significant size withing the value-chain and R&D capacity;
- *SMEs* are small companies and start-ups championing innovation and seeking growth;
- *Knowledge agents* are organizations either in academia or research centres that can provide know-how and independence to advances in research and specialised training;
- *Government agencies* with the role of supporting the cluster (*e.g.* EVE, SPRI, etc.).

In its most recent technology plan «EnergiBasque» detailing the industrial development and technology strategy of the «Energy Cluster» the following strategic areas have been highlighted: a) wind power, b) solar power, c) wave power; d) oil and gas, e) smart grids, f) electromobility, and g) energy efficiency and advanced energy services. These areas cover the whole value-chain (*i.e.* generation, transport and distribution, and consumption) and the latest technologies championing digitalisation, circular economy, and materials, etc. The strategy is implemented via working groups which are formed from a small group of businesses/agents interested in developing initiatives or projects in cooperation with others in response to seeking shared challenge.

3.3. **Interview approach and themes discussed**

Through a set of comprehensive interviews from key stakeholders driving best practices in the Basque Country energy value-chain perspectives have been captured and synthesised. These interactions allow us to outline the plans, challenges and initiatives organizations are facing to support the transition towards a low carbon economy; either by reducing their own carbon footprint or by providing services or products to energy intensive end-users or sectors. Findings from the interviews allow us to identify the problems being faced on the ground by stakeholders as they pursue a green agenda, while also highlighting the collaborative frameworks they embark upon as they seek to unlock know-how via collaborations. Understanding what drives the collaborative process and the value it provides has the purpose of exemplifying how healthy ecosystems can thrive.

Figure 5 depicts some of the most representative organizations in the Basque Country energy ecosystem. Core findings from the interviews present the diversity of thought and approaches or initiatives being devised for a quicker progression in carbon mitigation solutions. Emphasis is given to their respective perspectives while also highlighting the benefits partnerships and collaborations provide under a cluster framework. The stakeholders interviewed fall under the following categories:

- Energy agencies, the energy cluster, and other government bodies;
- Energy generation and supply companies;
- Energy infrastructure and service providers and SMEs;
- Research centres and universities.

Due to the challenging conditions derived from Covid-19 all interviews conducted were done remotely via videoconference. The set of interviews conducted with over 10 organizations in the Basque Country have the goal of depicting the findings from open and inclusive discussions that portray the narratives and distinct perspective each stakeholder faces. All the interviews followed a similar structure but were slightly adapted to understand the viewpoint of each stakeholder. The themes discussed in the interview were posed as open-ended questions covering the following subjects:

- Role of organizations in the sustainability transition;
- A perspective of the challenges being faced by industry;
- Sustainable flagship projects in the energy value-chain;
- The collaborative ecosystem in the Basque Country.

Figure 5. **ORGANIZATIONS OF THE BASQUE COUNTRY ENERGY ECOSYSTEM**

Source: Own elaboration.

4. RESULTS OF THE BASQUE COUNTRY CASE STUDY

The findings from the interviews portray the perspectives of each stakeholder and are presented under distinct themes. The role organizations have in the sustainability transition is discussed first, followed by flagship projects being undertaken. After these aspects are detailed a summary section highlights areas of strength and opportunity, while a discussion sections gives further thoughts on how the Basque Country energy ecosystem can take learnings from actions occurring abroad.

4.1. Role of organizations in the sustainability transition

The Basque Country energy ecosystem relies on key organizations that have acted as pillars thanks to the backing from the Basque Government despite the political cycles every few years.

At its core, the Basque Energy Agency (EVE) coordinates with the Basque Government and is responsible for laying the foundations of the energy strategies and policies of the territory with an emphasis on energy efficiency, uptake of renewables, smarter infrastructure, demand side management, distributed generation, and electromobility as well as playing a major role in supporting sustainability projects where public involvement may be required. One of the biggest virtues of EVE is that it funds its activities through the revenues generated in the projects it undertakes with companies. EVE by acting as an anchor to facilitate the execution of innovative projects provides a solid springboard so private organizations can develop new business energy models. Once these public-private partnerships grow, mature, and become sustainable is the moment at which EVE exits the venture and sells its stake.

EVE is supported by organizations that enact and support their agenda. As described in Section 3, the SPRI Group and the Energy Cluster are two key organizations that attempt to support private organizations to strengthen their competitive advantage by funding or supporting activities that enhances their know-how. SPRI seeks to help companies align their activities to sustainable best practices, shifting their corporate strategy to a «green agenda», while also helping them to gain exposure at an international level. But most important of all, SPRI has a priority to foster collaboration between large companies (*e.g.* Iberdrola) and SMEs/start-ups who seek to shake-up the industry. Through these activities the SPRI Group attracts companies to sign-up to the Energy Cluster and makes them appreciate the benefits from collaboration. The Energy Cluster is then responsible to support its members in funding calls and other collaborative opportunities so SMEs, start-ups, and research-oriented organizations can enhance their business models and become fully fledged business. By obtaining funds to undertake activities the stakeholders and knowledge ecosystem benefit by invigorating the sector, developing know-how, and improving their internationalisation prospects.

Another noteworthy mention supporting EVE in its sustainability mission is the Ihobe organization. Ihobe is a public company of the Basque Government, supporting the Ministry of Economic Development, Sustainability and Environment by implementing environmental policy and in collaborating with stakeholders to drive the sustainability agenda in private and public organizations; effectively establishing a network of alliances (Ihobe, 2020).

From a more autonomous viewpoint, it is worth highlighting the three territorial provinces of the Basque Country (Araba, Bizkaia, and Gipuzkoa) are committed to the EVEs strategy through its various public institutions and municipalities by enacting the «Sustainable Energy» law (Eusko Jaurlaritza – Gobierno Vasco, 2019). This law sets the tone and mandatory actions for public facilities and public transport units to be audited and pushes them to make concise efforts to reduce their demand, transition to electric fleets, and source 100% of their energy via green PPAs. Such a regulation inadvertently creates a market for low carbon solutions. Table 3 details the role of the private industry in supporting the sustainable transitions.

