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Factors Influencing the Transition to a Low-Carbon Energy Paradigm: A Systemic Literature Review

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Abstract: Research concerning energy transition has grown at a high pace over the past decade, exploring a variety of topics. This paper provides a systematic literature review focused on the factors and policy routes that can support and expedite the transition to a low-carbon energy paradigm. The results of the bibliographic search follow a theoretical organizational lens and are grouped into four main categories – economic, technological, social, and policy. Key findings include the role of environmental policy as the crucial driver for progress, as well as the need for active participation from industry, economic, and policy agents, along with energy experts. In addition, the lack of literature regarding developing and lower-income nations is highlighted. A discussion and practical implications of the results are provided within the context of the four main categories and with a prosperous post-transition society in mind. Our findings are relevant for policymakers, administrators, and all stakeholders involved in integrating low-carbon initiatives and policies within their organizational structures.

Keywords: energy transition, institutional factors, policy instruments, systematic literature review

1. Introduction

A crucial question for environmental and climate research has to do with how to facilitate the transformative changes required to slow down climate change while increasing energy security and economic growth.

In 2015, 178 nations signed the Paris Agreement, collectively aiming to achieve a long-term goal: limiting the global average temperature increase compared to the pre-industrial era to no more than 2°C, with a striving effort to keep it within 1.5°C. This agreement set world leaders on a shared path to ensure that global warming remains well below a 2°C temperature rise concerning pre-industrial levels[1]. In 2018, the United Nations Intergovernmental Panel on Climate Change published a special report on global warming, emphasizing the need to reduce human-induced net carbon dioxide (CO_2) emissions by 45% compared to 2010 levels by 2030 and ultimately achieve carbon neutrality by 2050. Yet, in 2022, during the Climate Change Conference (COP 27), it became evident that there was still a substantial emissions gap between the current national climate plans and the necessary reductions to limit temperature rise to 1.5°C. This gap highlighted the limited and incremental progress made in recent years toward emissions reduction.

The main goal of these international agreements is to assess the requirements for developing new action plans to fund, facilitate the transfer, and advance environmental technologies that improve green growth and address rising emissions levels [1]. In addition, international agreements, when coupled with technological progress, can potentially increase the speed of transitions [2]. Thus, complying with these environmental targets is vital and departing from local and temporary resolutions will require widespread rapid and radical transformations. An accelerating transition will be needed to move potential solutions quickly, reaching a decarbonization path. Indeed, comprehensive decarbonization and a low-carbon transition involve more than just technological shifts; they require a broader socio-economic transition that demands changes in user behavior, processes of power dynamics, finance, environmental policy, industry strategies, infrastructure, culture, and science [3–8].

Many countries have invested and developed their energy transformation agendas in recent years, specifically between 2019 and 2023, amid COVID and post-COVID recovery. However, the goal of this systematic literature review is to present an overview of the first decade of literature regarding energy transition, focusing on paths and developments that occurred before the arrival of the pandemic, which unequivocally altered and accelerated the trajectory of the energy transition with countries using funding to support their energy transitions as a way of economic recovery.

Indeed, from 2009 to 2019, a substantial body of literature started emerging, guiding and documenting progress toward a transition to a low-carbon economy. Concerning this initial decade of literature, the following research questions arise: what are the prevailing socio-economic, technological, and institutional factors that are most conducive to driving an energy transition? What are

[1]Pre-industrial refers to the period prior to the outbreak of large-scale industrial activity (around 1750).

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the central determinants in this context? Which areas still require further investigation? This paper conducts a systematic review of this diverse body of research following a theoretical organizational perspective.

Thus, a systematic approach is employed as a methodology to extract pertinent literature, aiming to produce results that are dependable, verifiable, and reproducible. This bibliographic search was conducted in the Scopus LibGuide database, chosen for its comprehensive coverage of journals and its established reputation as a trustworthy source of bibliographic data. First, a research framework was created considering a list of terms that better describe the literature related to energy transitions. To identify relevant publications and define the scope of results as academically relevant content, the fields of Economics, Econometrics and Finance; Engineering; Energy; and Environmental Sciences were selected. Restrictions were applied to make sure that only academic, written in English, and peer-reviewed journals were selected. A time restriction between 2009 and 2019 was imposed to make sure that the analysis is focused on the first decade of relevant research regarding the energy transition. Finally, journals, titles, abstracts, and keywords were assessed to ensure alignment with the scope of the review.

The objective of this paper is to comprehensively examine this literature, categorizing it into four principal domains: economics, technology, social, and environmental policy. Through this analysis, we contribute to the field of energy transitions by offering an overview of past research, identifying research gaps, and paving the way for future research. In addition, insights for industry, economics, and policy stakeholders are also provided.

Indeed, we aim to engage both political economists and energy practitioners in the discourse on energy transition and the quest for a sustainable and equitable post-transition society. This research becomes particularly relevant in a post-pandemic context, as there is an increased need for a transition toward cleaner business models. Sustainability has emerged as a crucial component of government recovery plans, underscoring the timeliness and significance of this research.

This paper is structured as follows. In the next section, key definitions and concepts regarding energy transitions are clarified and the theoretical contribution of the paper is specified. Then in Section 3 the research method employed in this systematic literature review is described. Section 4 presents the findings of the literature analyzed. This section is divided into three groups of factors – economic and market-related, technological, and social – plus a fourth transversal group – environmental politics – containing political pathways and instruments. In Section 5, implications for policy and practice are debated, and an agenda for future research is presented. Section 6 concludes.

2. Concepts of an Energy Transition

A transition is characterized as a comprehensive societal transformation encompassing fundamental and interconnected shifts in technology, organizational structures, institutions, and cultural norms, as formally defined by Shum [9]. As for the definition of energy transition, authors usually denote a long-term structural change in an energy system, usually referring to changes in particular fuel sources, technologies, or prime movers (e.g., devices that convert energy into useful services, such as automobiles or televisions) [10, 11]. The goal is to develop and diffuse innovations to meet current and future societal demands in a sustainable way, balancing social well-being, economic prosperity, and environmental protection.

As noted by Wesseling et al. [8], exogenous shocks and disruptions, like pandemics, extreme weather occurrences, or shifts in energy prices, have the potential to create new demands and stimulate the existing socio-technical and innovation systems, ultimately driving change. As exemplified by Jenkins et al. [11] and Guidolin and Guseo [10], the sudden external shock of the Fukushima nuclear disaster exerted a substantial influence on the energy sectors and socio-technical systems of multiple nations. Additionally, Klemeš et al. [12] and Sarkis et al. [13] state that crises, such as wars, famines, and pandemics, change institutions and can have lasting impacts on society. The pandemic occurred when environmental and energy policies were experiencing an increased momentum. Yet, the macroeconomic and political landscape that initially shaped these frameworks has since evolved, with many nations grappling with a significant economic downturn and inflation. How institutions and policymakers respond to these shifting circumstances and realign policy priorities could bear significant implications for the trajectory of the low-carbon energy transition.

