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Energy Transition and the Economy: A Review Article

Talat S. Genc and Stephen Kosempel

Special Issue

Public Policies and Development of Renewable Energy

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Review

Energy Transition and the Economy: A Review Article

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Abstract: The global energy sector is in a period of transition, during which time it is expected that renewable and low-carbon energy sources, such as wind and solar, will replace traditional fossil fuels, including oil, gas, and coal. The energy transition is happening not only to limit the environmental impact of fossil fuel production and consumption but also to ensure energy security, reliability, access, affordability, and sustainability. The importance of the energy transition has been amplified by recent events, notably the Russian-Ukraine conflict. Economic, financial, and trade sanctions against Russia, and in particular its oil and gas industry, have forced countries to find new suppliers in the short term, but also to investigate new and more sustainable sources to guarantee long-term energy security. Given the importance of energy, it is perhaps not unexpected that there is a considerable body of recent academic literature, particularly over the last 4–5 years, studying what industries, consumers, governments, and markets can do to help bring about a faster energy transition. In this paper, we provide a review of the literature that pertains to the economic aspects of the energy transition. While our initial search of the literature is targeted at uncovering all relevant articles on the subject, we focus most of our discussion on the most influential articles in prominent journals and articles published in this journal—Energies. This review is intended to help identify active topics and potential research gaps and provide future direction, so we hope it will prove useful to the readers and authors interested in this topic.

Keywords: renewables; conventional energy; pollution; environment; energy transition

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1. Introduction

The energy sector remains reliant on fossil fuels and accounts for the majority of human-caused global warming and greenhouse gas emissions. Most believe that global carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gasses (F-gasses) emissions need to be reduced to avoid more frequent and severe weather events, including heatwaves, devastating floods and droughts, risks to food and water security, population displacement, and loss of lives, jobs, and income. Fortunately, increased scrutiny, both from domestic and international sources, growing interest from the public, and a shift to responsible investing have all contributed to the movement away from the use of traditional energy sources and their harmful environmental effects. The global energy sector is in transition, that is, there is a movement towards greater use of low-carbon and renewable systems of energy production and consumption, such as wind and solar; and away from the use of fossil-based systems, including oil, gas, and coal. The motivation for the transition is not only to limit the environmental impact of the energy sector but also to ensure energy security, reliability, access, affordability, and sustainability. What industries, consumers, firms, governments, and markets can do to help bring about a faster transition and a decarbonized world is currently a very active topic in the academic literature. This article aims to provide a review of this literature.

This literature review is focused on the economic aspects of the energy transition. Our search reveals over 875 articles published on this topic over the last two decades: 2002—2022 (as of 15 October 2022). Perhaps more interesting than the total number is that 70% of these articles were published in the last 6 years. Given the amount of recent

activity in this area, this is a time when a review article may be particularly useful. Given the large number of recent articles on this subject across all journals, we narrow our analysis by focusing primarily on the most influential articles and articles published in this journal—Energies. The set of most influential articles is determined objectively, using a formula based on citations (for details, see Section 2). We also add articles in Energies to our list of discussed papers because the subject of this review article fits well within the scope of this journal, specifically the journal's coverage of all types of energy sources and research in the fields of energy economics and policy, and energy, environment, and sustainable transition. Given the aims and scope of Energies, it is not surprising to find that this journal is one of the top six outlets for research in this area. In fact, Energies would even rank higher as an outlet for economic research pertaining to the energy transition if not for the fact that it is a relatively new journal, with its inaugural issue appearing more towards the middle of our search window in 2008. However, a feature that Energies shares with other related field journals is the large amount of recent activity on energy transition. For Energies, 90% of articles covering economic aspects of energy transition have appeared in the last 6 years. We hope that this review will prove particularly useful to not only the readers and authors of this journal but also to those of other energy research outlets.

This study provides a review of the academic literature on the global transition to clean energy and is related to various other review articles. Given the large body of literature related to the energy transition, these review articles require some focus, and this is what tends to distinguish them. For example, the common characteristic of the review articles by Chang et al. [1], Mohd Chachuli et al. [2], Crespo del Grando et al. [3], Mardani et al. [4,5], Horschig and Thrän [6], Sueyoshi [7], and Song et al. [8] is that they all review the tools and approaches used to model the energy transition. While we also provide some discussion of the methods used to study issues related to the energy transition, our primary objective is to classify articles with respect to their main research area of emphasis and the energy type being studied. Next, Solomon and Krishna [9], and Fouquet [10] review case studies on past energy transitions to identify common features and lessons for success. These review articles have a more historical focus than ours. Perhaps the most related study to ours is by Zhang et al. [11], which provides a bibliometric review of the energy transition literature. Similar to us, they use the Web of Science (WoS) search tool to identify relevant studies. Their search is for documents that have "clean energy" listed as a keyword, whereas we search more broadly within the title, abstract, and keywords for combinations of the words renewables and environment or pollution. Since our search is broader, we initially obtain a larger set of articles (over 400,000), but we then narrow the list by reviewing only those with an economics focus. In fact, a feature that distinguishes our review from all of the other review articles listed above is its focus on economic aspects of the energy transition. Similar to our review, Jenniches [12] is also in the field of economics; however, his study has a narrower focus in that he reviews only the literature concerning economic impact assessments on a regional scale. There are also review articles, such as our previous work on energy transition, that deal with other subjects. For example, Lima and Miroslava [13] seek to identify strategies for the energy transition by reviewing the environmental engineering literature, whereas Vakulchuk et al. [14] and Hafner and Tagliapietra [15] provide reviews of the literature on the geopolitics of the energy transition.

The remainder of this article is organized as follows: Section 2 provides details of our literature search, and describes the general characteristics of the data. Section 3 examines individual articles more closely. Specifically, we classify the articles first concerning the source of energy (i.e., renewable, conventional, etc.), and then concerning the research area of emphasis. Here, we identify five fields of emphasis: (1) energy, growth, and productivity; (2) energy and finance; (3) energy and environment; (4) energy efficiency and sustainability; and (5) energy and trade. Section 4 provides a comparison of the top-performing articles (based on citations) in Energies to those in other journals. Section 5 concludes by discussing potential gaps in the literature and suggesting future directions.

2. Materials and Methods

The goal of our review is to identify articles written on the economic aspects of the energy transition and further discuss and classify them according to the type of energy studied and their primary area of focus. To review and classify these papers, we searched for relevant publications using the WoS database. We have also carried out the search using the Scopus database. We observe that the Web of Science (WoS) captures more comprehensive outcomes for a given keyword search in relation to renewable energy. Therefore, we choose to use WoS. Our search uses an "AND" string connector within each level and an "OR" connector between levels. In that regard, the keywords we search are "renewable" or "renewables" and "environment" or "pollution." We search for these keywords within the article's title, abstract, and/or keyword list. We restrict the publication years to the interval covering the last two decades: 2002–2022. In our search, we only select articles published or about to be published with the status "early access." Therefore, we ignored books, book chapters, proceedings, and research reports. We focus only on articles dealing with economic aspects of the energy transition by first restricting the publication or citation topic meso to include only economics, and then by including articles only from journals with significant economics content (25 or more papers)(WoS citation topics represent clusters of articles that have common subjects and are connected through citations). In this way, we exclude studies published in other fields such as Environmental Engineering, Energy Fuels, Green Sustainable Science Technology, and others. Based on these criteria, we find 875 relevant articles listed by the WoS. Our WoS search was performed on 15 October 2022. Screenshots of all of the WoS searches that we conducted can be found in Appendix A.

The journals that have published the largest number of articles satisfying the above search criteria are presented in Table 1. The top publisher is Elsevier, with 523 articles. The other publishers are MDPI with 250 articles, Springer Nature with 98 articles, and Kluwer Academic with 4 publications. The volume of publications reported here reveals that renewables-environment-pollution is an active area of research, but it does not reveal the entire story. A more detailed examination of publications in this area by date reveals that 70% of these articles have appeared in the last 6 years (2017–2022). Figure 1 presents publications by year, and the sharp increase observed in publications towards the end of the sample period suggests exponential growth is occurring in this area of research (the 2022 value represents the projected year-end by multiplying the data from January–October by 6/5).

Given the vast number of articles identified by our search criteria, our review must require additional focus. Specifically, we focus our review on the most influential articles and on articles published in this journal (Energies) to examine their features in terms of these papers' research focus, methodology, findings, and policy implications. The analyses in such specifications aim to specify the importance of these studies for policy implications and to identify research gaps between the studies so that we can recommend future research directions.

Table 1. Journals with 50 or more publications covering our search criteria.