Table 3. **ROLE OF PRIVATE ORGANIZATIONS IN THE SUSTAINABILITY TRANSITION OF THE BASQUE COUNTRY**

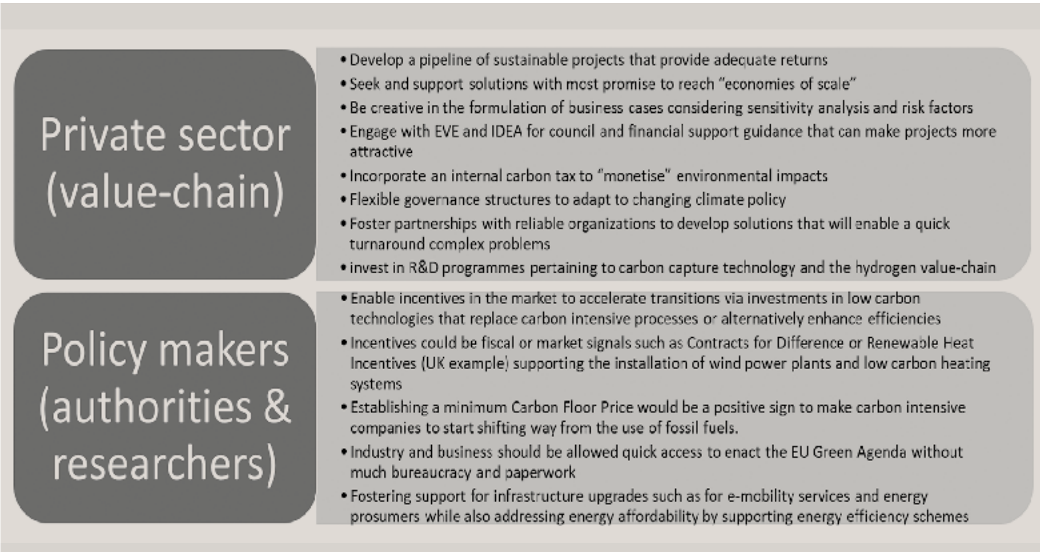
Sector	Measure
Energy suppliers	– Decarbonise operations and energy provision to customers by 2050. – Investment in renewable technologies such as wind power, photo-voltaic (PV) and photo-voltaic thermal (PVT) systems. – Support R&D in green hydrogen, biomethane, and synthetic fuel projects. – If fossil fuel is still to be used, employing CCS and CCU technology will be pursued to secure the carbon emissions are contained.
Energy service providers	– Provide services that are zero carbon by fulfilling the potential of digital services while reducing the carbon footprint associated to products in their supply-chain.
Consultancy firms	– Guide and enable customers to align their sustainability strategies with effective solutions and financing opportunities to foster such change.
SMEs	– Play a catalyst role in their niche market they are trying to address be it smart grids, electromobility, or renewable energy projects, etc.
Consumers	– Although have not committed to net zero yet, they are working on robust frameworks that facilitates them to reduce their carbon footprint. These actions include championing operational excellence, setting ISO 14001 standards and goals aligned to the UN 2030 Agenda for Sustainable Development and the European Green Deal.
Research centres	– Committed to a collaborative relationship with industry and government; sharing a technological strategy to achieve the highest value-adding proposals/funding and know-how to boost competitiveness and benefit society via educational, publications, and/or R&D activities.

Sources: (Gestamp, 2019), (Vidrala, 2019), (BC3, 2020), (Orkestra, 2020), (Fundacion Tecnalia Research and Innovation, 2018).

4.2. **A perspective of the challenges being faced by industry**

The challenges are many. From government agencies and public bodies, the main task is keeping the collaboration ethos fluid, dynamic, and moving forward despite the economic difficulties Covid-19 brings to the budgets of public organizations and private companies. For instance, EVE continues to evaluate innovative projects and is considering which ones are worth embarking upon. In addition, EVE is making sure the 3E2030 plan is progressing adequately in terms of energy efficiency and renewable energy goals and is currently in discussions to devise a more ambitious plan aligned to Paris Climate Accord. Meanwhile, SPRI is actively working on supporting its clusters under the pandemic storm, while driving the «EnergiBasque» agenda that is supporting the development of competitive industries: a) wind power, b) solar power, c) wave power; d) oil and gas, e) smart grids, f) electromobility, and g) energy efficiency and advanced energy services. Furthermore, SPRI is also supporting efforts in biosciences and industry 4.0 activities. Naturally, SMEs and start-ups are the ones which require more support and an opportunity can be made from the pandemic crisis with the momentum of the EU Green Agenda; developing cutting-edge energy products and/or services. Figure 6 lists some the issues that need to be addressed to foster a sustainable transition in the Basque Country energy ecosystem; these have been provided by industry and policy makers.

Figure 6. **LIST OF ACTIONS AND APPROACHES TO FOSTER A SUSTAINABLE ENERGY TRANSITION**



Source: own elaboration.

4.3. Sustainable flagship projects in the energy value-chain

There are many encouraging signs that the collaborative ecosystem in the Basque Country is yielding positive results. During the interviews key projects that are on-going or that are in the pipeline were outlined; most of these are available in the public domain. In this section we make mention of the most promising ones; summarised in Table 4.