Exogenous shocks might be sufficient for transformation, but they are not a necessary condition. As Geels et al. [14] observed, change and novel trajectories can emerge within established institutional systems, even without external shocks. Most of the post-industrial revolution transitions were neither intentionally planned nor centrally governed. However, with governments now taking proactive measures to create favorable conditions for a transition toward a low-carbon future, the upcoming energy transition has the potential to be significantly shorter than those experienced in the past [10, 15, 16]. State and local governments are the entities entitled to implement policy changes and to understand regional needs and interests. Country-specific circumstances and policy frameworks require the state to play a leading role when fostering energy or sustainability transitions.

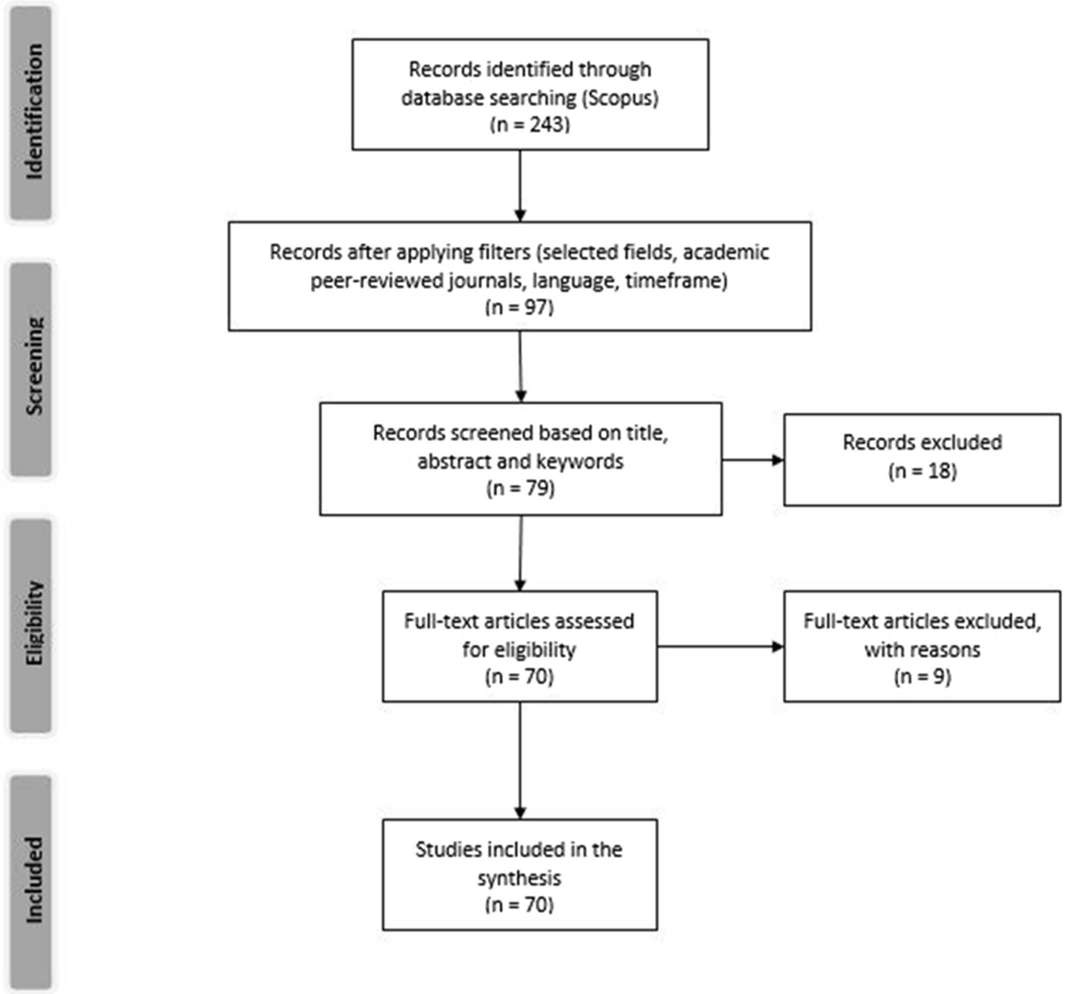
Given the crucial role of governance in shaping the nature and speed of transitions, an energy transition represents a blend of political, economic, technological, and social processes. Our goal in this paper is to bring together, with a systematic approach and organizational lens, different strands of literature to identify the policies and institutional factors that create a pathway toward transition.

The role of firms and other market players in curbing environmental degradation is undeniably relevant and extensively studied. Firms can seize macrotrajectories toward energy decarbonization and adapt and introduce them at a micro level.

Additionally, the ability and willingness to make such energy transition are extremely dependent on government policy, which, in turn, derives from long historical legacies and carbon lock-ins[2]. However, a society-wide transformation can only occur with a coordinated effort from all society actors. Indeed, dealing with environmental concerns, like climate change, demands committing to long-run policies. These policies imply short-run costs but promise significant long-run advantages [17–19]. Nevertheless, given the potential of green technologies to foster green economic growth, governments should increasingly prioritize the implementation of green tax policies. These policies can reinforce green initiatives by providing incentives for green investments and discouraging fossil fuel-based markets by imposing taxes [20].

[2]The term “carbon lock-in,” coined by Unruh [95], refers to a condition in which economies have become locked into fossil fuel-based energy and transportation systems through path-dependent processes driven by technological and institutional increasing returns to scale. This condition creates persistent market and policy failures, which constrain the diffusion of alternative technologies.

Figure 1
Framework for the data-gathering process



A clean energy transition can allocate its costs and benefits as unevenly as the fossil-based transitions of the past. Furthermore, these fossil-based transitions profoundly changed the relative positions of regions and countries in terms of competitiveness and existing allocations of capital and labor [19].

A transition to low-carbon energy system has the capacity to achieve a similar outcome. Indeed, geopolitical risks can act as obstacles to the low-carbon energy transition [4]. In addition, these geopolitical risks can also disrupt global electricity generation. Yet, guaranteeing the stability of global markets and coordination among governments is once again crucial to developing circular economy practices, including sustainable electricity generation, which can ultimately reduce these risks [21].

3. Method

Similar to the methodology employed by Mio et al. [18], we employed a systematic approach to extract pertinent literature, aiming to produce results that are dependable, verifiable, and reproducible. Following Farruk et al. [22], we conducted our bibliographic search in the Scopus LibGuide database[3], chosen for its comprehensive coverage of journals and its established reputation as a trustworthy source of bibliographic data.

In order to define which documents to include in our search, a research framework was created (see the PRISMA flow in Figure 1) and the following list of terms that describe the literature related to energy transitions was used: energy transition*, decarbonization, green polic*, environment*, sustainab*, climate policy, environmental policy, institutional, technological change, organizational change, emission*, low carbon, low-carbon, transition factor*[4], [5]. Our aim was to conduct an exploratory bibliographic search concerning the factors that impact a transition to low-carbon energy, without limiting the search to highly specific subjects or disciplines. Therefore, we utilized broader keywords. This initial search yielded 243 publications. Given the evolution and rapid growth of energy transition literature, there is a considerable body of research available for evaluation.