Journal Name	Number of Papers
Journal of Cleaner Production	153
Sustainability	141
Energy Economics	109
Environmental Science and Pollution	74
Energy Policy	63
Energies	58

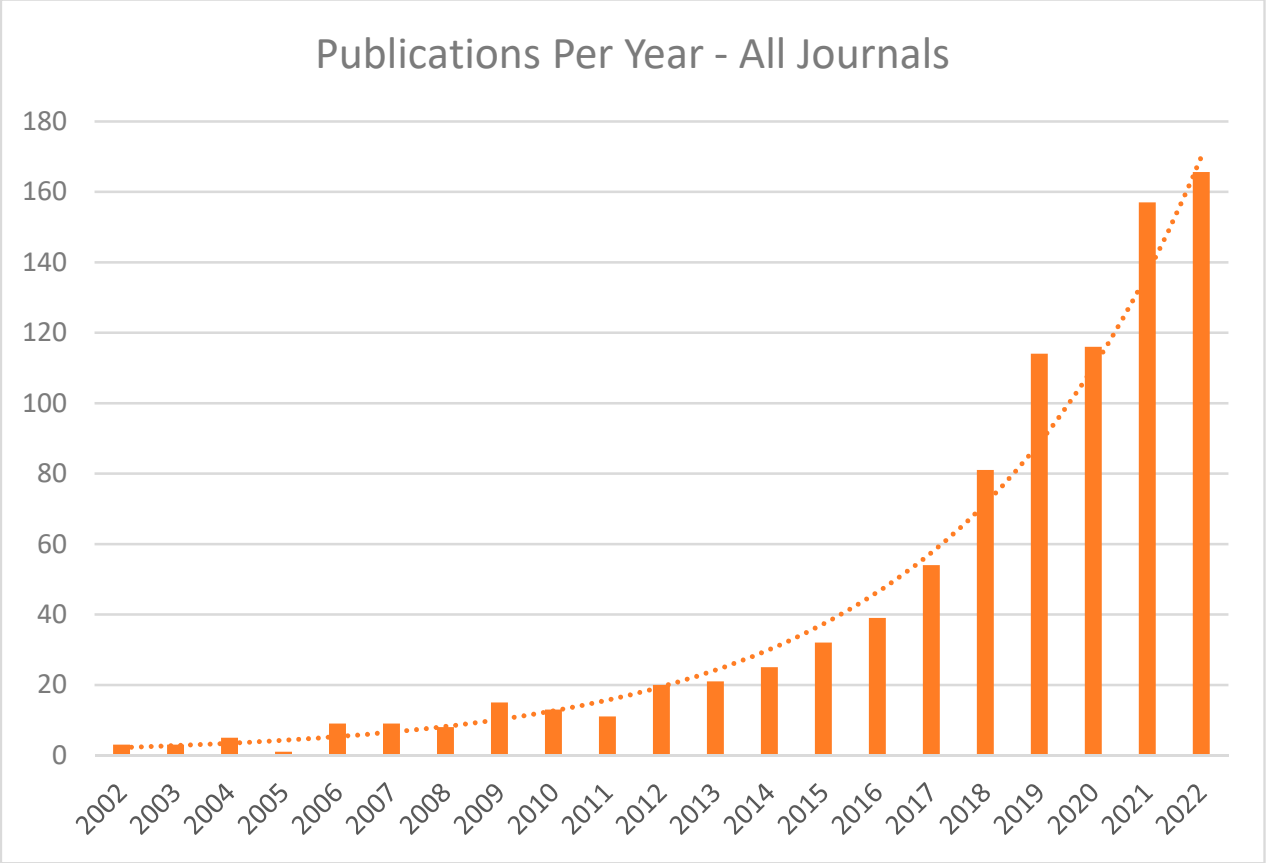

Figure 1. Publication per year, all journals.

Using the same search criteria (keywords, publication year, document type, and citation topic meso) we can narrow our list of articles to the most influential by focusing only on papers covered by our search that are also on the Essential Science Indicators (ESI) list of highly cited papers (ESI are search tools that can be used to identify high-impact publications within the WoS Core Collection. See Appendix A for a screenshot of the search). ESI groups research studies with a common field and year of publication and then ranks them based on the number of citations that they have received. Only publications ranked in the top 1% of each group receive the highly cited designation. Our list of the most influential papers on the topic of the economic aspects of the energy transition includes 31 papers. Citations for these papers range from 7 to 381. While seven citations may seem low, these are for a very recent publication—published in 2022. Recall that to be classified as highly cited an article must perform well relative to other articles that share the same field and publication year. Therefore, newer publications are not likely to require as many citations as older publications to be classified as highly cited. The top 5 outlets for these publications are, in order: Energy Economics with nine papers, Energy Policy with 6 papers, Journal of Cleaner Production with five papers, Resources Policy with four papers, and Journal of Environmental Management with three papers. Data for the most influential papers are presented in Figure 2. Years with zero publications have been omitted from the figure. The results show that all of the most influential papers covering the topic of economic aspects of the energy transition have been published in the last decade, and in fact, 84% (26/31) have appeared in the last 6 years.

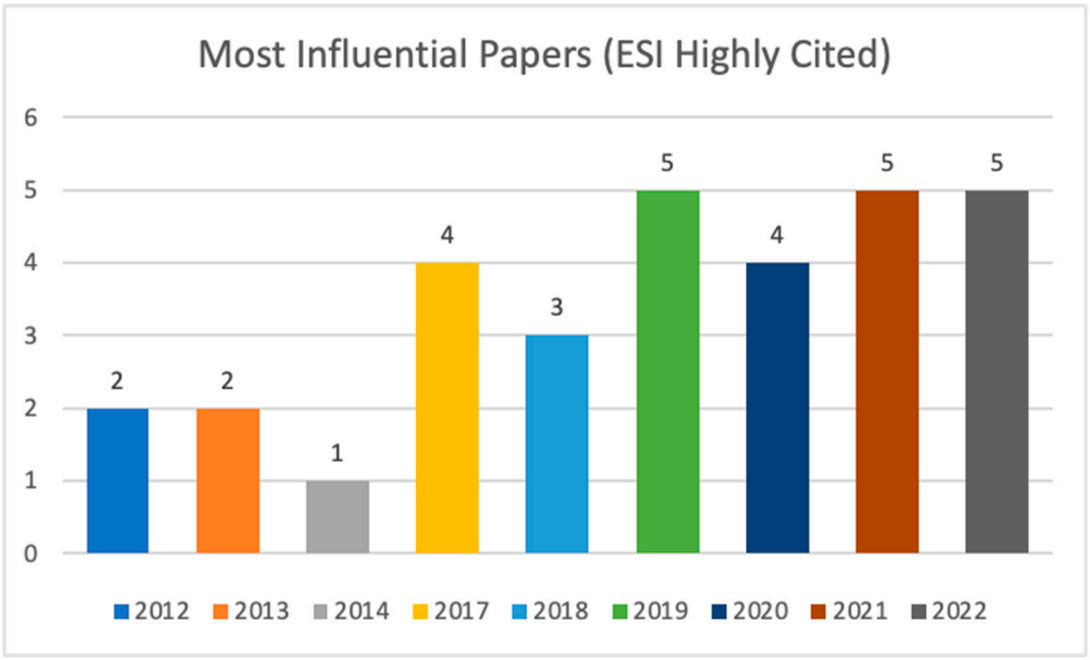

Figure 2. Number of articles versus publication year of most influential articles.

In this article, we also devote some attention to studies published in Energies, and this is because our search criteria fit well within the journal's scope. In Figure 3, we present the number of publications in Energies over the period 2002–2022 based on the same keyword search used above. Similar to before, our search uses the WoS database and was carried out on 15 October 2022. Perhaps noteworthy is first that Energies is a relatively new journal, with its first issue appearing in 2008, and second, if the 2022 number is projected to year-end, then the total will rise above 14. Similar to the general trend in publications, in the most recent years a sharp increase can be observed in articles in Energies that cover economic aspects of the energy transition. For Energies, 83% (48/58) of articles covering economic aspects of energy transition have appeared in the last 4 years.

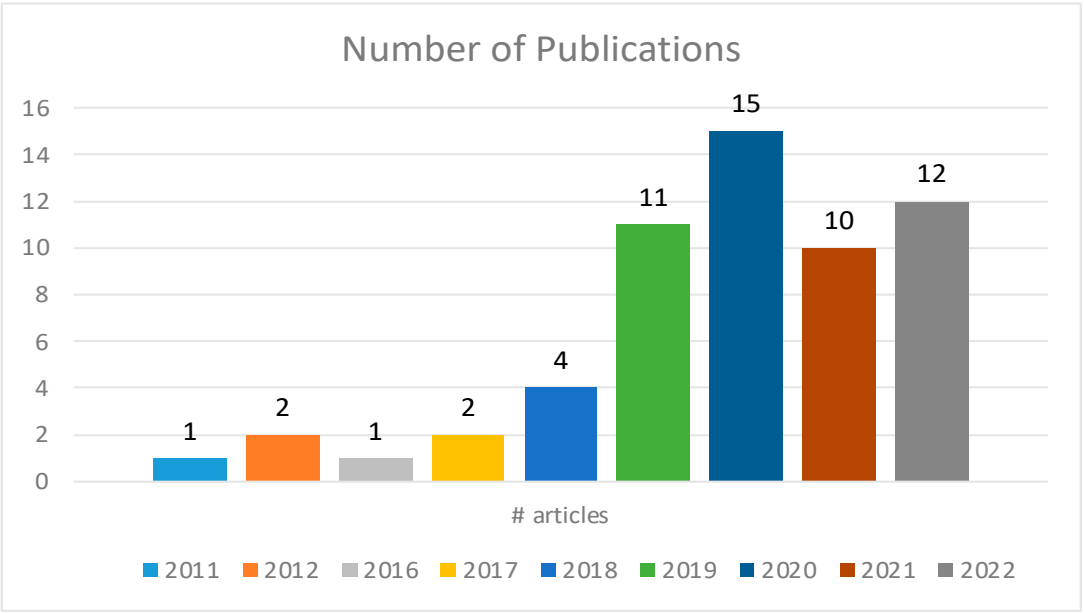

Figure 3. Number of papers versus publication year of the articles in Energies.