Table 4. **COLLABORATIVE PROJECTS FOR CARBON MITIGATION BEING DEVELOPED BY ORGANIZATIONS IN THE BASQUE COUNTRY ENERGY ECOSYSTEM**

Project	Lead	Partners	Scope
Net zero emission fuels (Part 1)	Petronor	EVE, Aramco	One of the world's largest plants to manufacture net zero emissions fuels (e.g. synthetic), using CO2 captured and also producing green hydrogen with renewable energy.
Net zero emission fuels (Part 2)	Petronor	EVE, Aramco	Plant for generation of biogas and biomethane from urban waste which replaces traditional fuels used in Petronor's production process.
Green hydrogen	Iberdrola	Fertiberia	The hydrogen Puertollano plant (in south of Madrid) will consist of a 100 MW photovoltaic solar plant, a lithium-ion battery system with a storage capacity of 20 MWh and one of the largest electrolytic hydrogen production systems in the world (20 MW); a futuristic project requiring an investment of 150€ million. Fertiberia will update its ammonia plant to be able to use the green hydrogen produced to manufacture green fertilisers.
EV fast charging services	IBIL	EVE, Petronor	Example of how a public-private partnership has grown into a full-fledged business is the story of Ibil, an organization focused on facilitating a fast charging EV network and electromobility services. Ibil now has partnerships with Santander and collaborating on projects such as E-Via Flex-E, CIRVE.
AIGeCo	Petróleos del Norte	Ingeteam, IBIL, Basque Government, EU, Petronor, Euskaltel, Tecnalia, Izertis	Intelligent aggregator project to encourage active generation and demand participation. Local energy system value-chain R&D activities covering aggregation services, smart charging, power electronic devices and software development.

…/…

…/…

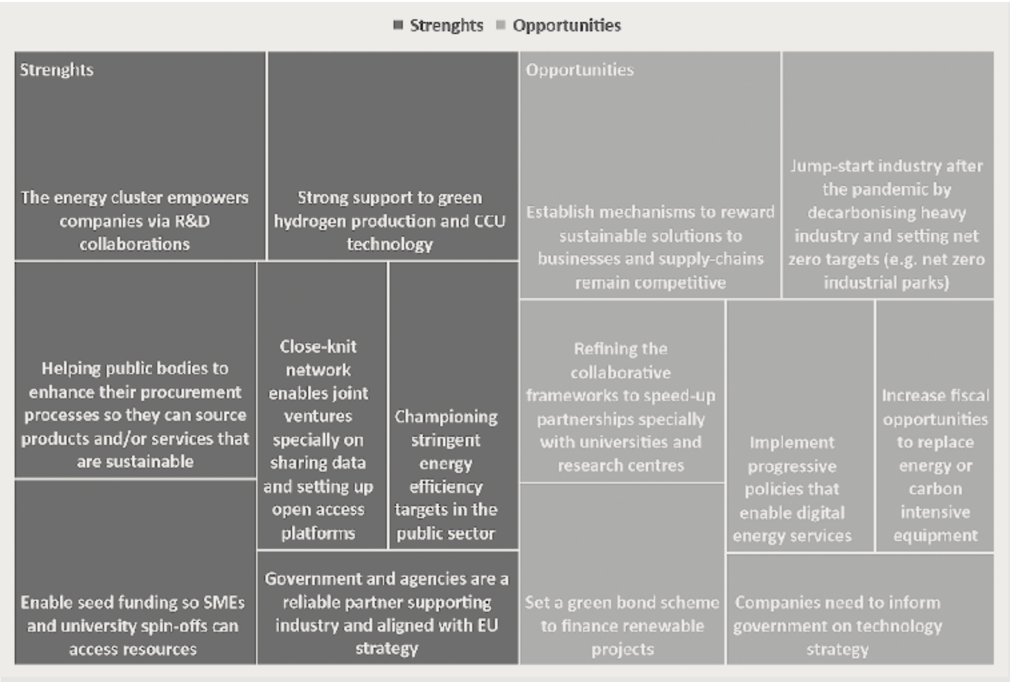
eMovLab	Petronor	Begas Motor, IBIL, Ingartek, Ingeteam, Ekide, Masermic, Ziv, Tecnalia, Energy Cluster	eMovLab has as its aim to conceptualise and develop innovative technologies and businesses, enabling Basque industry to adapt to future scenarios in sustainable mobility and energy. eMovLab has a budget of €5M and is funded by the Basque Government's Hazitek Programme, with support from the EU Regional Development Fund.
Basque Electrical Laboratories Alliance	Velatia-Ormazabal	Arteche, Tecnalia, Energy Cluster	This collaboration has the aim to do R&D and tests to improve the competitiveness of T&D equipment. Products developed will be certified and market ready for deployment.
Energy Intelligence Center (EIC)	Basque Government and Biscay Provincial Government	Iberdrola, Petronor, Siemens Gamesa, Sener, Ingeteam, Ormazabal, Arteche, Zigor, Cegasa, Solarpack	Public-private R&D hub that will specialize in innovative hydrogen, smart grid, wind generation and oil and gas technologies. Furthermore, industry 4.0 and advanced manufacturing concepts will be tested and developed.
Bidelek Sareak	Iberdrola Distribution	EVE, Velatia-Ormazabal, ZIV, Arteche, Tecnalia, Elecnor, Schneider Electric	This project aims to deploy Smart Grids in both cities and towns to increase the security and efficiency of the electric energy supply.
Territorial competitiveness (various)	Orkestra	SPRI, EVE, Iberdrola, Euskaltel, Petronor, Tecnalaia	Multidisciplinary projects between research and academic institutions to conduct studies influencing policy and informing about the nature of successful techno-economic and environmental transitions that promote economic growth and societal well-being.
Battery storage research	CIC energiGUNE	Energy cluster, Ingeteam, Solarpack	Multi-disciplinary research projects covering the value-chain of electrochemical and thermal energy storage systems as well as the power conversion and control devices that can enable their uptake.
Basque Research & Technology Alliance (BRTA)	Basque Network of Science	16 research centres supported by the Basque and Provincial Governments	BRTA has the mission to create collaboration vehicles to leverage resources to address industrial challenges. Also, this alliance allows a greater capacity to attract funding as the skillsets of various research centres create synergies and facilitates knowledge transfer.
Climate Change Research	Basque Centre for Climate Change (BC3)	Ikerbasque, Ihobe, UPV, Basque Government, Excelencia Maria de Maeztu	BC3 is a research centre on the causes and consequences of climate change. It produces multidisciplinary knowledge to support decision making towards sustainable development at the international level. BC3 is a world leader in supporting the significant parts of the lifecycle of transdisciplinary climate change research.