As a starting point to identify relevant publications and limit the results to academically relevant content, we selected the fields of *Economics*, *Econometrics and Finance*; *Engineering*; *Energy*; and *Environmental Sciences*. Then, we applied the filters "academic

[3]For more information, consult: https://elsevier.libguides.com/Scopus

[4]PRISMA stands for Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

[5]The asterisk (*) replaced multiple characters in the search. For example, sustainab* covers both sustainability and sustainable.

journals," "peer-reviewed" (conference and working papers were therefore excluded), and "Language= English." The following leading academic journals in energy and transition literature were chosen: *Applied Energy*, *Business Strategy and The Environment*, *Ecological Economics*, *Energy Policy*, *Energy Research and Social Science*, *Journal of Cleaner Production*, *Technological Forecasting and Social Change,* and *Research Policy*. Finally, we set the time restriction 2009–2019, in order to analyze the first decade of relevant research regarding the energy transition. The goal is to focus on paths and developments that occurred before the pandemic, which reshaped and accelerated the trajectory of the energy transition, with nations using investments toward a low-carbon future as a means for a green pandemic recovery. With these filters, 97 relevant publications were obtained.

In line with established systematic review procedures [23], we initially assessed titles, abstracts, and keywords to ensure alignment with the scope of our review. Following this initial screening, we retained 79 documents. During this phase, certain publications were excluded primarily due to their narrow focus on highly specific subjects.

Subsequently, we conducted a comprehensive reading of the papers in this final selection, leading to the exclusion of nine manuscripts that did not sufficiently align with the objectives of our review. Details of the final papers in our data set are provided in the Appendix in Table A, containing a summary of the articles, and in Figure A, presenting the distribution of articles by year.

In the following section, we present the descriptive findings in relation to the selected documents. This sets the context for a discussion on Section 5 on how political and industrial economists can advance the literature on energy transitions, stressing the topics that are being neglected or at least regarded as peripheral to this debate.

4. Results

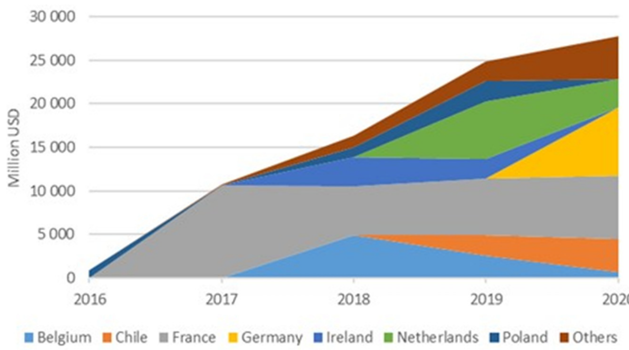
The results, which reveal the breadth of research on the determinants of a low-carbon energy transition, were grouped into four main subsections according to the four processes that arise from the analyzed literature and that, once combined, can originate a transition – economic and markets, technological, social, and political. Each subsection presents an overview of the main transition determinants.

4.1. Economic and market factors

This subsection is focused on the three main economic players according to the selected literature: general firms, investors, and fossil fuel incumbent firms. All of them have a crucial role when triggering a transition, even though some incentives (provided by policies) are generally needed.

Enterprises can have a leading role in the transition to a low-carbon economy. The discourse surrounding the mitigation of global climate change and the associated reduction of greenhouse gases (GHGs) is increasingly emphasizing the role that businesses can and perhaps should assume. Fierce market competition, coupled with government incentive policies and growing consumer demand for environmentally friendly products, drives firms to expand their innovative capabilities. Since firms have a crucial role in the selection and control of production processes, their choices and willingness to adopt sustainable approaches shape the diffusion of low-carbon strategies and the means by which solutions are introduced to the market [24–27].

Figure 2
Sovereign Green Bond Issuance



Note: Data as of July 2020. "Others" include Fiji (2017), Hong Kong (China) (2019), Hungary (2020), Indonesia (2018, 2019 and 2020), Lithuania (2018), South Korea (2019), Nigeria (2017), Seychelles (2018) and Sweden (2020).

When taking the decision to innovate in sustainable and low-carbon solutions, firms are influenced by a wide range of socio-economic and institutional factors, which can be internal (such as resources, capabilities, or company's managerial culture) or external (such as regulation or market structure). These factors are determinants (drivers or barriers) of innovation and can, ultimately, make or break a transition toward a low-carbon future [28–30].

When considering internal factors, a critical prerequisite for companies to make tangible progress and succeed in a low-carbon transition is their endorsement of market-based environmental policies. Consequently, as businesses confront mounting social and environmental challenges, their leadership must be able to steer the company toward sustainable economic growth, all while striving to achieve a triple-bottom line of economic, environmental, and social value creation. This entails that leaders must develop strategies capable of harmonizing multiple and potentially conflicting objectives [30, 31].

One must stress the role of top-level management commitment and environmental behavior, which is widely present in the body of literature analyzed. Employees' support, especially within senior management ranks, plays a pivotal role in fostering environmentally responsible behavior. Given that technological change often require substantial investments, innovation, and the incorporation of environmental technologies, having top-level management keen on environmental considerations is advantageous, ultimately leading to the development of proactive environmental strategies [28, 31–34].

Concerning external factors, environmental regulations often carry significant influence in driving companies to develop and integrate environmental technologies. Nations that are poised for a transition toward a low-carbon framework are those in which both obstacles and incentives are thoroughly addressed and regulatory measures send a clear signal of commitment. Conversely, in markets where obstacles and incentives receive only partial attention and policies remain limited and incomplete, progress tends to align with an incremental change scenario rather than a radical transition [28, 31, 35, 36].

Another powerful external factor is the market structure, particularly one characterized by competition and stakeholder pressure. Firms operating within more competitive landscapes often exhibit a propensity for greater risk-taking, as these environments offer enhanced prospects for leveraging innovation. Moreover, the need to enhance corporate legitimacy and gain a competitive edge in the market compels companies to enhance their sustainability practices, even in the absence of regulatory pressures [25, 28, 37].

Economic stability also significantly impacts sustainable practices. As noted by Pinkse and Kolk [25], an economic slowdown highlights some contradictions in terms of climate impacts. Whereas a recession may be helpful for reducing carbon emissions and meeting international agreements targets, it is not beneficial for attracting investments in renewable energy and energy-efficiency. Indeed, stable economic and political circumstances can aid a low-carbon transition since more conducive contexts enable companies to direct their resources toward operational and strategic concerns [37–39].

Finally, a pro-environmental social climate can incentivize corporate responsibility for environmental protection and energy conservation. When businesses are part of a social community that places a high value on environmental concerns, they are more likely to embrace pro-environmental principles. In fact, many companies voluntarily participate in environmental initiatives to meet societal expectations [30].

Regarding incumbency, it is widely accepted that fossil fuel players are one of the factors hampering the transition [16, 40]. Emerging low-carbon technologies often do not align with the prevailing engineering and institutional framework. In fact, the existing energy structure was mostly developed and designed to use electricity generated from fossil fuels. This creates a carbon lock-in and path dependency toward fossil fuels, which in turn hinder investments in alternative infrastructures [40–45].

For this reason, during the initial stages of business development and market entry, specialized technology-specific mechanisms are imperative for niche low-carbon innovations. In the absence of such support, the lock-in effects of incumbent technologies offer incentives to concentrate the investment in incremental innovation (along with existing trajectories), with the consequence that potentially disruptive technologies cannot emerge.