3. Classification of Articles: Energy Type and Research Area of Emphasis

In this section, the articles identified by our search criteria are further classified and discussed. More specifically, we will classify our list of articles in terms of the type of energy studied and by primary research area of emphasis. Similar to before, we maintain two sets of articles: (i) the set of 31 most influential articles across all journals, and (ii) the 58 articles published on the topic in Energies. This will enable us to compare the highly cited articles in other journals to the articles published in Energies to pinpoint their differences in terms of research emphasis, methodology, and fuel types examined.

Figures 4 and 5 display the number of publications by energy source. The number at the top of a bar indicates the number of publications. Among the list of influential articles, four categories of fuel sources can be identified: a mix of renewable and conventional energy; renewable energy in general, conventional energy (oil, gas, coal), and unspecified. In comparison, the articles in Energies have a broader and more detailed scope of energy types, which enables us to identify seven categories. In the articles in Energies, we can identify two additional categories of renewables—solar and electricity—and along with our conventional fuels, we add a biofuel category.

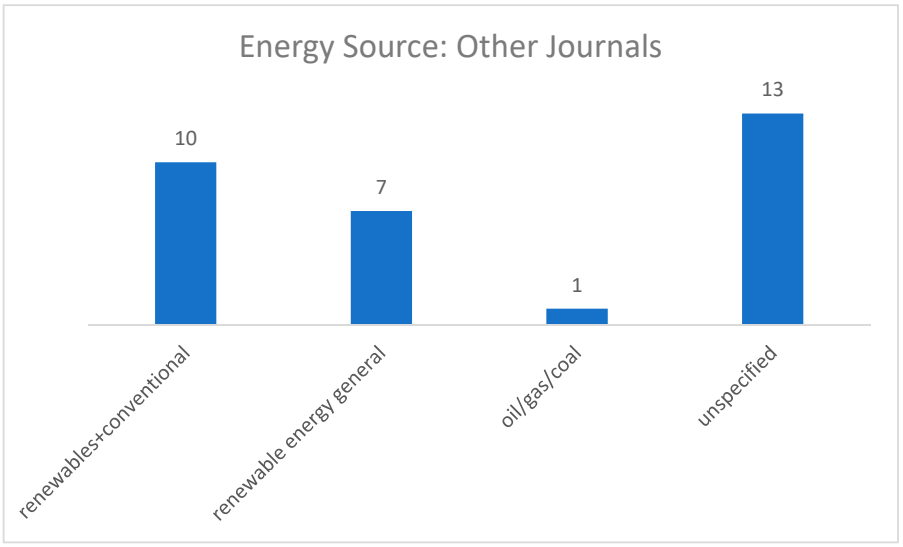

Figure 4. Number of influential articles by type of energy source.

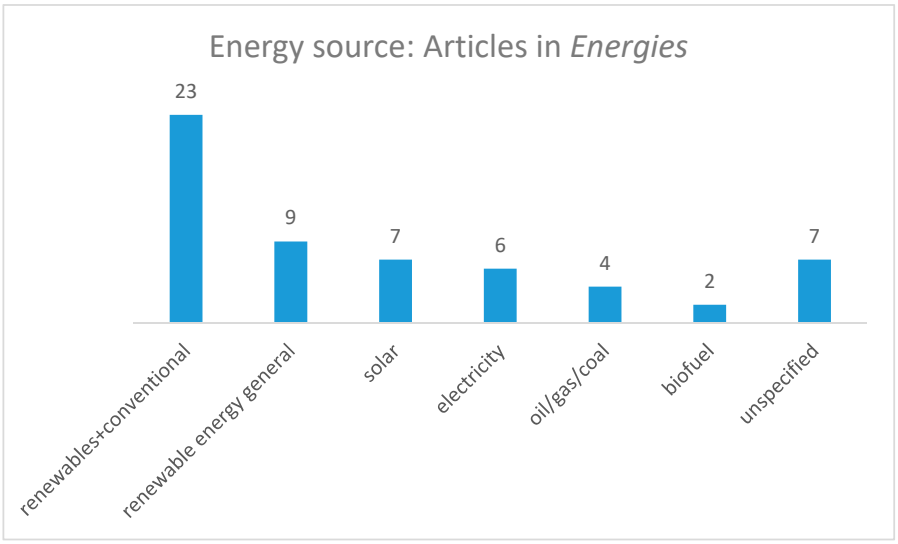

Figure 5. Number of articles in Energies by type of energy source.

In addition to fuel sources, articles will also be categorized according to the research area and emphasis. Based on their primary focus, content, and research questions, we classify the papers into five genres: (1) energy, growth, and productivity; (2) energy and finance; (3) energy and environment; (4) energy efficiency and sustainability; and (5) energy and trade. There is often overlap between categories, and therefore the primary area of focus reflects a judgment call by the authors. In Tables 2 and 3, we report the number of papers in each area and their weight among all the papers.

Table 2. Number of papers by area of emphasis—Most Influential Papers.

Emphasis	No. of Papers	% of Papers
Category 1: Energy, Growth, Productivity	3	9.7
Category 2: Energy and Finance	10	32.3
Category 3: Energy and Environment	11	35.5
Category 4: Energy Efficiency and Sustainability	7	22.6
Category 5: Energy and Trade	0	0
Total	31	100

Table 3. Number of papers by area of emphasis—Energies.

Emphasis	No. of Papers	% of Papers
Category 1: Energy, Growth, Productivity	5	8.6
Category 2: Energy and Finance	24	41.4
Category 3: Energy and Environment	11	19.0
Category 4: Energy Efficiency and Sustainability	16	27.6
Category 5: Energy and Trade	2	3.4
Total	58	100

In the remainder of this section, the articles in each fuel subcategory are discussed in detail, and their primary research areas of emphasis are identified. This information is also summarized in Table 4 at the end of this section.

Table 4. Categorization of Articles.

	Area of Emphasis				
Energy Type	**EGP**	**EF**	**EES**	**EE**	**ET**
RC	[16–21]	[22–40]	[41–44]	[45–48]	
REG	[49,50]	[51–57]	[58–60]	[61–64]	
SOL		[65]	[66–69]	[70]	[71]
EL		[72–75]	[76,77]		
OGC		[78,79]	[80]	[81]	[82]
BIO		[83]	[84]		
UN			[85–92]	[7,93–103]	

Energy Types	Research Area of Emphasis
Renewables and Conventional (RC)	Energy, Growth, and Productivity (EGP)
Renewable Energy—General (REG)	Energy and Finance (EF)
Renewable Energy—Solar (SOL)	Energy Efficiency and Sustainability (EES)
Renewable Energy—Electricity (EL)	Energy and Environment (EE)
Oil, Gas, Coal (OGC)	Energy and Trade (ET)
Biofuel (BIO)	
Unspecified (UN)	

3.1. Renewable and Conventional Energy

The largest category across the two groups contains articles that study both renewables and conventional (i.e., oil, gas, and coal) energy. We found 33 total papers offering broad

coverage of energy choices. Our review of these articles begins with the most influential papers, and then we discuss papers in Energies.

In the cluster of studies containing both renewable and conventional energy sources, eight of the ten influential articles cover topics in the areas of energy and finance. The most cited papers are by Sadorsky [22] with 381 citations, Reboredo et al. [23] with 199, and Ferrer et al. [24] with 196. These articles are all published in Energy Economics. Using multivariate GARCH models, Sadorsky performed volatility analysis between crude oil prices and share prices of green energy and technology firms. He concludes that while green energy stock prices are sensitive to technology stocks, they are less related to the movements in crude oil prices. Reboredo et al. [23] use nonlinear Granger causality and wavelet functions to examine the correlation and causality between crude oil prices and renewable energy stock prices for the period 2006–2015. They conclude that the relationship between these assets is not strong in the short term, but that a relationship in the long term does exist. Moreover, they revealed that stock prices for renewable energy have non-linear effects on the price of crude oil at different time horizons. Additionally, Ferrer et al. [24] look at US data involving renewable energy stock prices, oil prices, and critical financial variables (such as profit and cost) to examine time and frequency dynamics. They use impulse response analysis. Their key finding is that there is strong short-term connectedness between their volatilities and returns. Furthermore, they show that the price of oil does not affect the performance of renewable energy firms both in the short and long term. In connection with the renewable energy and fossil fuel markets, Song et al. [25] investigate information spillovers between these markets by examining their returns and volatilities. They demonstrate that stock prices for renewable energy firms and conventional energy firms are closely related. Very similar to Song et al. [25], Corbet et al. [26] use a spillover index and a volatility analysis (called DCC-FIGARCH) to investigate volatility spillovers among energy stocks during the COVID-19 era. They find positive and significant spillovers ranging from oil prices to clean energy and coal prices. Dawar et al. [27] use weekly data to detect if the price of crude oil affects the prices of clean energy stock indices. They run a quantile regression to show that renewable energy stock returns depend less on crude oil returns. On a similar topic, Ji et al. [28] compare renewable energy fund returns to conventional energy fund returns in Europe during 2010–2019. Their observation is that renewable energy funds do not perform as well as conventional energy funds and market benchmarks. More recently, Samour and Pata [29] examined the U.S. interest rate and crude oil price spillovers on renewable energy utilization in Turkey using annual data from 1985–2016. They utilized an econometric method based on the bootstrap autoregressive distributed lag approach and showed that there exist significant spillover effects from the U.S. federal funds rate to renewable energy usage, and this spillover happens via effects on local interest rates and real income.

