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Review

Visualization of International Energy Policy Research

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Abstract: The complexity of policy decision making is well recognized. It is not clear, however, what role academic policy research has played in influencing the directions of policy outcomes and how the research has intertwined with notable issues globally. Given the importance of energy choices on sustainable development, we have developed a comprehensive and powerful visualization of the research trends worldwide in energy policy studies over the past five decades using the literature metrology theory and its techniques. The analytical framework provides a visual tracking of research activity, directional flow and a robust basis for judging progress. The emergent findings are an aid to decision makers drawing insights from specific policy studies within a fully transparent view of the historical context on a global scale.

Keywords: energy policies; historical perspective; literature metrology; visualization analysis; research evolutionary path

1. Introduction

Energy policies are deeply intertwined with several broad considerations, such as resource security, ecological impacts and commitments for achieving national sustainable development goals. Moreover, policy studies is also a dynamic inter- and intra-disciplinary research field. This explains the rationale for this research and our attempt to better understand the basic structure and evolutionary paths of energy debates as well as the transitions of energy policy research.

Several efforts are highlighted by four broad strands of research regarding energy policy review: one strand in the literature focuses on reviewing the development and achievement of energy policies in a country, region, state, union, or sector [1–5]; the second stream discusses regulations and their corresponding outcomes as they relate to specific energy forms (e.g., oil, gas, electricity) worldwide [6,7]; another area of research is the applications and effects of different types of policy frameworks for energy regulation [8]; and the last group of research compares the features of energy governance in different countries [9]. Although such studies reveal certain aspects of energy policy studies, little comprehensive research has been done so far to identify the structure and transition of the evolution of the topic from a broad, global, historical and quantitative perspective.

Scientific research bases, fronts and focuses evolve over time. Although some changes to the structure are relatively modest, often there are tipping points and large dramatic changes occur. Gaining a prior understanding of the implications of such changes is essential given the importance of

energy policy creation. Mapping and visualizing the structure and dynamics of specialized expertise will also give researchers a clearer and deeper insight for study scenarios.

Here, we provide a visualization of the world literature based on bibliometric analysis of relevant studies. This paper attempts to enrich the extant literature by developing a visualized spatial and temporal perspective—akin to a map—of the historical, global, and dynamic trends of energy policy studies. The analyses add to the limited research by highlighting transitions of theoretical foundations, emerging research fronts and "hot topics" (research focuses) in the field. Literature data dating from 1960 to 2010 are retrieved from the "Web of Science (WOS)", a reputed and well-recognized scientific literature database, and are further summarized, processed, analyzed and presented in a dynamic and graphical form using certain bibliometric approaches.

2. Methods and Samples

2.1. Research Method

A research front and its intellectual base are two critical concepts, as well as the main components of this paper. The concept of research front was first used by Price [10] to characterize the transient nature of a research field. It is defined as an emergent and transient grouping of concepts and underlying research issues. The intellectual base of a research front is its citation and co-citation footprint in scientific literature, an evolving network of scientific publications cited by researchers.

In order to gain a comprehensive and accurate understanding of the emerging scientific trends and to explore the structure and distribution of energy policy research, we have developed an analytical framework following the idea of Chen [11,12] (Figure 1). Selected articles and their citations (*i.e.*, cited references) with a certain topic are retrieved from reliable and well-recognized databases (e.g., the WOS platform). These retrieved data, including citing articles and their references, thus form a foundation of bibliometric analysis. In the framework, salient co-cited articles comprise an intellectual basis of research, while terms derived from citing and cited articles are utilized to detect research fronts and focus over time [13]. The inter-relationships among the analyses are shown in Figure 1 as well.