Quoting Ahmad et al. [37], "sustainable development is, in essence, a strategic problem," and involvement in low-carbon practices and technologies can provide firms with first-mover advantage for future energy systems, while addressing emissions reduction pressure. It is crucial to shift toward post-fossil fuel consumption and production technologies, as well as chart a new path for the adoption and widespread use of innovative technologies.

4.1.1. Investment

Investments in environmental technological change and innovation are also central determinants of an energy transition, as abundance (lack) of financial capital can drive (hamper) technological development [29, 38, 46]. Still, according to Masini and Menichetti [46], the reason behind the limited diffusion of low-carbon alternative technologies is that private finance has played a relatively marginal role in the industry up until this point. For instance, around 2020 only 16 countries had so far issued green bonds to finance green projects in governments' budgets as Figure 2 [47] shows, and the size of the sovereign green bond market was extremely small when compared to the market of traditional bonds.

Radical innovative systems, which hold significant long-term potential for a sustainable low-carbon energy transition, struggle to attract the amount of capital needed to fund their initial high investments. Committing capital to renewable energy funds carries both financial and opportunity costs when compared to conventional funds. Nevertheless, renewable energy mutual funds serve as essential financial instruments for channeling private resources into climate finance [25, 46, 48]. Furthermore, prevailing investment strategies tend to exhibit short-term myopia because they reduce valuable opportunities for diversifying energy portfolios and hedging against price fluctuations [46, 49].

The investment process and an agent's willingness to invest in low-carbon energy technologies are affected by the a priori beliefs the investor has on the low-carbon technologies and on the regulatory context in which he/she operates. It is also affected by the extent to which investors respond to institutional pressure. Typically, decision makers tend to conform to the rules and the norms prevailing in their institutional environment (the so-called institutional isomorphism). Finally, the lack of propensity to invest in radical technological innovations with a high degree of technical uncertainty also influences the propensity to invest in low-carbon technologies. Indeed, the energy sector presents different forms of uncertainty, including regulatory, technical, and market uncertainty [25, 46].

Marti-Ballester [48] states that investments in renewable energy funds have a financial cost in relation to conventional funds, so investors are paying a premium for investing in mutual funds that implement renewable energy criteria. Still, renewable energy mutual funds are crucial as financial instruments for moving private resources into climate finance, but managers must be able to increase investor's wealth by adopting sustainable and low-carbon solutions in their portfolios.

Using China as an example, the natural emergence of green finance is evident as the country adopted green development as a key national strategy to achieve sustainable long-term objectives. Indeed, Jin and Han [50] show evidence that green funds' industry preference has a positive impact on innovation and R&D activities. As a result, green funds can work as a financial catalyst, driving green technological innovation within industries. In addition, implementing sustainability accounting, sustainable financing, and regulations contributes to establishing a green financing system in emerging economies [51]. It should also be noted that recent evidence shows that green finance promotes renewable energy not only directly but also indirectly by driving R&D, enhancing market openness, and expanding economic activity [52].

4.2. Technological factors

Technological eco-innovation can reduce our reliance on fossil fuels, addressing one of the most critical challenges posed by climate change. This type of innovations can be a critical initiator of a low-carbon transition and act as a link between environmental regulation and green growth [16, 24, 25, 29, 36, 38, 45, 53–56].

For these eco-technologies to displace other, more conventional, technologies, they must present a superior performance and become widely adopted through the action of market forces. Yet, in the absence of policy regulations, low-carbon-related markets may not be able to produce sufficient incentives to replace conventional technologies [45, 57, 58]. Given that the characteristics of the technology and domestic policy are the most influential technological change factors, successful transformations are characterized by strong national commitment to the technologies and a pre-existing supportive socio-technical structure. The interaction among these two factors influences the rate and direction of the technological change [28, 59].

In terms of sectoral technological change, the two sectors widely referred in the literature as potential propellers of change are the urban and the mobility sectors. Essentially, cities are drivers of global ecosystem changes because, as innovation hubs, concentrated centers of production, consumption, and waste disposal, they have the ability to make relevant actors, sometimes with contrasting interests, interact toward the sustainability of the urban system [55, 60–65]. Hence, cities present the right context to apply climate change policies and strategies [44, 61, 63, 66].

Mobility, especially urban mobility, is also acquiring an increasingly central role in supporting the future development of sustainable and low-carbon infrastructures [44, 67]. According to the literature assessed, there are two (interlinked) approaches to reach the full potential of efficient low-carbon transportation in densely populated urban areas: the use of electric vehicles (EV) and the implementation of car-sharing systems [35, 53, 62, 67, 68]. Ideally, low-carbon mobility technologies would be strongly subsidized until becoming competitive with incumbent technologies. Yet, policymakers face budgetary limitations and subsidies are often shortened or cancelled early [69]. For this reason, policymakers tend to promote hybrid mobility solutions, primarily through emissions regulations and tax incentives, applied in a way that allows most needs to still be met by internal combustion engine solutions [53].

Currently, the main advantage of low-carbon technologies may be the social benefit of helping to mitigate environmental hazards, rather than the private benefits to users of those technologies [16]. Some authors support the implementation of a carbon price (for instance through a tradable permit scheme such as the European Union Emission Trading Scheme (EU ETS)) to convert this social benefit to a private benefit and overcome this barrier to technological change[6]. Naqvi and Stockhammer [70] suggest continuously increasing market-based carbon taxes and subsidies over a long-run perspective to achieve a green transition, instead of chasing a one-time optimal target level.

While eco-innovations and sectoral technological change are certainly a necessity for achieving a low-carbon energy system, they are not a panacea for climate change, as technological progress does not automatically translate into green and sustainable growth. Consequently, other complementary measures must be enacted [38].

4.3. Social (behavioral) factors

Informal institutions, such as consumption habits and behavioral patterns, can play a significant role in either advancing or impeding a sustainable transition. Individual aspects like convenience, cultural inclinations, risk tolerance, and openness to new products also exert influence on the dynamics of transitions [38, 69].

The importance of the consumers in an energy transition is clear across the literature, as the consumers' behavior and product preferences can be a critical aspect to firms' strategic choices. Hence, consumers' behavior is another factor that can facilitate a transition toward a low-carbon path [24, 26, 41, 71]. Indeed, the rate of low-carbon adoption can potentially achieve full saturation, up to 100%, if all consumers transition into "green consumers" – individuals who exclusively purchase low-carbon products and are both willing and financially able to pay a premium for such products. As consumer environmental consciousness grows and their willingness to pay for low-carbon products increases, the demand structure changes, which in turn influences firms' strategic choices [24, 26].

Moreover, it is becoming clear that a low-carbon sustainable transition needs to be accompanied by strong sustainable consumption, even though consumption is still pretty much cost driven. Spangenberg and Lorek [72] establish the normative concept of sufficiency (or "enoughness") as the main solution to reach sustainable consumption. This notion is a result of the acknowledged fact that the levels, rather than the patterns of consumption, are what causes environmental degradation. The authors note that sufficiency requires radical change and incremental steps will not be enough[7].

Consequently, it is imperative to consider both production and consumption aspects when overseeing an energy transition. Still, as noted by Blok et al. [24], policies and programs are generally more focused on the production side than on the consumption side. One possible reason might be that, historically, policies and regulations were initially focused on end-of-pipe solutions (a pollution control approach that remediates the harm already done). Additionally, existing perspectives, social traditions, infrastructures, and power structures all constrain transformation [42].