There are two remaining influential articles in this fuel category, and both have a focus on energy, growth, and productivity. First, Feng et al. [16] used data envelopment analysis to examine factors that affected green total-factor productivity (TFP) for China's metal industry from 2000–2015. They illustrate that the green TFP in this industry has risen at an annual rate of 11.52%. This has been explained by technological progress. Despite these improvements, green TFP levels remain low in this industry, and this stems from scale and technical inefficiencies. Similar to Feng et al. [16], Zhu et al. [17] also studied green TFP in the mining and quarrying industry in China during 1991–2014. They also used data envelopment analysis and showed that the green productivity in this sector increased by approximately 72%. However, productivities vary considerably across the sub-sectors.

Within this energy category, articles in Energies are similar to the set of influential articles from other journals in that a high share (11 of 23) cover topics in the area of energy and finance. The two most cited articles in this area, each with fifteen citations, are those of Hsiao et al. [30] and Czech and Wielechowski [31]. While the former uses data for oil prices and stock prices of renewable energy companies in China to examine the relationship between these prices, the latter uses renewable and conventional energy data to examine the

impact of COVID-19 on stock market indices. Other articles by Nie et al. [32], Attarzadeh and Balcilar [33], Jaworski and Czerwonka [34,35], De Blasis and Petroni [36], Velasquez-Gaviria et al. [37], Fuentes and Herrera [38], Dominioni et al. [39], and Chang et al. [40] studied energy and finance. The first two articles are the most recent. Nie et al. [32] studied return and volatility spillovers between renewable energy and technology stocks, oil futures, and carbon allowances over different investment horizons. They found a strong spillover effect between these assets and showed that technology stocks influence clean energy stocks more than oil futures. In a related recent paper, Attarzadeh and Balcilar [33] studied the connectedness and spillovers between the renewable energy, common stock, oil, and technology markets. They showed that the oil and clean energy markets have bidirectional volatility spillover. They suggest that if the price of oil remains low, then industries producing alternative energy will not need tailored policy interventions to lessen their susceptibility to shocks to crude oil prices.

In this energy category, there are four papers in Energies in the area of energy and the environment by Mehmood et al. [45], Hsieh et al. [46], Zhou et al. [47], and Li et al. [48]. Mehmood et al. [45] assessed intertemporal changes in energy efficiency and CO_2 emissions for select developed and developing countries from 2001 to 2011. They also employed a network data envelopment analysis and found that the countries examined do not exhibit perfect efficiency in the production and distribution of economic outputs simultaneously. They suggested that efficiencies could be improved if countries prioritized economic restructuring and the expansion of the middle-income class. Hsieh et al. [46] measured environmental efficiency in EU countries from 2006 to 2013. They used dynamic data envelopment analysis and showed the predictive power of their model. Specifically, they measured environmental efficiency in Europe and reported that most countries needed to improve their environmental efficiencies. Zhou et al. [47] measured the environmental efficiency in Chinese provinces for the period 2006–2015. They also used data envelopment analysis to quantify the environmental efficiency in each province. Their results revealed that Beijing, Guangdong, and Shanghai showed high performance in unified environmental efficiency and scale efficiency. Finally, Li et al. [48] analyzed energy and air pollution efficiency scores in China during 2013–2016. Using a meta-frontier approach, they observed large differences between western and eastern cities. The western part of China had the lowest scores for efficiency.

There are also four articles in Energies covering energy efficiency and sustainability, including Hsiao et al. [41], Moutinho and Madaleno [42], Fidanoski et al. [43], and Wang et al. [44]. Hsiao et al. [41] measured the total factor energy efficiency (TFEE) in ten countries across the Baltic Sea region during 2004–2014. The input variables in their analysis include labor, capital, energy, and carbon dioxide (CO_2). For the output variable, they used real gross domestic product, and their environmental variables included consumption of renewable energy and population in urban areas. Using a stochastic frontier analysis, they demonstrated that Finland, Latvia, Norway, and Sweden performed well in energy efficiency performance compared to other Baltic countries. Moutinho and Madaleno [42] measured environmental and economic efficiencies in Asian and African countries between 2005 and 2018. Using stochastic frontier analysis, they found an inverted U-shape function for eco-efficiency concerning the shared consumption of fossil fuels. They showed that technical eco-efficiency increased labor and renewable energy shares, and decreased fixed capital. Similar to this paper, Fidanoski et al. [43] assessed energy efficiency in OECD countries from 2001 to 2018. They considered renewable energy capacity and environmental constraints for energy efficiency estimations. Using data envelopment analysis, they found that OECD countries exhibited inefficiency margins of 16.1% from primary energy sources (e.g., oil and gas) and from 10.8 to 13.5% for electricity. However, environmental constraints and renewable energy did affect efficiency figures. Finally, Wang et al. [44] quantify energy efficiency in the Americas, Asia, and Europe. They used the data envelopment analysis method and found that the energy efficiency in European countries was higher than that

in the Americas (except the U.S.) and Asian countries. They pinpointed the source of inefficiency, which stems from excessive consumption and waste.

Within this fuel category, there are four articles in Energies covering energy, growth, and productivity by Ding et al. [18], Lin et al. [19], Fujii et al. [20], and Ziolo et al. [21]. Ding et al. [18] studied the impact of human capital on green production. They also considered physical capital to measure green and traditional GDPs for 143 countries using a regression model. They found that human capital was more important than physical capital and that green GDP had a higher sensitivity to variations in human capital compared to standard GDP. Note that before Ding et al., Lin et al. [19] proposed a Green GDP index, considering both energy and pollution intensities, to measure the environmental and energy performance in China using a data envelopment analysis. Fujii et al. [20] looked at technology and examined the relationship between productivity and technology within a distributed renewable energy system. They specifically differentiated technology between information technology and software and found that the technology contributed to increased productivity in output. Lastly, Ziolo et al. [21] used data envelopment analysis and a regression model, to consider sustainable economic development in OECD countries. In the realm of growing renewable energy investments and pollution control programs in both developing and developed OECD countries, they found upward trends in energy efficiency that positively contributed to economic growth.

3.2. Renewable Energy Only

Twenty-nine total articles across the two sets are focused on renewable energy sources only. In this fuel subcategory, there are seven influential articles and nine papers in Energies that do not specify the specific type of renewable energy. Six of these seven influential papers are directly related to China and its renewable energy policies. Within Energies, there are also articles dealing with renewables that are focused on a particular type. For example, in the category of solar energy, seven papers specifically consider solar energy and its benefits. In the category of electricity, there are six papers in which electricity is generated using conventional and renewable energy sources. These papers address various issues in the electricity sector involving pricing, trade, outages, and emissions.

In the fuel category of renewable energy only, the most cited article is by Bai et al. [49] in the Journal of Cleaner Production, with 125 citations. This article is in the research area of energy, growth, and productivity. The authors study companies that are energy-intensive during the period 2010–2015 to determine if government research and development subsidies impacted the amount of green innovation activity. Using a propensity score matching method, they show that subsidies facilitate energy firms' innovation of green products. In this category, the second highly cited paper is by Wu et al. [58], which falls in the research area of energy efficiency and sustainability. This paper is one of the hottest, having been cited 97 times since 2021. This paper has received so many recent citations that it is also on the ESI hot paper list, which is a designation given to very high-performing papers published in the most recent two years. Hot papers satisfy two conditions: (i) the publication date must be within the last two years; and (ii) over the most recent bimonthly period, these articles perform in the top 0.1% based on citations when compared to other articles in the same field. Their empirical study examines the relation between internet development and usage and green total factor energy efficiency (GTFEE) in China for the period 2006–2017. They find that internet development has significant positive and nonlinear effects on GTFEE and that these effects can spillover to nearby regions.

IN this fuel category, there are two articles in the influential group with an energy and finance focus. First, Xu and Li [51] examine the impacts of green energy credit on the debt financing cost in China for the period 2001–2017. Using a fixed effect model, they find that both green credit policy and green credit development reduce the debt financing cost of green enterprises but have a small impact on their debt maturity. Second, Wen et al. [52] investigate Chinese A-share listed renewable energy companies during 2007–2019 to study how corporate innovation investment is influenced by fiscal policy uncertainty. Based

on a dynamic data envelopment analysis, they find that the research and development investment of renewable energy firms is negatively influenced by fiscal policy uncertainty. However, these effects are reduced by the amount of product market competition.

The remaining three influential articles in this fuel category all cover topics related to energy and the environment. Zhang et al. [61] study the environmental effects of green credit policy (GCP) in China and question the effectiveness of these policies to promote green development. Using an empirical difference-in-difference method, they show that, for firms with both high energy consumption and levels of pollution, the GCP provides incentives for short-term financing, but it restricts investment behavior in the long term. Most importantly, the GCP reduces sulfur dioxide and wastewater emissions. Additionally, the GCP has an asymmetric impact on the investment behavior of state-owned large firms and independent small firms. Deng et al. [62] investigate the relationship between green technology innovation and tax competition. Using a dynamic spatial Durbin model along with a threshold panel model, they find that green technology innovation over different regions shows positive spatial agglomeration effects and that an inverted U-shape describes the relationship between tax competition and green technology innovation. Finally, Zeng et al. [63] investigate green technology innovation (GTI) in 30 Chinese provinces for the period 2001–2019. Their empirical results demonstrate that innovation efficiency is low but show progress in that the GTI has increased over the years. Furthermore, while total emissions of carbon dioxide in China have been increasing at a marginal rate, the intensity of carbon emissions has been falling over the years.