Sources: (Repsol, 2020b), (Iberdrola, 2020), (Ibil, 2020), (Ingeteam, 2019), (CIC energiGUNE, 2019).

4.4. Strengths and opportunities for the Basque Country energy ecosystem

Although the virtues of the collaborative ecosystem in the Basque Country are many, the system has elements that can be improved upon. Figure 7 outlines the most frequently mentioned strengths and opportunities identified by the stakeholders.

Figure 7. **STRENGTHS AND OPPORTUNITIES PORTRAYED IN THE INTERVIEWS WITH BASQUE COUNTRY ENERGY ECOSYSTEM STAKEHOLDERS**



Source: Own elaboration.

As the figure above suggests the stakeholders seem to be in general agreement that the main ingredients collaborative framework set by the Energy Cluster, SPRI, EVE and the Basque Government has many positive elements. Particularly the alignment with local authorities (see Table A.1), industry, and SMEs to develop a strong value-chain that delivers the solutions required. However, the areas of opportunities indicate the post-pandemic policies need to be well targeted to revitalise industry that champion competitiveness. Also, it is stressed progressive policies are enacted and green bond schemes set to finance innovation; just like Scandinavian and USA local or regional authorities have done with considerable success. Some noteworthy comments made by the interviews also stated the following:

- Strengths
  - Persist in incentivising energy service companies and large consumers to invest in energy efficiency technology and/or renewable technologies via EVE or IDEA to support the market, making it less difficult to burden organizations with the capital such investments have on balance sheets.
  - Communication channels that enable companies to be well informed on activities made by competitors and changes to regulatory processes in the countries where operations are taking place needs to continue and become embedded as best practice.
  - The province of Bizcay is offering support to start-ups, such mechanisms need to be refined and increased to foster innovation and local economic growth.
- Opportunities
  - Many organizations delay investments as such works disrupt key operations and create a loss in revenues, can a mechanism be introduced to alleviate this loss in production?
  - Promote best «corporate sustainability report» (CSR) practices across the Basque companies so they report the environmental impact from their activities and develop carbon mitigation pathways.
  - Governments need to give greater powers to regulatory bodies that do not have enough power to enact a sustainability agenda, otherwise delay in investments will occur.
  - Review land use policies and refurbishment of infrastructure that could increase the feasibility of renewable energy projects.
  - The Energy Cluster could re-consider its strategy by including hydrogen and bioenergy production to reduce reliance on fossil fuels, digitalisation of energy services to increase end-user engagement, review transmission infrastructure at high-voltage levels to seek high power capacity interconnectors from where renewable energy could be sourced.

4.5. **Discussion**

Private and public organizations must play their role to prevent the worst impacts of climate change, but solutions are very complex. Robust internal decision-making processes and solutions are required by supporting technology development and through collaborative frameworks with 3rd parties (*e.g.* governments, regulatory bodies, SMEs, etc.) to drive innovation and implement cost-effective solutions.

As this research has shown net zero pledges are in vogue and it is a matter of time for key stakeholders to ask if the results from many promising investments are matching the rhetoric. Developing adequate decision-making tools that allow us to identify the right time to invest, where to invest, and what to install is fundamental for each organization. Another point worth highlighting is the tricky nature of how organizations will mitigate emissions they cannot reduce directly. Careful due diligence is needed to reassure that carbon credits, offsets, or removal solutions applied do not have unattended consequences that erase the carbon savings they claim. Therefore, embedding sustainability best practices, carbon awareness, and a committed working culture of having a positive environmental impact is paramount to drive organizational change. This last point gathers more weight as the world recovers from the economic fallout generated from Covid-19. Now more than ever governments, institutions, and companies need to lead with support from the public to enact a green recovery that unlocks economic growth and simultaneously reduces carbon emissions.

A promising example of leadership is being done particularly by those countries enacting legislation to reach net zero targets by 2050. Of those countries, the UK is the one who is articulating the range of technology solutions that will enable a «green revolution» (Afry, 2020). Such advocacy and clarity are appreciated by stakeholders as it gives direction of travel and confirms the net zero legislation will drive flagships projects soon. Albeit such announcements do not detail the supportive policies that will be enacted to drive the «revolution», but it can help to drive grant and investment for niche technologies. For the UK the decarbonization strategy will most likely support the development of the following technologies:

- Off-shore and on-shore wind farm projects;
- Hydrogen generation, infrastructure, and market;
- Large and small-scale nuclear power plants;
- Electric vehicles, batteries, and fast-charging infrastructure;
- Public transport, cycling and walking;
- Aviation and greener maritime;
- Refurbishment of homes and public buildings and upgrading its heating systems;
- Carbon capture and sequestration in fossil fuel power plants;
- Massive tree-planting programmes;
- Green financing.

The above solutions should kick-start an entrepreneurial journey in the UK that fosters collaboration and R&D programmes to refine solutions that are fit for purpose, implementable, effective, and scalable. Indeed, the UK collaborative cluster of public, private, and academic organizations will be tested. In a very similar fashion, such as in the Basque Country, governments and regions around the world will be required to enact funding programs and legislation to support the green agenda. Public policy is to play a key role to enable and accelerate this transition to net zero.