Thus, institutional changes ought to be made, and regulations, societal norms, and values must shift to make low-carbon products competitive [24, 35, 42].

4.4. Environmental policy

Addressing climate change is a public good, so an effective and systemic environmental policy is vital to instigate a shift toward a low-carbon system and to avoid the risks associated with partial or incremental measures. Environmental policy can destabilize the regime and foster new sustainable innovations and infrastructures, influencing and accelerating the diffusion of low-carbon-related solutions [16, 25, 28, 38, 40, 49, 57, 71, 73, 74]. Thus, the political drivers are the ultimate drivers; they can prompt change on their own, but they are also necessary to induce change in the other economic, technological, and social dimensions.

Yet, as noted by Stokes and Breetz [49], a low-carbon energy transition can be constrained by political barriers. The effectiveness of environmental policy strategies depends on their coherence, credibility, and comprehensiveness, with a key requirement being the transmission of clear signals regarding future interventions [38, 45, 66, 75, 76]. Since a low-carbon transition takes place over a long period of time, no single government can launch and sustain it. As a solution, Dumas et al. [77] suggest that governments should consider different electoral scenarios when planning a transition, bearing in mind technological change and the effects that energy policy can have on electoral results.

Additionally, while climate change is a global problem, effective actions need to be tailored to different temporal and spatial scales, ranging from local to global and from domestic energy policies to international agreements. Pasimeni et al. [55] advocate for the coordinated engagement of lower institutional levels, like municipalities, to implement more effective climate

[6]For instance, when a firm participating in the ETS becomes more efficient and less pollutant, it can sell the surplus of allowances to other more polluting companies, and profit from helping to mitigate climate change.

[7]Within the field of sustainability transitions, radical change refers to significant and transformative shifts in technological, economic, and societal systems [see, for instance, the work of Geels et al. [96]]. These changes are often characterized by a departure from existing norms and practices and the adoption of fundamentally different approaches or technologies. Accordingly, the innovations generated can have several dimensions, such as a new behavioral practice (e.g., car sharing), a new technology (e.g., storage technologies), or a new business model (e.g., energy service companies).

and energy policies. This bottom-up approach empowers municipalities to shape strategies, policies, and targets that align with their unique characteristics, thereby improving the quality of life for their residents while contributing to broader global goals.

Ultimately, this bottom-up implementation of environmental policy might lead to a democratization of the energy system. The notion of energy democracy stands for an energy system more decentralized (far from the corporate, utility-scale energy model) and socially controlled. The political power and decision-making are transferred from a central structure to a more local and regional level, wherein the state, municipalities, trade unions, and cooperatives all play significant roles [78]. This democratization process may already be underway, as decentralized individual, community, and cooperative renewable energy producers are gaining traction within electricity markets (prosuming) and emerging as influential political entities [79–81].

To analyze the political dimension of an energy transition, it is necessary to distinguish between general policies, which are formulated based on a specific future objective, typically established at the state level, and specific policy instruments, which encompass the various tools accessible to decision-making entities [40]. For instance, where the overall national policy might be 20% of deployment of renewable energy, policy instruments might include feed-in-tariffs or carbon taxes.

The next two subsections are divided accordingly. First, in Section 4.4.1., the three principal goals of environmental policy for a low-carbon transition are discussed: deployment of renewable energy, increase in energy efficiency, and implementation of a circular economy. Then, in Subsection 4.4.2., the policy instruments expected to support the achievement of these goals are presented.

4.4.1. Policy pathways for a low-carbon transition

Currently, energy policies are gravitating toward the three catalysts of a low-carbon transition discussed below: wide usage of renewable energies, a more efficient energy system, and a more circular economic system. One example is the case of the European Union, which displays specific targets toward time for the share of renewable energy in electricity production, for reductions in energy intensity and, in 2020, introduced a new Circular Economy Action Plan. This plan stands as a cornerstone within its broader agenda for sustainable growth, known as the European Green Deal.

Renewable energy sources are central in political discussions. Increasing the proportion of renewables is a pivotal strategy in addressing climate-related issues and replacing limited resource inputs in industrial operations. This presents an unparalleled opportunity to transition from fossil fuel-dominant systems to those centered around renewable sources [24, 77, 78, 82, 83].

According to Masini and Menichetti [46] and Hultman et al. [57], institutional and behavior factors, as well as market formation and competition, are key dimensions in determining the share of renewable energy in countries. A wide range of factors motivate renewable targeted policy, with examples including air quality and emissions, the creation of green jobs, the security of energy supply, economic growth, and reduction of poverty and inequality [36, 49, 83–86].

Energy efficiency also stands as a central conceptual and procedural policy strategy assisting policymakers in facilitating a sustainable transition. Furthermore, embracing an eco-efficiency approach encourages firms to enrich product differentiation for their customers while aiding managers in discovering more sustainable and efficient practices [16, 24, 65, 72, 87].

Energy efficiency regulations aim to reduce the energy intensity of economic activities, thereby minimizing the amount of primary energy consumed per unit of GDP. Both institutions and technological progress play crucial roles in developing and optimizing global energy efficiency. According to Sun et al. [65], countries with robust institutional frameworks tend to prioritize sustainable economic development and prosperity, which inadvertently leads to gains in energy efficiency and progress toward climate change objectives. Consequently, there is a significant positive impact from both technological progress (through eco-innovation) and institutional quality on energy efficiency improvements. Additional factors influencing energy efficiency encompass variations in relative factor prices, specialization patterns, and rebound effects [42, 72].

Finally, the development of a circular (low-carbon) economy arises as a solution to deal with the dependency that rapid economic development has on resources and energy consumption, and to manage the resulting waste [24, 61, 71, 88]. The circular economy approach advocates for a shift from the linear economy model, characterized by one-way processes of extraction, production, distribution, consumption, and disposal, to a continuously regenerative economic system [61].

The implementation of a circular economy depends not only on cooperation and multi-actor systemic integration but also on the eco-innovation system, which, in turn, is significantly influenced by government support for the advancement of low-carbon technology, as well as sustainable waste disposal practices. Additionally, entrepreneurial activity and corporate middle management also play a decisive role. Thus, facilitating and promoting the development of a circular economy rely on institutional and regulatory drivers [61, 88].

4.4.2. Policy instruments

Different sets of policy instruments generate different technological paths, while offering institutional incentives for both continuous improvement and disruptive transformations [43].

The overall objective of an optimal environmental tax is to internalize negative externalities and so energy taxation can be used as an appropriate instrument to influence energy demand. Naqvi and Stockhammer [70] show that continuously increased market-based taxes facilitate a green transition. Additionally, these environmental taxes help closing the technological gap created through path dependencies by supporting or hindering the development and market introduction of relevant technologies [89].

Yet, energy taxation must be combined with planned government spending and public incentives, like subsidies, to further spur demand and boost investment, which highlights the need for a coordinated mix of policy instruments favoring the change toward clean technologies while keeping the economy on a growth path [32, 57, 70, 90].