In the renewable energy only category, the source of renewable energy was not explicitly specified by the authors in 9 articles of the 58 Energies publications covered by our search criteria. Five of these papers are in the area of energy and finance. Sotnyk et al. [53] study renewable energy development in Ukraine's regions to identify optimal investment strategies. Day et al. [54] explore the impact of diverse technical trading investment strategies on investing in clean and traditional energy ETFs. Liu and Hamori [55,56] examine spillovers from conventional energies to renewable energy stocks in the US and Europe and the performance of the environmental, social, and governance indexes along with renewable energy securities. Reboredo et al. [57] examine the dependence structure between renewable energy assets and non-energy assets in the US and EU markets. In the area of energy, growth, and productivity, Sart et al. [50] study the relationship between educational attainment and renewable energy use. In the area of energy efficiency and sustainability, Liu et al. [59] measure the technical efficiency of the green energy industry in China, whereas Chodakowska and Nazarko [60] assess the functioning of sustainable development goals for EU countries. Finally, in the area of energy and environment, Wang et al. [64] calculate the efficiency scores of highly industrialized and newly industrialized countries using renewable energy capacity and CO_2 emissions.

In terms of a specific renewable energy source, we observe that most of the papers published in Energies examine solar energy. Seven papers in this category are all empirical and mostly concern Asian countries. For example, Mariano et al. [66] and Lee et al. [67] analyze the performance of solar photovoltaic (PV) power plants in Taiwan. Yang et al. [68] focus on China and evaluate the PV power generation efficiencies in 30 regions. Wang et al. [70] examine a region of Vietnam and investigate the optimal location choice for solar farms. We observe only one paper on the USA, which is written by Assereto and Bryne [65]. They investigate the impact of subsidy and electricity price uncertainty on solar investments in Pennsylvania, New Jersey, and Maryland electricity markets. In addition, two studies do not specify the location, and these are by Hajdukiewicz and Pera [71] and Lee and Tong [69]. While the former studies trade disputes in the solar sector, the latter examines the transfer efficiencies of PV systems. The research areas emphasized are energy efficiency and sustainability by Mariano et al. [66], Lee et al. [67], Yang et al. [68], and Lee and Tong [69]; energy and environment by Wang et al. [70]; energy and finance in Assereto and Bryne [65]; and energy and trade by Hajdukiewicz and Pera [71].

Six papers in Energies focus on electricity as an intermediate energy input without explicitly specifying the fuel burned to generate electricity. Four of these papers are in the area of energy and finance. In the only theoretical paper in this group, Maekawa and Shimada [72] examine power producers' speculative behavior in the day-ahead electricity market of Japan. Haugom et al. [73] examine the characteristics of forward premiums in the Nord Pool power market. Kaufmann et al. [74] emphasize the reliability issue of wind power and its impact on electricity prices. They offer a risk assessment tool for power traders to navigate the risks involved in intermittent wind generation. To complement this paper, Lin et al. [75] look at the impact of renewable energy from the system operator's perspective and offer a risk assessment of renewable energy connected to a power grid. The remaining two papers are in the area of energy efficiency and sustainability. Siksnelyte and Zavadskas [76] conduct an empirical study using a multi-criteria decision-making model to assess the EU's energy policies in its electricity markets. Their paper reviews the EU's renewable energy subsidies, which have aimed to bolster investments in renewable energy generation to diversify its power generation portfolio and achieve environmental targets for reducing greenhouse gas emissions in its power sector. Finally, Kufeoglu et al. [77] look at power interruptions in the Finnish electricity market and compute the costs associated with power outages.

3.3. Conventional Energy

In the categories of oil, gas, coal, biogas, and biomass, there is one influential article and 6 papers published in Energies. Taghizadeh-Hesary et al. [80] are the only influential paper in the conventional energy segment. While this article focuses on the linkage between oil prices and food prices, it also promotes renewable energy usage in food production to entail food security. Therefore, we classify the focus of this article as being in the area of energy efficiency and sustainability. The remaining papers in this fuel category were all published in Energies. Yan et al. [84] are categorized in the area of energy efficiency and sustainability; Iotti and Bonazzi [83], Jianu and Jianu [78], and Puka et al. [79] cover topics in energy and finance; Mo and Wang [81] have an energy and environment focus; and Gorecka et al. [82] have an energy and trade focus. For biofuel, Yan et al. [84] investigate economic and technical efficiency in the Chinese biomass sector, whereas Iotti and Bonazzi [83] examine biogas firms and their performance in Italy. For conventional energy, Jianu and Jianu [78] focus on oil and gas companies and examine how their investments in infrastructure, including exploration, drilling, and extraction, impact their share prices in the London Stock Exchange market. Puka et al. [79] provide a methodological contribution to examining risk mitigation for crude oil prices. Mo and Wang [81] emphasize gasoline markets to search for the sustainability of road transportation. Finally, Gorecka et al. [82] consider coal, oil, and gas markets to study energy trade in the EU.

3.4. Energy Type Unspecified

In the final category, which we call "Unspecified," the energy source is not explicitly defined. This means that energy may be produced from a renewable source or a fossil fuel. There are thirteen influential articles in this segment, with five falling into the energy efficiency and sustainability category and eight in the energy and environment category. Since the articles covering energy efficiency and sustainability tend to be the most heavily cited, those are reviewed first. The most cited paper in this category is by Chang et al. [85]. This article was published in Energy Policy and has been cited 292 times. They analyze the environmental efficiency of the transportation sector in China. Using a data envelopment analysis with a slacks-based measure, they show that the levels of environmental efficiency in most provinces are below half of their optimal levels. Second, Li and Hu [86] compute the ecological total factor energy efficiency (ETFEE) in 30 regions of China during 2005—2009. Their empirical results reveal that regional ETFEE in China is low, but they observe a monotonically increasing relation between regional ETFEE and national GDP per capita. Furthermore, they find a positive correlation between the ETFEE and the ratio of R&D

expenditure to GDP and the degree of foreign investment. Third, Huang et al. [87] examine the dynamics of regional eco-efficiency using Chinese data for the period 2000–2010. Similar to others in this research stream, they use a data envelopment analysis model to show that the average eco-efficiency of China over years displays a V-shape. Furthermore, the eco-efficiency levels show significant differences between the regions in China. In another study with a focus on energy efficiency and sustainability in China, He et al. [88] examine China's iron and steel industry from 2001 to 2008 to evaluate the industry's energy efficiency and productivity growth. Using a data envelopment analysis, they find that most of China's steel and iron-producing plants are inefficient. However, productivity has increased, and they identify technical change as the main catalyst for this. Finally, Shao et al. [89] studied China's industrial sectors between 2007 and 2015 to evaluate the eco-efficiency of these sectors. Using a network data envelopment analysis, they showed that the eco-efficiency and process efficiencies of China's industries have improved. However, there are important differences across the sectors in efficiency rates: the lowest eco-efficiency comes from the mining sector, whereas the electricity and gas production sectors have shown the highest rates.

The remaining eight influential articles in this fuel category are all in the area of energy and the environment. Sueyoshi et al. [7], which is published in Energy Economics and has citations totaling 261, provide a literature review of papers that use data envelopment analysis and have a research focus in the area of energy and the environment and that were published starting in the 1980s. Chen and Jia [93] examine the environmental efficiency in China's regional industry during 2008–2012. Using a data envelopment analysis, they show that the environmental efficiencies of China's industries tend to be low and are not showing improvement. However, some regions in China show better efficiency factors than others. Asongu et al. [94] examine the relationship between information and communication technology (ICT) and carbon dioxide emissions in Africa during 2000—2012. Using a generalized method called the moments method, they find that ICT (measured by internet and cellphone usage) can be employed to reduce environmental pollution. Miao et al. [95] explore China's energy use and pollution levels. Using a data envelopment analysis, they show that the source of air pollution and the environmental inefficiency comes from SO_2 emitted from the industrial sector and NO_x emitted from the transportation sector. They suggest governments increase air pollution regulations. Chen et al. [96] study the relationship between industrial agglomeration and environmental quality. Using a spatial econometric analysis involving the Durbin model, they show that significant spatial spillover effects exist between industrial agglomeration, pollution, and ecological efficiency. They find a U-shaped relationship between industrial agglomeration and wastewater, SO_2, and soot emission. In a related study, Zhu et al. [97] measured energy efficiency and the impact of energy usage on the environment. They use data envelopment analysis to analyze industrial production and pollution control data and provide remedies to improve environmental efficiency in transportation sectors across Chinese provinces. In the nexus of trade, growth, and environmental pollution, Wang et al. [98] use an empirical threshold model to show that when the degree of trade is below a threshold, technological progress may raise the level of pollution; otherwise, technological progress can diminish emissions. The final paper in this category is a very recent one by Khan et al. [99]. Their study examines how the quality of institutions impacts foreign direct investment inflow and improves environmental quality. They use static and dynamic panel models to show that institutional quality affects foreign direct investment positively and significantly. Additionally, energy usage and carbon emissions are positively related to economic growth.