The stakeholders interviewed in the Basque Country showed a sensible degree of optimism at the future ahead as they believe the inertia towards sustainability is unstoppable. The decarbonization challenge needs to be converted into a great opportunity to propel the know-how developed thus far and used for cutting-edge sustainable solutions that will make organizations competitive and cement their position as leaders in their field; securing economic growth that benefits the wider society.

Making the most of the EU Green Deal is a must, acting as a springboard to drive innovation and serving to leapfrog current best practices. The Basque energy ecosystem needs to be ready to embrace this opportunity by embarking on stimulating collaborative projects and showing it is possible to develop business models that do not rely on fossil fuels. Attracting investment to the Basque region from multiple sources is also key to enable the flourishment of sustainable solutions that provide economic growth. Either through fiscal incentives or green financing mechanisms, authorities and companies need to find winning formulas that put innovation at the heart of the energy ecosystem in the Basque Country.

Energy transitions are not easy due to their disruptive nature and foreseeing unattended consequences should also be priority. Perhaps providing support for financing investments or reducing the loss generated from lower productive output would make companies accelerate their transition towards net zero. Furthermore, the speed at which a transition can take place - its timing, or temporal dynamics - is a critical element of consideration. If we analyse previous transitions from technologies developed since the industrial revolution it could be argued that meeting climate goals by 2050 will be very challenging indeed as socio-technical, sociology, regulation, and political trends need to be aligned (Sovacool, 2016).

Many stakeholders interviewed expect the Basque Government through the EVE will soon set ambitious carbon mitigation goals aligned to the Paris Climate Accord – articulating the various pathways, mechanisms, and approaches available to make a net zero future viable is desired. Maybe a carbon tax, fossil fuel duties or a carbon floor price can be implemented with the support of EU authorities to send a clear signal.

Enabling a more competitive environment through net zero innovation seems to make a lot of sense for the Basque Country and preaching with flagship projects would signal organizations are ready to meet the challenge head on. A great example would be to invest and develop net zero industrial (*i.e.* green) clusters in the areas where many companies have their operations such as petrochemical plants, manufacturing clusters, and technology parks; benefitting not only the energy intensive users but also the value-chain of companies providing products and services. Reaching such goals via collaboration and partnerships would be very positive as they have the effect of transforming governance and are inclusive which improves the capacity to resolve complex problems at scale (McAllister & Taylor, 2015).

5. CONCLUSION

Private and public organizations must play their role to prevent the worst impacts of climate change by reducing their greenhouse gas emissions to meet the Paris Climate Accord. In recent times many nations have enacted climate legislation, while also many private organizations have either committed to net zero emission targets or are following Science-based target frameworks. The positive inertia to for a «green revolution» seems palpable and we must act upon it. Expectations need to be carefully managed and tangible results delivered otherwise there would be a breach of trust and positive sustainability inertia gathered will lose steam and support. Consequently, organizations need to implement lean and progressive decision-making processes to ensure their investments programmes are aligned with their long-term roadmap strategy. Getting the temporal dynamics of this transition is not an easy endeavour, especially for those organizations with a high carbon footprint distributed across many facilities and with large and complex supply-chains.

This work reviewed the best practices to reduce CO_2 emissions in energy intensive organizations and energy value-chains by highlighting the synergy that can be built with like-minded organizations via collaborations; taking the Basque Country as a case study. An academic review covers how corporate strategies are attempting to curtail emissions in a systematic manner. The study is then complimented by findings obtained from interviews of key stakeholders in the Basque Country responsible for playing an important role in implementing a green agenda. The interviews allowed us to outline the key organizations driving the sustainability transition, highlight flagship projects and assess the collaborative framework strengths and challenges. Results indicate that organizations are well underway in implementing and researching low carbon solutions, but issues surrounding governance, strategy, and regulatory challenges can slow progress of goals. Some projects such as the ones from Petronor and Iberdola already indicate the shift towards exploring next generation solutions such as green hydrogen, while other companies are fostering know-how by public-private partnerships in transport electrification and digital energy services.

Although challenges remain the Basque Country energy ecosystem is aligned to EU environmental targets and it is expected that key stakeholders such as EVE will set a clear strategy to strive for net zero goals by 2050. Setting up an adequate regulatory and incentive framework will be no easy task but the collaborative relationship between public-private organizations puts the Basque Country in a great position to succeed in making the region an exemplar in net zero solutions in the upcoming decades. Becoming a regional industrial powerhouse that runs on low carbon energy is an ambition worth aiming for to enact transformative change, develop a competitive advantage, and generate economic prosperity. It is the case that for the Basque industry a shift towards net zero would put them at the forefront against other European regional hubs, making their products and services a desired commodity elsewhere.

APPENDIX

Local Authorities

Table A1. **ENERGY POLICIES INSTRUMENTS AVAILABLE FOR LOCAL AUTHORITIES IN THE BASQUE COUNTRY**

Political instruments available to local authorities	Private buildings			Public buildings		
	New	Renovated	Existing	New	Renovated	Existing
Regulations on minimum energy efficiency	++	++	-	+	+	-
Tax incentives and credits	++	++	+	+	+	-
Information and training	++	++	++	++	++	++
Promotion of good practice	++	++	+	++	++	+
Demonstration buildings	++	++	-	++	++	-
Promotion of energy audits	-	++	++	-	++	++
Regulations and urban development plans	++	+	-	++	+	-
Increase in rate of rehabilitation	-	++	-	-	++	-
Energy taxes	+	+	+	+	+	+
Coordination of policies with authorities at different levels	++	++	++	++	++	++

Note: ++ Very relevant + Relevant - Not very relevant
Source: EVE, 2017.