Additionally, the implementation of a carbon price is perceived as one of the most efficient ways for nations to reduce carbon emissions. Carbon regulations, whether in the form of carbon taxes or tradable emissions permits (e.g., the EU ETS) (such as the EU ETS), simultaneously internalize the negative externality of carbon emissions and facilitate the uptake of low-carbon technologies, which can harness positive externalities and spillover effects [16, 43, 91, 92].

Independently of all the options available in terms of mechanisms, what all authors agree is that policymakers need to combine different instruments, each with its distinct policy goals, into a comprehensive policy mix aimed at addressing diverse energy drivers.

Thus, several authors reject the use of a one-size-fits-all policy approach to promote green growth. Instead, they endorse the alignment of proven effective support mechanisms and the use of a diverse and flexible policy mix. Ideally, this policy mix should be implemented by a committed and credible government represented in different domains and institutional levels [38, 55, 56, 89, 93].

5. Discussion

The need to shift from the fossil fuel-dependent production model and consumption style to a low-carbon paradigm is widely supported. A low-carbon paradigm refers to a shift in societal and economic practices toward reducing GHG emissions and mitigating climate change. It involves adopting strategies and technologies that produce fewer carbon emissions, primarily by reducing the use of fossil fuels and increasing energy efficiency. It is driven by the recognition that continued reliance on fossil fuels and the current patterns of consumption are unsustainable in the face of climate change and environmental degradation. This change demands a coordinated effort from the society, largely triggered by integrated and committed policy agendas, and with facilitators from the economic, technological, and social fields.

This systematic literature review has examined the drivers and political pathways that can assist and accelerate a clean energy transition. These findings have important implications for public decision makers, managers, and other stakeholders concerned with implementing low-carbon measures and policies in their institutional frameworks. Understanding better these factors and policy instruments can create a fruitful path to achieving global emissions reductions and a clean energy system.

The literature widely covers the economic and market perspectives on how to facilitate an energy transition. A set of best practices and strategies for companies is presented within this systematic literature review. Indeed, these best practices include the importance of firms' having sustainable choices regarding the selection and control of production processes, since the willingness to adopt sustainable approaches by firms directly shapes the diffusion of low-carbon strategies. Ultimately, firms have the ability to influence which solutions are introduced in the market and the pace of integration and diffusion of such solutions within the economic and energy system. Regarding leadership and top management, the literature stresses the crucial role of top-level management commitment and environmental behavior, as well as the need for leaders to develop strategies capable of harmonizing multiple and potentially conflicting objectives of economic, environmental, and social value creation. Indeed, another example of a critical prerequisite for firms to make tangible progress toward a low-carbon future is their clear endorsement of market-based environmental policies.

In addition, the role of investors is highlighted, and the incumbency of fossil fuels is recognized as one of the main factors blocking a transition. From the firms' viewpoint, it is relevant to explore how will competition look like in renewables-dominated markets. Will market power decrease as easiness to enter the market increases, due to the enhanced role that both municipalities and households (prosumers) play in the energy markets? Will the lower cost of renewables be appropriated by the producers or passed on to consumers? Which price discriminations strategies should we expect? How relevant are the impacts of renewables capacity constraints and demand fluctuations? What is the role of regulation in these markets? All these are questions for energy economists to answer, in an expected and promising approach to the energy field.

From the perspective of fossil fuel incumbents, it is relevant to investigate their participation in these renewables-dominated markets, especially when assuming that the intermittency of renewables will be a certainty for many years to come. Finally, as fossil fuels will lose their present importance in the energy outlook, it is also relevant to explore what will happen to fossil fuel communities and how can a transition from a fossil fuel system to a decarbonized system take place without devastating consequences for these communities.

Regarding technological factors, the literature analyzed emphasizes the role that eco-innovations and sectoral technological change have on a low-carbon transition. Yet even though the literature broadly agrees on the role and importance that urban regions have on technological change, it generally neglects rural regions. Since many rural regions are characterized by the dichotomy of low income and abundance of renewable resources opportunities, future research should consider distributive matters between the two regions. Cities are expected to present a high level of energy consumption and a low level of energy generation, while rural areas are expected to present a low level of consumption but a high level of energy generation. Thus, two questions arise: (1) how energy wealth should be distributed between the two regions and (2) which region will detain more decision-making power, the consumers (urban) or the generators (rural).

Within the four groups of drivers that structured the literature review, the social driver's group is the one that has received the least attention in the literature up until this point. As hypothesized in Section 2, this may be due to the fact that, traditionally, environmental problems triggered mainly technological fixes and actions required from firms and other market players. For instance, of the 70 articles analyzed only less than 9% cover social topics and only one paper [94] discusses the energy justice of a low-carbon transition.

Lastly, the political environment has a transversal and crucial role managing all the institutional factors and upscaling and bridging a low-carbon transition. Thus, political motivations are the ultimate drivers of change. As noted by Johnstone et al. [40] and Pitkänen et al. [36], sustainable transitions are rarely based on pure win–win outcomes and policy instruments do not act in isolation. Therefore, the negotiation between multiple goals and diverse stakeholders with varying priorities can help mitigate conflicts and eliminate barriers. Further research should investigate the role of environmental policy instruments, revenue use options regarding carbon pricing and respective distributional implications, and the future of taxation in a decarbonized society, bearing in mind that taxes collected by the government due to fossil fuels and other pollutant sources use will considerably decrease.

When discussing the need for an energy transition, emphasis is almost always focused on GHGs emission mitigation. However, it should be noted that such transition and the mass production of renewable energy might have some negative impacts that are often neglected. These may include stress on biochemical flows, alterations in land use, implications on biodiversity, oceans, and climate systems, among others. Indeed, determining the energy mix for a transition toward deep decarbonization involves ethical decisions, given the far-reaching impacts of energy-related choices on economics, the environment, and society. Questions such as the preservation of ecosystems for current and future generations, the prevention of resource use conflicts, and the mitigation of adverse effects on human lives resulting from energy extraction should all be taken into account when formulating future policies and instruments.

Despite the effort of several countries toward a green path, shifts to more sustainable and low-carbon forms of energy production are not occurring at the rates deemed necessary. According to several authors, most policy instruments are largely applied in ways that favor incremental innovation. In order to meet the agreed ambitious climate targets, transformation of the energy system needs to be accelerated. Radical change is required to successfully tackle climate change, leaving policy incrementalism and existing practices behind. All actors involved should think outside the box and beyond the current path.

The COVID-19 era and the following economic repercussions pose a challenge to the acceleration of the low-carbon transition. However, one should recall that while economic stability plays a role in facilitating the transition, environmental policy remains the primary determinant of progress and success toward a low-carbon path. If effectively managed with good governance, such disruption has the potential to bring about significant and enduring changes in economic structures, promoting carbon neutrality and shifting away from systems and lifestyles characterized by overproduction and overconsumption. This shift is critical for steering toward a more sustainable trajectory for the future, as it is the level of consumption, rather than consumption patterns, that causes environmental problems.