Within Energies, seven papers do not specify the fuel type explicitly. They mainly use energy as an input, which could come from any source, to explain the production of intermediate products and their environmental impacts in various sectors. Four of these articles focus on energy and the environment. The focus of these papers is diverse, with wide coverage of industries. In particular, Tu et al. [100] investigate environmental efficiency in the Chinese cement industry. Their methodology relies on data envelopment

analysis. They show that the environmental efficiency of this industry in China is very low. They suggest several remedies, including the reduction of air emissions through pollution control measures, and forcing cement producers to carry out technological innovations on scrubbers, filters, and carbon capture mechanisms. Wang et al. [101] use data from China's mining industry for 2007–2016 to study total factor environmental efficiency. Using an epsilon-based measure model, they find that China's provincial mining industry has a low average total factor static environmental efficiency and that there exist significant spatial-temporal differences. Feng et al. [102] use industrial production and pollution control data for China from 2013 to 2017 to study the influence of pollution control measures on industrial production efficiency. Their empirical study is based on the directional distance function and the technology gap ratio. They compute the technology gap ratios for 31 provinces, cities, and administrative regions. They offer remedies to improve resource allocation and pollution prevention and control. Debkowska et al. [103] examine whether public funds for climate policies have been effectively and efficiently utilized in the EU during 2005–2019. They carry out an empirical study relying on a data envelopment analysis. They show that public funds have not been efficiently used to mitigate climate change. However, a case study based on the replacement of heating resources in Poland indicates some efficient use of public funds.

The remaining three publications in Energies that do not specify the fuel type explicitly all have a focus on energy efficiency and sustainability. Sueyoshi et al. [90] study the sustainable development of Chinese provinces to detect patterns of economic and environmental performance at a regional level. Similar to the other papers in this category, their empirical study relies on a data envelopment analysis. Their analysis reveals that the pace of sustainable development is stable in some provinces, whereas other provinces reveal radical swings in performance. In addition, they find sustainable development performance to be low in some provinces with fast-growing economies. In another study for China, Yang and Li [91] evaluate efficiency scores in relation to industrial wastewater for Chinese sectors. Finally, Hernandez and Prakoso [92] emphasize the difficulties with Indonesia's energy transition. Their study relies on a learning-activation approach. They essentially offer a teaching guideline that provides recommendations as to how Indonesia's energy transition stages could be applied to other countries that have just started working on transitioning their energy industries to include renewable energy.

3.5. Summary

Our objective for Section 3 was to categorize the 89 articles covered by our search criteria and identify them as either highly cited ESI articles or articles published in Energies. These articles have been categorized according to both the energy type studied and the area of primary focus. In our analysis of the literature, we found seven categories of energy types and defined five areas of emphasis. A summary of our analysis is contained in Table 4. The most active areas are energy and finance with 34 studies; energy efficiency and sustainability with 23 studies; energy and environment with 22 studies; energy, growth, and productivity with 8 studies; and energy and trade with 2 studies.

4. A Discussion of the Top Performing Articles: Energies versus Other Journals

In Tables 5 and 6, we present the ten most cited articles published from both our list of the most influential articles and articles in Energies, respectively. When comparing Tables 5 and 6, there are certainly more similarities that are noticeable than differences. For example, in both cases, most research activity is in the areas of energy efficiency and sustainability (five in Energies vs. three elsewhere), and energy and finance (three vs. three). Another area with highly cited papers is energy and environment (4). These results can be expected since these three areas were previously identified as having the most published articles (see Tables 2 and 3). In terms of methodology, half of the articles in both Tables 5 and 6 use data envelopment analysis—an empirical technique for measuring production efficiency. Therefore, this is the most widely used tool to analyze the research questions posed

by the articles reviewed here, and in particular, articles that fall within the research areas of energy efficiency and sustainability and energy, growth, and productivity. Finally, notice that both tables have a large fraction of articles that have been published in the last 6 years: 7/10 for Energies and 5/10 for the other journals. To some extent, this result is surprising, and this is because newer papers have less time to build up citations compared to older papers. However, having recent papers that are also the most highly cited is probably an implication of the fact that the majority of the work being conducted in this area is also recent, as we showed previously in Figure 1. In fact, the data that we have presented for both publication numbers and citations supports our claim that the topic of economic aspects of the energy transition is an incredibly active area of current research activity.

When comparing Tables 5 and 6, we also observe some differences. For example, one of the more noticeable differences is in the number of citations between the top ten cited papers across all journals—the best of the best—and the top cited papers in Energies. In particular, we observe roughly a factor of ten difference in citations between the articles listed in these two tables. Perhaps the difference in citation numbers is expected. For example, there are more articles when searching across all journals compared to when focusing on just those published in Energies. In addition, most (eight of ten) of the top cited papers are in Energy Economics and Energy Policy, and these journals are more focused within the field of our search—economics, whereas Energies and the Journal of Cleaner Production have a more interdisciplinary focus. Finally, Energies is a relatively new journal. Notice that six of the top ten cited articles in Energies have been published in the last three years. For this reason, we expect citations for these articles to rise. These studies examine several interesting issues, such as the efficiency analysis of renewable energy technologies, the environmental impact of renewable energy, the assessment of green energy policies, the impact of COVID-19 on renewable energy producers, measuring green GDP in connection with renewable energy and pollution, and the effects of conventional energy (crude oil and natural gas) price and volatility on renewable energy stocks.

Four articles in the area of energy and environment make the list of the most cited across all journals (Energy Economics 1, Energy Policy 1, Journal of Cleaner Production 2). While there are no articles in this area that make the list of the most cited in Energies, the data presented previously (Section 3) shows that energy and the environment are active research areas for articles published in Energies. Specifically, within Energies, there are eleven articles in this category, ten of which have been published between 2019 and 2022. The highest number of papers, four out of eleven, were just recently published—in 2022. These papers cover several diverse industries and geographical regions to examine energy consumption and its environmental impacts. The uptick in research intensity in this area, as reflected in the number of new articles and the number of highly influential articles, is most likely a response to countries' green energy and environmental policies, which aim to reduce reliance on fossil fuels and decrease greenhouse gas emissions to tackle global warming and mitigate the side effects on the environment and economic growth. These issues and remedies have been clearly documented in international agreements such as the Kyoto Protocol and Paris Accord (see Jenniches [12]) and the UN's sustainable development goals (see Genc [104]), aside from local, state, and federal decrees.

Table 5. Ten most cited papers related to economic aspects of the energy transition.

Author(s)	Research Question	Methodology	Key Findings	Research Field	Citation	Journal
Sadorsky (2012) [22]	Volatility spillovers between oil prices and share prices of clean energy and tech companies	multivariate GARCH	Clean energy companies' share prices correlate more highly with technology share prices than with oil prices.	Energy and Finance	381	Energy Economics
Chang et. (2013) [85]	The environmental efficiency of China's transportation sector	data envelopment analysis	E nvironmental efficiency levels in most of the provinces are low.	Energy efficiency and sustainability	292	Energy Policy
Sueyoshi et al. (2017) [7]	Literature review of papers published during 1980s to 2010s using data envelopment analysis	data envelopment analysis	Explain the importance of this methodology and its predictive power.	Energy and Environment	261	Energy Economics
Reboredo et al. (2017) [23]	Studying co-movement and causality between oil and renewable energy stock prices.	nonlinear granger causality and wavelets	The short-run return dependence between oil and renewable energy was weak. It is stronger in the long run.	Energy and Finance	199	Energy Economics
Ferrer et al. (2018) [24]	Assessing the dynamics between stock prices of U.S. clean energy companies and oil prices	impulse response analysis	Oil prices do not impact the performance of renewable energy companies in short- and long-terms.	Energy and Finance	196	Energy Economics
Li and Hu (2012) [86]	Calculating ecological total-factor energy efficiency (ETFEE) in China	a slack-based model	China's regional ETFEE is 0.6, and ETFEE increases in China's GDP per capita.	Energy efficiency and sustainability	187	Energy Policy
Chen and Jia (2017) [93]	Environmental efficiency in China	data envelopment analysis	The environmental efficiencies of China's industries are generally low and have not been improving.	Energy and Environment	177	Journal of Cleaner Production
Huang at al. (2014) [87]	Dynamics of regional eco-efficiency in China	data envelopment analysis	The average eco-efficiency of China over years displays a "V" shape.	Energy and Environment	159	Journal of Cleaner Production
He et al. (2013) [88]	Examining China's iron and steel industry to evaluate energy efficiency and productivity.	data envelopment analysis	Chinese steel and iron plants are inefficient. Productivity has been increasing over time.	Energy efficiency and sustainability	154	Energy Policy
Asongu et al. (2017) [94]	Examine the relationship between information and communication technology (ICT) and carbon dioxide emissions in Africa.	a generalized method of moments	ICT can be employed to reduce the environmental pollution.	Energy and Environment	135	Energy Policy

Table 6. Ten most cited articles in Energies related to economic aspects of the energy transition.