Abbreviations

AD	Anaerobic digestion
AR5	5th Assessment report
BC3	Basque Centre for Climate Change
BEIS	Business, Energy & Industrial Strategy
BELA	Basque Electrical Laboratories Alliance
BRTA	Basque Research & Technology Alliance
CAPEX	Capital expenses
CCS	Carbon capture and sequestration
CCU	Carbon capture unit

.../...

.../...

CDP	Carbon disclosure project
CHP	Combined heat and power
COP21	2015 United Nations Climate Change Conference
CO	Carbon monoxide
CO_2e	Carbon dioxide equivalent
CPPA	Corporate power purchase agreement
ECA	Enhanced capital allowance
EVE	Energy Basque Agency
GDP	Gross domestic product
GHG	Greenhouse gas
HFC	Hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
KPI	Key performance indicators
Ktoe	Kilo tonnes of oil equivalent
LNG	Liquified natural gas
LSE	London School of Economics
MW	Megawatt
NO_x	Nitrogen oxides
PV	Photo-voltaic
PVT	Photo-voltaic thermal
RIS3	Regional innovation smart specialization strategy
R&D	Research and development
UNFCCC	United Nations Framework Convention on Climate Change
UPV	University of the Basque Country

REFERENCES

Acha, S. (2013): Modelling distributed energy resources in energy services networks. The Institution of Engineering and Technology; 2013. doi:978-1-84919-559-1.

Acha, S.; Le Brun, N.; Damaskou, M.; Fubara, T.C.; Mulgundmath, V.; Markides, C.N.; Shah, N. (2020): Fuel cells as combined heat and power systems in commercial buildings: A case study in the food-retail sector. Energy, 206, 118046. https://doi.org/10.1016/j.energy.2020.118046

Acha, S.; Mariaud, A.; Shah, N.; Markides, C.N. (2018): Optimal design and operation of distributed low-carbon energy technologies in commercial buildings. Energy, 142. https://doi.org/10.1016/j.energy.2017.10.066

Afry (2020): «2050 Holistic & Efficient Roadmap for a Zero-Emissions EU Energy» https://afry.com/sites/default/files/2020-05/afry_managementconsulting_publicreport_05072020.pdf (Accessed: 18 October 2020).

Aggarwal, R.; Dow, S. (2012): Corporate governance and business strategies for climate change and environmental mitigation. European Journal of Finance, 18(3-4), 311–331. https://doi.org/10.1080/1351847X.2011.579745

AMAZON (2020): «Reaching Net Zero Carbon by 2040». Available at https://sustainability.aboutamazon.com/ (Accessed: 4 September 2020).

AYOUB, A.; GAIGNEUX, A.; LE BRUN, N.; ACHA, S.; SHAH, N. (2020): The development of a low-carbon roadmap investment strategy to reach Science Based Targets for commercial organisations with multi-site properties. Building and Environment. https://doi.org/10.1016/j.buildenv.2020.107311

BC3 (2020): «Basque Centre for Climate Change». https://www.bc3research.org/about_us.html (Accessed: 16 November 2020).

BIZKAIA FORU ALDUNDIA – DIPUTACION FORAL DE BIZKAIA (2020): «Concierto Economico». https://web.bizkaia.eus/es/concierto-economico (Accessed: 31 July 2020).

BUSTOS-TURU, G.; VAN DAM, K.H.; ACHA, S.; MARKIDES, C.N.; SHAH, N. (2016): «Simulating residential electricity and heat demand in urban areas using an agent-based modelling approach», 2016 IEEE International Energy Conference (ENERGYCON), Leuven, 2016, pp. 1-6, doi: 10.1109/ENERGYCON. 2016. 7514077.

BUSTOS-TURU, G.; VAN DAM, K.H., ACHA, S.; SHAH, N. (2014): «Estimating plug-in electric vehicle demand flexibility through an agent-based simulation model», IEEE PES Innovative Smart Grid Technologies, Europe, Istanbul, 2014, pp. 1-6, doi: 10.1109/ISGT Europe. 2014.7028889.

— (2015): «Integrated planning of distribution networks: interactions between land use, transport and electric vehicle charging demand», presented at the 23rd International Conference on Electricity Distribution (CIRED), Lyon, France, 2015.

CAMPBELL-ÁRVAI, V.; BESSETTE, D.; KENNEY, L.; ÁRVAI, J. (2019): Improving decision making for carbon management initiatives. International Journal of Risk Assessment and Management, 22(3-4), 342–358. https://doi.org/10.1504/IJRAM.2019.103338

CARBON DISCLOSURE PROJECT (CDP) (2020): «CDP Scores». Available at https://www.cdp.net/. (Accessed: 10 August 2020).

CARBON INTELLIGENCE (2020): «Companies that have set net zero targets». Available at https://carbon.ci/insights/companies-with-net-zero-targets/ (Accessed: 31 August 2020).

CARITTE, V.; ACHA S.; SHAH, N. (2015): «Enhancing Corporate Environmental Performance Through Reporting and Roadmaps». Business Strategy and the Environment, Volume 24, Issue 5, pp. 289-308. https://doi.org/10.1002/bse.1818

CEDILLOS ALVARADO, D.; ACHA, S.; SHAH, N.; MARKIDES, C.N. (2016): A Technology Selection and Operation (TSO) optimisation model for distributed energy systems: Mathematical formulation and case study. Applied Energy, 180, 491-503. https://doi.org/10.1016/j.apenergy.2016.08.013

CHAKRABARTI, A.; PROEGLHOEF, R.; TURU, G.B.; LAMBERT, R.; MARIAUD, A.; ACHA, S.; MARKIDES, C.N.; SHAH, N. (2019): Optimisation and analysis of system integration between electric vehicles and UK decentralised energy schemes. Energy, 176, 805-815. https://doi.org/10.1016/j.energy.2019.03.184

CIC ENERGIGUNE (2019): «CIC energiGUNE website». https://cicenergigune.com/en (Accessed: 18 September 2020).