Indeed, focusing on practical implications and providing examples of good governance arising from this systematic literature review, one should consider engaging a wide range of stakeholders, such as environmental organizations, firms and industry, local communities, and the public. This helps ensure that different perspectives are considered in policy development and decision-making. In addition, long-term planning, which goes beyond the immediate political cycle, and clear goals are also required to provide stability and signal government commitment. Indeed, while implementing incentives, such as subsidies, tax breaks, and grants, can encourage the adoption of clean energy technologies and practices, establishing clear and consistent regulatory frameworks is also essential for the development and operation of clean energy projects. Local governance initiatives, such as supporting community-based renewable energy projects or initiatives to improve energy efficiency in buildings, are also crucial in influencing the transition to a low-carbon energy paradigm. Finally, governments should also invest in public awareness and education campaigns to inform citizens about the importance of the low-carbon energy transition, energy conservation, and sustainable consumption practices.

One should be aware that, in the time period considered in this systematic literature review, the literature is widely focused on policies created and employed by developed countries with high-income levels. This leaves the field blank for developing nations with lower incomes. Indeed, the only exception is the work of Opeyemi et al. [83], which investigates the shift toward renewable energy adoption in Sub-Saharan Africa. For these countries, economic growth is intricately linked with the extraction of primary products (highly energy-intensive activities), and institutions, stability, investment, and technology transition oriented are still lagging or even lacking. Yet, these are the countries with fewer carbon lock-ins and less path dependency on a fossil fuel system, which provides some prospects for an accelerated transition. Consequently, there is a critical need for research that specifically addresses lower-income countries. This research should aim to identify the factors that facilitate a transition to low-carbon energy and best practices, thus ensuring a successful and timely transition within these nations.

6. Conclusion

The implementation of a low-carbon transition is related to a myriad of factors and causalities depending on the economic, technological, social, and political context.

This paper provides a systematic literature review of the main factors influencing the low-carbon energy transition in the literature between 2009 and 2019, the first decade of relevant research regarding the energy transition. The goal is to focus on paths and developments that occurred before the pandemic reshaped and accelerated the trajectory of the energy transition. A bibliographic search is employed, using the Scopus LibGuide, to extract academically relevant content from the fields of Economics, Econometrics and Finance, Engineering, Energy, and Environmental Sciences.

Most of the research developed in the last decade covers measures to initiate and facilitate an energy transition in developed countries. In addition, environmental policy arises as the foremost factor influencing progress and achievements in moving toward a low-carbon trajectory. What is needed now is the engagement of industrial and political economists as well as energy practitioners to ensure that this clean energy transition will result in an equitable and just decarbonized society, not only in high-income and developed countries but globally. Pitkänen et al. [36] recommend patient, meticulous, and forward-thinking planning, coupled with continuous learning and the ability to adapt based on past experiences, as essential strategies for successfully implementing such a crucial societal shift.

Regarding the limitations of this paper, even though systematic literature reviews are a valuable tool for summarizing and synthesizing existing research, there are limitations associated with following this approach. First, this methodology depends on the availability of published research and some studies may not be included in the review due to language barriers. Second, there might be an overrepresentation of positive findings and an underrepresentation of studies with null or negative results due to publication bias (the tendency for articles with positive or significant results to be more likely to get published). Third, the results are influenced by the scope of the review and the search terms used. Yet, we took into consideration these limitations and addressed them as much as possible, especially concerning the data extraction and selection of the search terms. Nevertheless, future research should include more search terms as the energy transition evolves toward new fields of knowledge. Special attention should be given to power and energy firms since they represent an important part of the energy mix and have increasingly directed their investments toward the development of clean and renewable technologies in recent years. In addition, a literature review focused on bibliographic information of articles published in the pandemic and post-pandemic context (2020–2023) would also be fruitful to assess priority shifts and compare the results regarding the drivers for low-carbon energy transition in the post-COVID-19 era.

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Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data sharing is not applicable to this paper as no new data were created or analyzed in this study.

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Appendix

Table A
List of the analyzed papers by year of publication

Year	Author	Journal	Factor(s)	Methods/Objectives	Region
2009	del Río González	Ecological Economics	- Economic and market - Technological - Environmental policy	Review of empirical literature regarding determinants for environmental innovation	–
2010	Pinkse and Kolk	Business Strategy and the Environment	- Economic and market - Technological - Environmental policy	Review of firm-level literature focused on corporate innovation for climate change	–
2010	Bleischwitz and Bader	Energy Policy	- Environmental policy	Analysis of EU policy framework	European Union
2012	Firnkorn and Müller	Business Strategy and the Environment	- Technological	Empirical analysis of mobility data collected by survey	–
2012	Pearson and Foxon	Energy Policy	- Economic and market - Technological - Social - Environmental policy	Review of literature regarding previous industrial revolutions	–
2012	Hultman et al.	Energy Policy	- Technological - Social - Environmental policy	Case selection, interviews, and survey analysis regarding nuclear and bioenergy	Brazil, Sweden, and the United States of America
2012	Midttun	Energy Policy	- Economic and market - Environmental policy	Analysis of the electricity industry	European Union
2013	Masini and Menichetti	Technological Forecasting and Social Change	- Economic and market	Empirical analysis of data regarding investment decisions	European Union
2014	Spickermann et al.	Technological Forecasting and Social Change	- Technological	Delphi method for scenario development regarding urban mobility	European Union
2014	Pasimeni et al	Energy Policy	- Technological - Social - Environmental policy	Review of literature regarding climate change, land use, and energy	–
2015	Blok et al.	Journal of Cleaner Production	- Technological - Social - Environmental policy	Review of articles focused on sustainable production and consumption	–
2015	Borghesi and Cainelli	Research Policy	- Environmental policy	Empirical analysis of the effects of the EU ETS	Italy
2015	Ghisetti and Pontoni	Ecological Economics	- Technological	Meta-regression analysis	–
2015	Knopf et al.	Energy Policy	- Environmental policy	Scenario setup and sensitivity analysis of cost-effective renewable energy share	European Union
2015	Olazabal and Pascual	Journal of Cleaner Production	- Technological	Q methodology to explore what underpins a potential local low-carbon transition	Bilbao, Spain
2015	Wang et al.	Journal of Cleaner Production	- Economic and market	Empirical analysis of survey data about the characteristics of managers and their environmental behavior	Shaanxi, China
2015	Bohnsack et al.	Technological Forecasting and Social Change	- Technological	Analysis of archival data from 1997 to 2010 about LEV-specific developments	Europe, Japan, the United States
2016	Nilsson and Nykvist	Applied Energy	- Economic and market - Technological	Multi-level perspective applied to scenario setup and identification of strategies	European Union
2016	Dijk et al.	Technological Forecasting and Social Change	- Technological	Explanatory case study approach to develop a theory of disruptive innovation	Europe and the United States of America
2016	Pasaoglu et al.	Technological Forecasting and Social Change	- Technological	System dynamics simulation model incorporating major factors that influence the technology transition	European Union

(*Continued*)