Author(s)	Research Question	Methodology	Key Findings	Research Field	Citation
Yang and Li (2017) [91]	Evaluating total factor efficiency	data envelopment analysis	Explain the differences in total factor efficiencies across Chinese industries and offer policy recommendations for industrial wastewater control.	Energy efficiency and sustainability	44
Lee et al. (2012) [67]	Examining performance of PV firms in Taiwan.	data envelopment analysis, and analytical hierarchy process	Quantify efficiencies of crystalline silicon PV firms.	Energy efficiency and sustainability	31
Lin et al. (2011) [19]	Measuring the environmental and energy performance.	data envelopment analysis	Propose a Green GDP index (GGI) for China	Energy, Growth, Productivity	22
Ziolo et al. (2020) [21]	Measuring green GDP, taking into account of energy and pollution intensity.	data envelopment and regression analysis	Developed OECD countries have higher total factor energy efficiency levels than developing OECD countries.	Energy, Growth, Productivity	18
Siksnelyte and Zavadskas (2019) [76]	Assessing policy efficiencies in the EU electricity sector in 2017.	multi-criteria decision-making method	The Slovenian electricity market is the most sustainable electricity market followed by Luxembourg.	Energy efficiency and Sustainability	16
Hsiao et al. (2019) [30]	The impact of oil prices on the stock prices of China's renewable energy companies.	vector autoregressive model with a Factor-GARCH	Oil prices impact the share prices and market capitalization volatility of renewable energy companies.	Energy and Finance	15
Czech and Wielechowski (2021) [31]	The impact of COVID-19 on the stock market indices.	a Markov-switching model	The green energy sector is more resistant to COVID-19 than the conventional energy sector.	Energy and Finance	15
Hsiao et al. (2019) [41]	Measuring total factor energy efficiency and disaggregate input efficiency for 10 countries across the Baltic Sea during 2004—2014.	a stochastic frontier analysis	Finland, Latvia, Norway, and Sweden perform better with respect to energy efficiency than other Baltic countries.	Energy efficiency and Sustainability	14
Liu and Hamori (2020) [55]	Crude oil, natural gas, and securities return and volatility spillovers on renewable stocks in the US and Europe.	time series impulse response analysis	The impact of return and volatility from all variables to renewable stocks in the US are higher than that of Europe.	Energy and Finance	13
Lee and Tong (2012) [69]	Examine transfer efficiency of PV system components.	data envelopment analysis, rough set theory, and genetic programming	Quantify the efficiency ratings of PV system components.	Energy efficiency and Sustainability	12

5. Conclusions: Research Gaps and Future Directions

This study provides a literature review of articles within the field of economics and was published in connection with the keyword search for renewable energy, pollution, and the environment in the WoS database. Our broad search of the literature on the economic aspects of the energy transition revealed 875 published articles covering the last two decades. A key characteristic of the data is that publication activity in this area displays exponential growth, with 70% of the articles appearing in the last 6 years (2017—2022). Given the large number of recent articles on this subject across all journals, we then narrowed our analysis by focusing primarily on two sets of articles: (i) the most influential articles, that is, ESI highly cited articles; and (ii) articles published in this journal—Energies. We added articles in Energies to our list of reviewed papers because the subject of our literature review fits well within the scope of this journal, specifically the journal's coverage of all types of energy sources and research in the fields of energy economics and policy, energy, environment, and sustainable transition. Given the aims and scope of Energies, it was not surprising to find that this journal is one of the top six outlets for research in this area. We found 31 highly cited ESI articles and 58 articles in Energies that matched our search criteria. Similar to the aggregate data, publication activity for both subgroups was concentrated over the past few years. In particular, 84% of the most highly cited papers and 93% of the articles in Energies have been published in the last six years. Therefore, we conclude that research on the topic of the energy transition is more active than ever.

We further classified the papers in terms of research emphasis and fuel type. With the first classification, we group the papers into six categories. We identified that the most active areas are energy and finance, energy and the environment, and energy efficiency and sustainability. Based on the analysis in Sections 3 and 4, we observe two areas of research emphasis that would substantially benefit from additional studies. Specifically, we note that there are no articles in the areas of energy, growth and productivity, and energy and trade that make up the top ten list of most cited papers from other journals (see Table 5). In addition, these areas show only modest activity within Energies. For example, within Energies there are five total articles in the areas of energy, growth, and productivity. However, a closer look does reveal that four of the five papers have been published between 2020–2022. This shows that while the number of total publications is still low, it has been gaining the attention of researchers in recent years. In addition, based on total publications, energy, and trade appear to be the least studied areas. However, this area has been discussed among researchers and disseminated through media outlets due to the continuing conflict in Ukraine and the aftermath of the recent pandemic. These critical events, along with lengthy ongoing curfews, lockdowns, and shutdowns of businesses in China (the world's manufacturing hub) and elsewhere, have paved the way for discussions of several critical issues, including questions on trade with China, energy security, and independence, and importance of high-carbon conventional (oil, gas, and coal) energy and the vitality of nuclear energy in the realm of Europe's energy crisis. Several reputable media outlets and policymakers around the world have been questioning the advantages and disadvantages of renewable energy, and governments are reviewing their greenhouse gas emission targets. Consequently, these issues naturally attract the attention of academicians, who should revisit this research field in connection with current events.

While we identified 875 publications matching our search criteria, most of our focus was on the 31 most influential publications and 58 publications in Energies. No doubt there is interesting research being conducted outside of these 89 articles. In the hinterland of research concerning renewable energy and the environmental implications, these papers examined several interesting issues, such as wind energy and emissions reductions (Novan [105]), valuing intermittent solar energy (Gowrisankaran et al. [106]), wind capacity and energy price (Acemoglu et al. [107]), cross-border trading of electricity generated from conventional and renewable sources and the environmental implications of trade (Genc and Aydemir [108]), renewable energy ownership and its impact on prices and emissions

(Genc and Reynolds [109]), and dynamic competition in electricity markets with renewables (Genc et al. [110]).

Based on our review of the literature, we believe that several additional topics could be considered to fill the research gap between the papers published in Energies and elsewhere. One notable area of research is the impact of severe events (such as global warming, extreme weather, COVID-19, and financial and economic crises) on energy markets. We pinpoint just one publication in Energies on these issues, while there are many publications in other journals. In addition, examining consumer behavior in relation to transitioning to renewable energy could be an interesting future research venue (e.g., see Genc [111] for energy demand response analysis during the 2008–2009 financial crisis). Given the remarkable production capacity investments in renewable energy, which have been spurred by government policies and incentives, and which have been growing constantly, especially wind and solar, another research area could involve investigation of optimal investments and examination of equilibrium strategies developed by conventional energy (oil and gas) firms as a response to capacity expansions by renewable energy firms (see, for example, Genc and Thille [112] and Genc [113] for equilibrium investments by renewable and conventional energy producing firms).

Another possible area for future research pertains to quantifying the impact of the energy transition on short-term and long-term macroeconomic outcomes. Recent work in this area has been conducted by Abban et al. [114], who study the energy-economic growth-CO_2 emissions nexus for a set of African countries. Another study by Dupont et al. [115] constructs a macroeconomic model to assess the pace at which a complete energy transition can be achieved on a global scale. One factor identified by Dupont et al. for achieving a faster energy transition is technological advancements that promote energy efficiency. This may be possible, as the costs of renewable technologies are currently falling, thereby opening up new possibilities in both developed and less developed countries. These advancements have created a more optimistic outlook for the security, inclusiveness, and sustainability that are inherent in having a transformed energy sector based on renewables. The impact on the pace of economic growth of declining prices for capital goods resulting from investment-specific technological change has been studied extensively in the macroeconomics and growth literature (e.g., Greenwood et al. [116], Kosempel [117]). However, these papers all have a very broad definition of capital. To quantify the impact of the technical change embodied in renewable energy sources, a study that provides more disaggregation of the capital stock is needed. In general, more research is needed to show that the energy transition is important not just for cutting harmful emissions from fossil fuel-based sources but also for economic growth and development.

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Data Availability Statement: Data were obtained from WOS on 15 October 2022. Refer to Section 2 and Appendix A for search keywords.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Web of Science (WoS) Searches