CLUSTER ENERGIA (2019): «Strategic Areas». http://www.clusterenergia.com/strategic-areas (Accessed: 10 September 2020).

DAMERT, M.; PAUL, A.; BAUMGARTNER, R.J. (2017): Exploring the determinants and long-term performance outcomes of corporate carbon strategies. Journal of Cleaner Production, 160, 123-138. https://doi.org/10.1016/j.jclepro.2017.03.206

DELANGLE, A.; LAMBERT, R.S.C.; SHAH, N.; ACHA, S.; MARKIDES, C.N. (2017): Modelling and optimising the marginal expansion of an existing district heating network. Energy, 140. https://doi.org/10.1016/j.energy.2017.08.066

EFSTRATIADI, M.; ACHA, S.; SHAH, N.; MARKIDES, C.N. (2019): Analysis of a closed-loop water-cooled refrigeration system in the food retail industry: A UK case study. Energy, 174, 1133-1144. https://doi.org/10.1016/j.energy.2019.03.004

EVE (2017): «Basque Energy Strategy 2030». https://www.eve.eus/Conoce-la-Energia/La-energia-en-Euskadi/Energy-Policy-2030?lang=en-gb (Accessed: 15 August 2020).

EUSKO JAURLARITZA – GOBIERNO VASCO (2019): «LEY 4/2019, de 21 de febrero, de Sostenibilidad Energética de la Comunidad Autónoma Vasca». https://www.euskadi.eus/gobierno-vasco/-/eli/es-pv/l/2019/02/21/4/dof/spa/html/ (Accessed: 15 August 2020).

FINNERTY, N.; STERLING, R.; CONTRERAS, S.; COAKLEY, D.; KEANE, M.M. (2018): Defining corporate energy policy and strategy to achieve carbon emissions reduction targets via energy management in non-energy intensive multi-site manufacturing organisations. Energy, 151, 913–929. https://doi.org/10.1016/j.energy.2018.03.070

Fundacion Tecnalia Research and Innovation (2018): «2018 ANNUAL REPORT». https://www.tecnalia.com/images/stories/Informes_anuales/2018/INFORME_ANUAL_2018_INGLES_PAGINAS_DOBLES.pdf (Accessed: 16 November 2020).

Gestamp (2019): «Gestamp Sustainability Report 2019». https://www.gestamp.com/Gestamp11/media/GestampFiles/Sustainability/Sustainability%20Report/2019/Gestamp-Sustainability-Report-2019.pdf?ext=.pdf (Accessed: 16 November 2020).

Gonzato, S.; Chimento, J.; O'Dwyer, E.; Bustos-Turu, G.; Acha, S.; Shah, N. (2019): Hierarchical price coordination of heat pumps in a building network controlled using model predictive control. Energy and Buildings, 202, 109421. https://doi.org/10.1016/j.enbuild.2019.109421

Griffin, P.W.; Hammond, G.P. (2019): Industrial energy use and carbon emissions reduction in the iron and steel sector: A UK perspective. Applied Energy, 249(May), 109-125. https://doi.org/10.1016/j.apenergy.2019.04.148

Grupo Spri Taldea (2020a): «SPRI Group Working Framework». https://www.spri.eus/en/who-we-are/ (Accessed: 31 July 2020).

— (2020b): «SPRI Group Cluster Policy». https://www.spri.eus/en/ris3-euskadi/cluster-policy/ (Accessed: 31 July 2020).

Hart, M.; Austin, W.; Acha, S.; Le Brun, N.; Markides, C.N.; Shah, N. (2020): «A roadmap investment strategy to reduce carbon intensive refrigerants in the food retail industry». Journal of Cleaner Production, Vol. 275, pp. 123039. https://doi.org/10.1016/j.jclepro.2020.123039

Hickel, J. (2020): The sustainable development index: Measuring the ecological efficiency of human development in the anthropocene. Ecological Economics, 167(March 2019), 106331. https://doi.org/10.1016/j.ecolecon.2019.05.011

Ibil (2020): «Ibil About Us» https://www.ibil.es/en/quienes-somos/ (Accessed: 31 August 2020).

Ingeteam (2019): «Ingeteam and Solarpack sign an agreement to supply 200 MVA to PV plants». https://www.ingeteam.com/Pressroom/Corporate/tabid/1574/articleType/ArticleView/articleId/2404/Ingeteam-and-Solarpack-sign-an-agreement-to-supply-200-MVA-to-PV-plants.aspx (Accessed: 17 September 2020).

Iea (2020): Energy Technology Perspectives 2020 - Special Report on Clean Energy Innovation Accelerating technology progress for a sustainable future. Energy Technology Perspectives 2020, 61-89. https://doi.org/10.1787/9789264109834-en

Ihobe (2020): «About Ihobe». https://www.ihobe.eus/about-ihobe (Accessed: 10 October 2020).

Institute for Government (2020): «UK Net Zero Target». Available at https://www.instituteforgovernment.org.uk/explainers/net-zero-target (Accessed: 9 August 2020).

Iso (2020): «ISO 50001 Energy management». Available at https://www.iso.org/iso-50001-energy-management.html. (Accessed: 1 October 2020).

Kramer, G.; Haigh, M. (2009): No quick switch to low-carbon energy. Nature 462, 568-569 (2009). https://doi.org/10.1038/462568a

Langshaw, L.; Ainalis, D.; Acha, S.; Shah, N.; Stettler, M.E.J. (2020): Environmental and economic analysis of liquefied natural gas (LNG) for heavy goods vehicles in the UK: A Well-to-Wheel and total cost of ownership evaluation. Energy Policy, 137 (December 2019), 111161. https://doi.org/10.1016/j.enpol.2019.111161

Mace (2020): «Mace announces it will be net zero carbon in 2020». Available at https://www.macegroup.com/media-centre/200129-mace-announces-it-will-be-net-zero-carbon-in-2020 (Accessed: 21 July 2020).