Table A
(*Continued***)**

Year	Author	Journal	Factor(s)	Methods/Objectives	Region
2016	de Jesus et al.	Journal of Cleaner Production	- Technological - Environmental policy	Review of eco-innovation literature	–
2016	Pitkänen et al.	Journal of Cleaner Production	- Economic and market - Technological - Environmental policy	Definition of case studies to identify approaches for implementing a green economy	Finland, France, Germany, Netherlands, and Denmark
2016	Rogge and Reichardt	Research Policy	- Environmental policy	Review of literature to derive a policy mix concept	–
2016	Yang et al.	Energy Policy	- Economic and market	Empirical analysis based on data collected from surveys regarding carbon market pilots	China
2016	Hirschnitz-Garbers	Journal of Cleaner Production	- Economic and market - Social - Environmental policy	Review of literature on drivers for unsustainable resource use	–
2016	Ydersbond and Korsnes	Energy Research and Social Science	- Environmental policy	Empirical analysis applying most-different systems design in combination with document studies and interviewing	China and the European Union
2016	Mat et al.	Journal of Cleaner Production	- Technological	Socio-ecological system framework to analyze and compare case studies	China, Europe, and South Korea
2016	Dumas et al.	Ecological Economics	- Social - Environmental policy	Dynamic game theory of political competition and renewable energy policy	–
2016	Wu et al.	Applied Energy	- Economic and market	Case study method with empirical data including in-depth interviews of politico-economic strategies	Nanjing, China
2016	Darmani et al.	Energy Research and Social Science	- Economic and market - Social	Longitudinal case study of a Swedish multinational energy company	Sweden
2016	Kang and Hwang	Energy Policy	- Technological	Empirical analysis of network structural properties for innovation performance	European Union
2017	Guo et al.	Journal of Cleaner Production	- Technological - Environmental policy	Empirical analysis to investigate the relationships among regulation, innovation, and green growth performance	China
2017	Wan Ahmad et al. 2017	Journal of Cleaner Production	- Economic and market	Best worst method (MCDM) to assess external forces affecting the sustainability of fossil fuels supply chain	–
2017	Johnstone et al.	Energy Research and Social Science	- Economic and market - Social - Environmental policy	Analysis of policy mixes around renewables and energy efficiency, fracking, and nuclear power	United Kingdom
2017	Ford et al.	Technological Forecasting and Social Change	- Environmental policy	Empirical analysis based on interviews with early adopters of PV, stakeholders, and households	New Zealand
2017	Laakso et al.	Journal of Cleaner Production	- Environmental policy	Meta-study of 25 articles on experimental climate governance	–
2017	Zhao et al.	Journal of Cleaner Production	- Economic and market	System dynamics to model enterprises' compliance with a government policy	China
2017	Cherry et al.	Energy Research and Social Science	- Technological	Expert interviews and public focus groups to explore the visions of a low-carbon future	United Kingdom
2017	Graziano et al.	Energy Research and Social Science	- Environmental policy	Scenario development for the development of a new policy and governance paradigm	Scotland
2018	Burke and Stephens	Energy Research and Social Science	- Environmental policy	Review of literature on energy systems and democratic political power	–
2018	de Jesus and Mendonça	Ecological Economics	- Social - Environmental policy	Review of literature on eco-innovation and the circular economy	–

(*Continued*)

Table A
(*Continued***)**

Year	Author	Journal	Factor(s)	Methods/Objectives	Region
2018	Cherp et al.	Energy Research and Social Science	- Social	Meta-theoretical framework for analyzing national energy transitions	–
2018	Stokes and Breetz	Energy Policy	- Economic and market - Social - Environmental policy	Longitudinal case study for solar, wind, biofuels, and electric vehicles policy	United States of America
2018	Sequeira and Santos	Journal of Cleaner Production	- Environmental policy	Review of literature dealing with politics, policy, and renewable energies	–
2018	Purkus et al.	Journal of Cleaner Production	- Economic and market - Technological - Social	Application of the innovation systems approach to the bioeconomy transition	Germany
2018	Zhao and Chen	Journal of Cleaner Production	- Environmental policy	Multi-facet content analysis and surveys to identify factors affecting the development of renewable energy	China
2018	Moradi and Vagnoni	Technological Forecasting and Social Change	- Economic and market - Technological	Multi-level perspective analysis of urban mobility system dynamics	–
2018	Scarpellini et al.	Journal of Cleaner Production	- Economic and market	Empirical analysis to classify and measure different sets of financial resources applied to eco-innovation	Spain
2018	Inderberg et al.	Energy Research and Social Science	- Environmental policy	Comparison of national case studies	Germany, Norway, and the United Kingdom
2018	Cai and Aoyama	Energy Research and Social Science	- Social	Analysis of multiple axes of institutional misalignments in clean energy transition	China
2018	Dasgupta and de Cian	Energy Research and Social Science	- Environmental policy	Synthesized findings from applied econometrics studies on the influence of institutions	–
2018	Kiefer et al.	Business Strategy and the Environment	- Economic and market - Environmental policy	Review of literature regarding resource-based view and eco-innovation	–
2018	Roelich et al.	Journal of Cleaner Production	- Technological - Social	Semi-structured interviews with municipality officers responsible for energy	United Kingdom
2018	Naqvi and Stockhammer	Ecological Economics	- Technological - Environmental policy	Development of a post-Keynesian ecological macromodel	–
2018	Hillman et al.	Energy Policy	- Social	Semi-structured interviews capturing insights into the social enterprise landscape	North West England
2019	Singh and El-Kassar	Journal of Cleaner Production	- Economic and market	Empirical analysis of survey data about green supply chain and sustainability performance	–
2019	Wang and Zheng	Journal of Cleaner Production	- Social	Evolutionary game theory model on low-carbon diffusion in complex network context	–
2019	Sun et al.	Energy Policy	- Technological - Environmental policy	Empirical analysis of the effects of institutional quality on energy efficiency	Global
2019	Le and Nguyen	Energy Policy	- Economic and market	Empirical analysis of the effects of energy security on economic growth	Global
2019	Brisbois	Energy Research and Social Science	- Environmental policy	Development of a framework for assessing the impact of decentralized ownership of energy on political decisions	–
2019	Schanes et al.	Ecological Economics	- Environmental policy	Scenario narratives development for a low-carbon Europe in 2050	Europe
2019	Opeyemi et al.	Energy Policy	- Environmental policy	Empirical analysis of the role of trade, institutions, renewables, and finance	Sub-Sahara African countries
2019	Guo et al.	Journal of Cleaner Production	- Technological	Empirical analysis of survey data for energy innovations, markets, and socio-technical regimes	China

(*Continued*)

Table A
(*Continued*)

Year	Author	Journal	Factor(s)	Methods/Objectives	Region
2019	Capasso et al.	Technological Forecasting and Social Change	- Economic and market - Technological - Social - Environmental policy	Review of literature on green growth	–
2019	Trencher et al.	Energy Policy	- Environmental policy	Identification of key narratives regarding coal regime actors and other stakeholders	Japan
2019	Turnheim and Nykvist [97]	Research Policy	- Environmental policy	Feasibility analysis of scenarios of multi-faceted sustainability transition pathways	–
2019	Marti-Ballester	Business Strategy and the Environment	- Economic and market	Empirical analysis of the role of mutual funds in sustainability	Europe
2019	Spangenberg and Lorek	Energy Policy	- Social - Environmental policy	Comparison of theories on how to reduce energy consumption	–
2019	Yin et al.	Journal of Cleaner Production	- Environmental policy	Empirical analysis of the evolution of regional low-carbon innovation systems	Yangtze River Delta, China

Figure A
Distribution of the relevant papers by year of publication