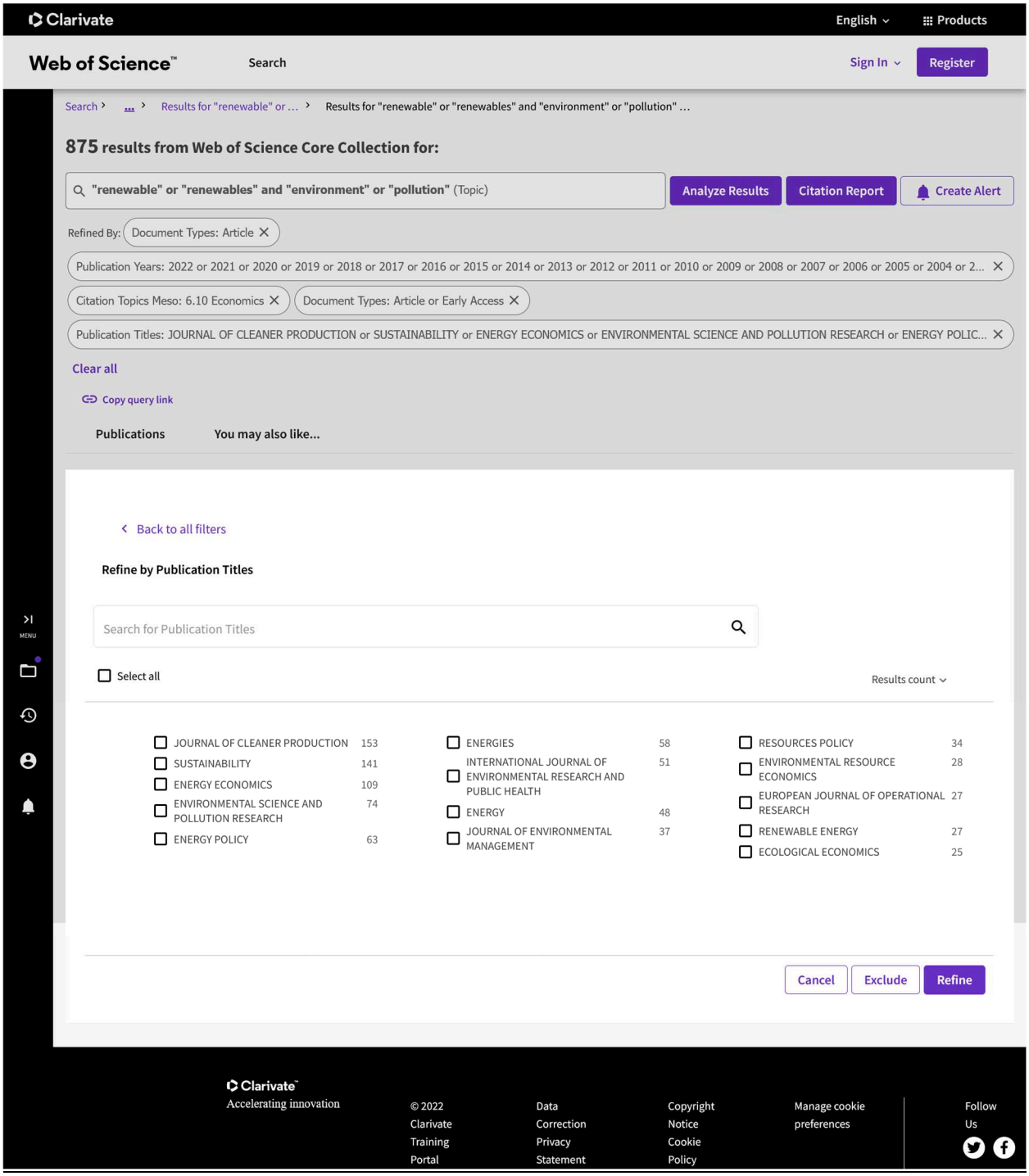

Figure A1. WOS Search—All Journals.

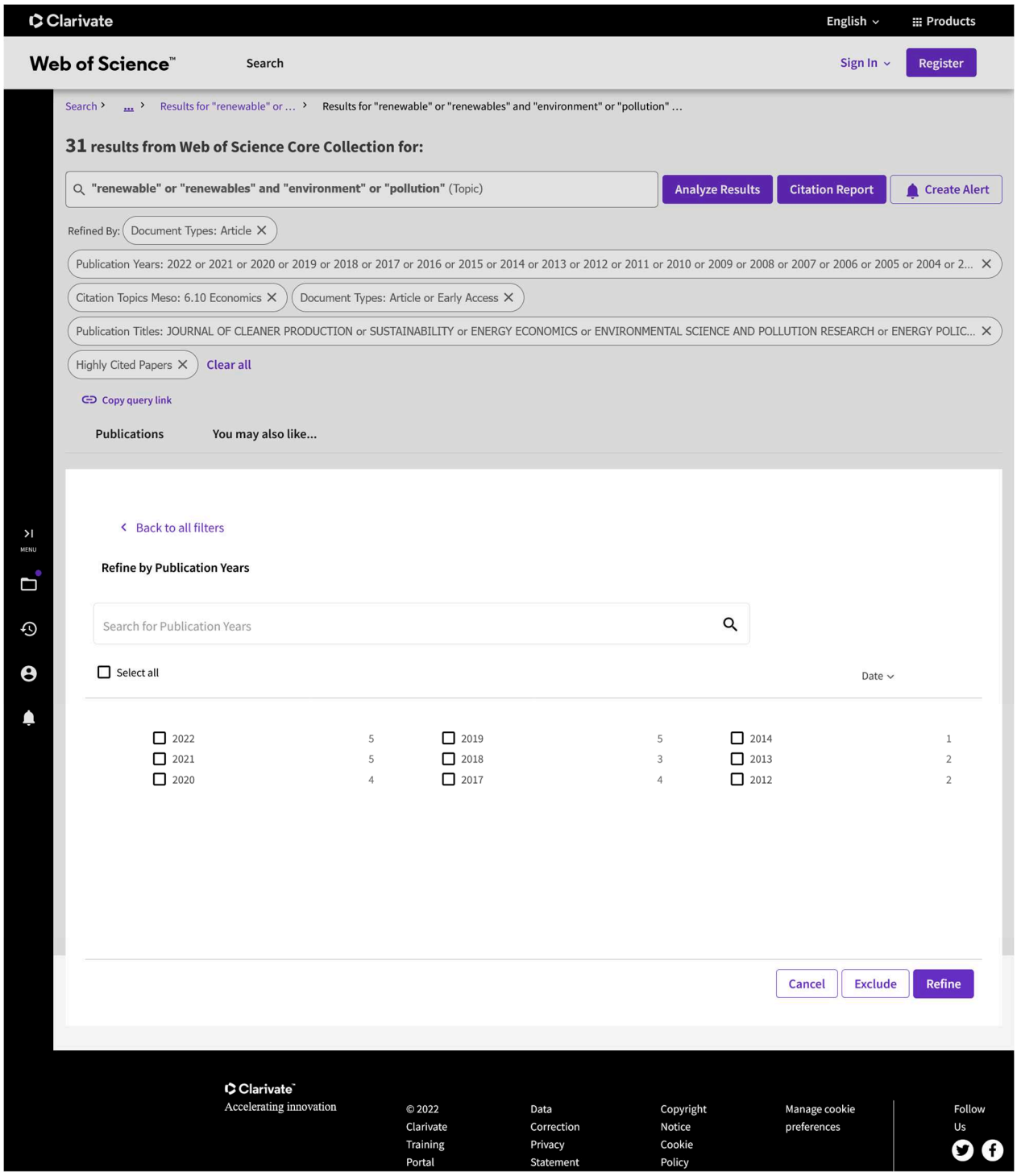

Figure A2. WOS Search—ESI Highly Cited Articles.

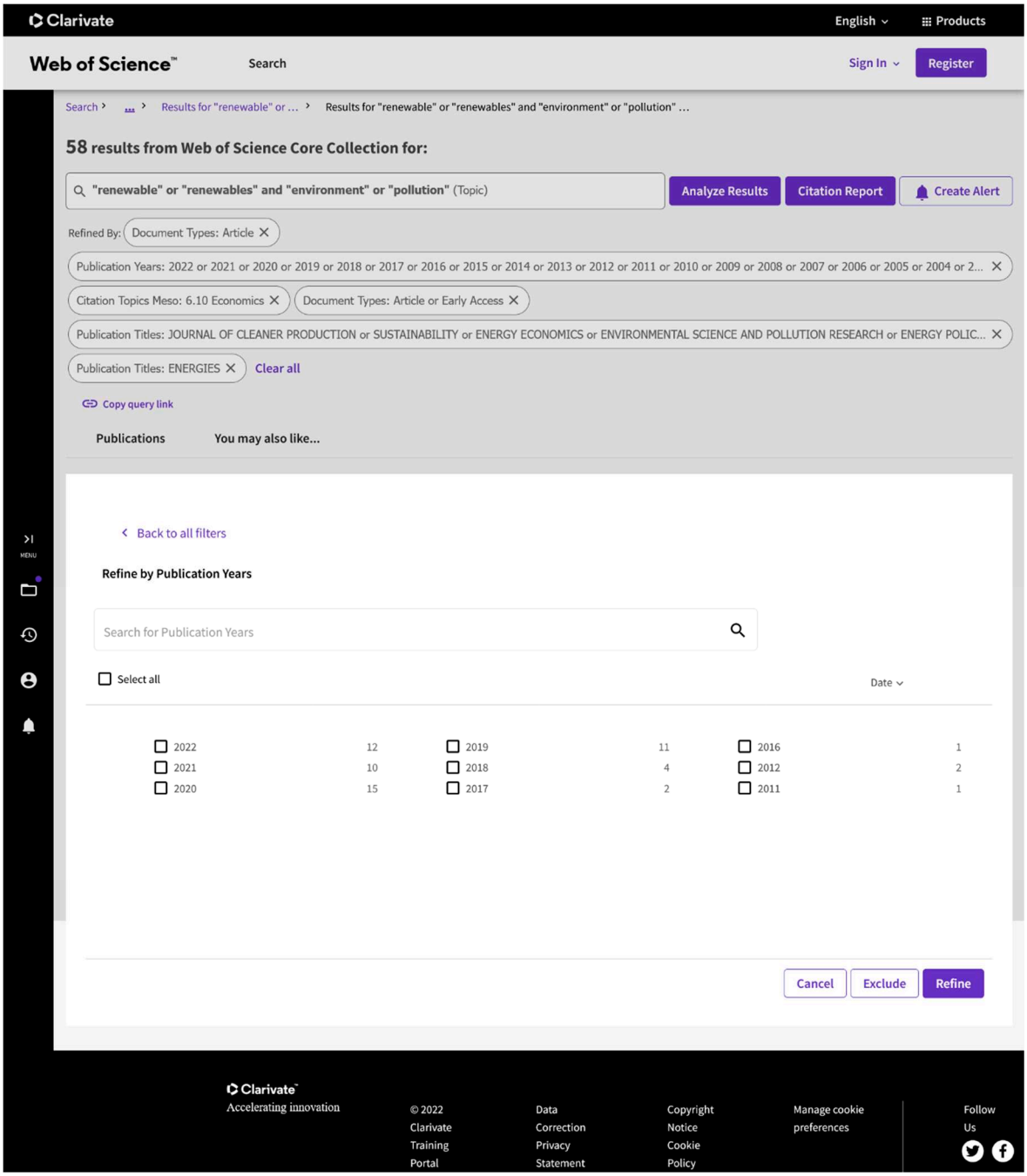

Figure A3. WOS Search–*Energies.*

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