Mariaud, A.; Acha, S.; Ekins-Daukes, N.; Shah, N.; Markides, C.N. (2017): Integrated optimisation of photovoltaic and battery storage systems for UK commercial buildings. Applied Energy, 199. https://doi.org/10.1016/j.apenergy.2017.04.067

Maouris, G.; Sarabia Escriva, E.J.; Acha, S.; Shah, N.; Markides, C.N. (2020): CO2 refrigeration system heat recovery and thermal storage modelling for space heating provision in supermarkets: An integrated approach. Applied Energy, 264(March), 114722. https://doi.org/10.1016/j.apenergy.2020.114722

Microsoft (2020): «Microsoft will be carbon negative by 2030». Available at https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/#:~:text=By%202030%20Microsoft%20will%20 be,goal%20but%20a%20detailed%20plan (Accessed: 25 June 2020).

O'Dwyer, E.; Pan, I.; Acha, S.; Shah, N. (2019): Smart energy systems for sustainable smart cities: Current developments, trends and future directions. Applied Energy, 237(November 2018), 581–597. https://doi.org/10.1016/j.apenergy.2019.01.024

Olympios, A.V.; Le Brun, N.; Acha, S.; Shah, N.; Markides, C.N. (2020): Stochastic real-time operation control of a combined heat and power (CHP) system under uncertainty. Energy Conversion and Management, 216 (May), 112916. https://doi.org/10.1016/j.enconman.2020.112916

Orkestra (2020): «Basque Institute of Competitiveness». https://www.orkestra.deusto.es/en/about-orkestra/basque-institute-competitiveness (Accessed: 16 November 2020).

Pressman, S. (1991): Book Review: The Competitive Advantage of Nations. Journal of Management, 17(1), 213-215. https://doi.org/10.1177/014920639101700113

Repsol (2020a): «Repsol será compañía cero emisiones netas en 2050». https://www.repsol.com/es/sala-prensa/notas-prensa/2019/repsol-sera-compania-cero-emisiones-netas-en-2050.cshtml (Accessed: 12 November 2020).

— (2020b): «Repsol to develop two major emissions-reductions projects in Spain». https://www.repsol.com/en/press-room/press-releases/2020/repsol-to-develop-two-major-emissions-reductions-projects-in-spain.cshtml (Accessed: 12 October 2020).

Rissman, J.; Bataille, C.; Masanet, E.; Aden, N.; Morrow, W.R.; Zhou, N.; Elliott, N.; Dell, R.; Heeren, N.; Huckestein, B.; Cresko, J.; Miller, S.A.; Roy, J.; Fennell, P.; Cremmins, B.; Blank, T.K.; Hone, D.; WiLliams, E.D.; de la rue du can, S.; Sisson, B.; Williams, M.; Katzenberger, J.; Burtraw, D.; Sethi, G.; Ping, H.; Danielson, D.; Lu, H.; Lorber, T.; Dinkel, J.; Helseth, J. (2020): «Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070». Applied Energy, Vol. 266, 114848. https://doi.org/10.1016/j.apenergy.2020.114848

Sarabia Escriva, E.J.; Acha, S.; Le Brun, N.; Soto Frances, V.; Pinazo Ojer, J.M.; Markides, C.N.; Shah, N. (2019): Modelling of a real CO2 booster installation and evaluation of control strategies for heat recovery applications in supermarkets. International Journal of Refrigeration, 107(April 2014), 288-300. https://doi.org/10.1016/j.ijrefrig.2019.08.005

Science Based Targets (2017): «Companies Taking Action». Available at: https://sciencebasedtargets.org/companies-taking-action/ (Accessed 8 September 2020).

— (2020): «Over 150 global corporations urge world leaders for net-zero recovery from COVID-19». Available at https://sciencebasedtargets.org/2020/05/18/uniting-business-and-governments-to-recover-better/ (Accessed: 11 June 2020).

Slawinski, N.; Pinkse, J.; Busch, T.; Banerjee, S.B. (2017): The Role of Short-Termism and Uncertainty Avoidance in Organizational Inaction on Climate Change: A Multi-Level Framework. Business and Society, 56(2), 253-282. https://doi.org/10.1177/0007650315576136

Sovacool, B.K. (2016): How long will it take? Conceptualizing the temporal dynamics of energy transitions. Energy Research and Social Science, 13, 202-215. https://doi.org/10.1016/j.erss.2015.12.020

Sunny, N.; Mac Dowell, N.; Shah, N. (2020): What is needed to deliver carbon-neutral heat using hydrogen and CCS? Energy & Environmental Science, 4204-4224. https://doi.org/10.1039/d0ee02016h

Tapia, J.F.D.; Samsatli, S.; Doliente, S.S.; Martinez-Hernandez, E.; Ghani, W.A.B.W.A.K.; Lim, K.L.; Shafri, H.Z.M.; Shaharum, N.S.N.B. (2019): Design of biomass value chains that are synergistic with the food-energy-water nexus: Strategies and opportunities. Food and Bioproducts Processing, 116, 170-185. https://doi.org/10.1016/j.fbp.2019.05.006

Vidrala (2019): «Vidrala 2019 Sustainability Report» https://www.vidrala.com/default/documentos/1077_en-sustainability_statement_2019.pdf (Accessed: 5 August 2020).

United Nations Climate Change (2016): «The Paris Agreement». Available at https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement. (Accessed: 25 September 2020).

Zhou, S.W.W. (2020) : Carbon Management for a Sustainable Environment. In Carbon Management for a Sustai nable Environment. https://doi.org/10.1007/978-3-030-35062-8