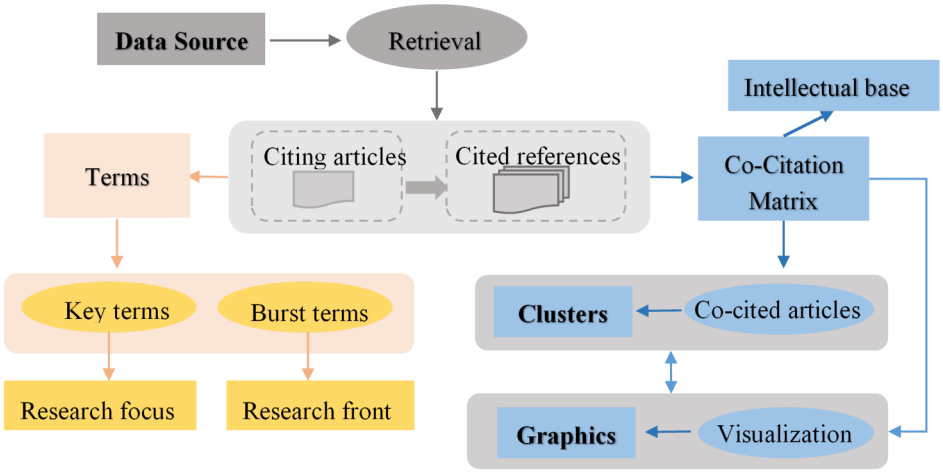

Figure 1. Analytical framework (adapted based on Chen, 2006; 2010 [11,12]).

In Figure 1, the "terms" under analysis are extracted from titles, abstracts, keywords and keywords plus of bibliographic records (*i.e.*, citing articles and their citations) that are used to capture key components of articles. Technically, the co-word approach, burst-detection technique, and co-citation analysis in the bibliometrics have been selected to observe and detect hot topics, research fronts and the knowledge basis of a specific research topic or field.

Specifically, knowledge discovery and data-mining techniques, such as the burst-detection technique, are expected to play a critical role in identifying a research front. Kleinberg's algorithm, first introduced in 2002, is considered as a sustainable and reliable technique to detect sharp increases of interest in a specialty [14]. The algorithm is based on modeling the stream using an innate-state automaton, in which bursts appear naturally as state transitions. The resulting algorithms are highly efficient, and yield a nested representation of the set of bursts that imposes a hierarchical structure on the overall stream. Consequently, research fronts will be observed based on "burst-terms" detecting outcomes using the Kleinberg's algorithm in the study.

In order to find when and where the most influential changes took place so that the evolution of a research domain can be characterized and visualized, salient citations that were co-cited by at least two different articles are detected and analyzed based on the co-citation analysis. The knowledge domain visualization (KDViz) approach of co-citation analysis is considered as a promising way to detect and monitor the evolution of a knowledge domain [15]. The method first derives a sequence of co-citation networks from a series of equal-length time interval slices. These time-registered networks are merged and visualized in a panoramic view in such a way that intellectually significant articles can be identified based on their visually salient features.

The co-word approach is employed to detect "terms" that co-occur in at least two different records in a time span. Therefore, terms with high frequency and centrality calculated with the Kamada–Kawai algorithm can be identified as indicators of "hot topics" (*i.e.*, research focuses) in a time period [16].

To fulfill the aforementioned intentions, an applicable and powerful literature mapping and visualizing program called CiteSpace is utilized to complete the empirical tests. The program builds on the theory of literature metrology with a fusion of clustering analysis, social network analysis and multidimensional scaling analysis methods. Computer graphics, data mining and other computer technologies are incorporated as well. CiteSpace and its updated versions have been widely used in various disciplines to observe patterns and transitions of a certain topic or scientific field due to its validity, reliability and flexibility [17,18].

2.2. Data Source and Distribution

To ensure a comprehensive and accurate visualization and high explanatory power of original data, strict steps and scope control are set for data collection from the WOS database, including the Science Citation Index Expanded, the Social Sciences Citation Index, the Conference Proceedings Citation Index and the Arts and Humanities Citation Index databases. Articles with the topic of "energy policy" or "energy policies" published between 1961 and 2010 are mined to get 10,222 records (consisting of 3009 articles and 7213 cited references) to form the retrieved data for further analyses.

In order to gain a basic understanding of the research in the field, initial statistics have been summarized to demonstrate certain distributions of the studies with the help of the analysis function of Web of Science, (Figure 2 and Table 1).

Figure 2 reveals the published articles with the topic of energy policy in each year from 1961 to 2010. The preliminary statistics in the figure reveal several burst periods for energy policy research. The "peaks" are consistent with the world's significant energy-related issues, including: the Stockholm Conference on the Environment under UN (United Nations) auspices (1972), the first oil crisis (1974/75), the second oil crisis (1979), the third oil crisis (1990), the Soviet collapse and independence of the Central Asia-Caspian region (1991), the declaration of the UNFCCC (he United Nations Framework Convention on Climate Change) (1992), the United Nations' framework convention on Climate Change (1995), the power crisis in California (2001), the financial crisis, release of the UNFCCC Bali Road Map, and the escalation of the Russia–Belarus energy dispute (2007), and the largest natural gas supply crisis in EU history and the release of the Copenhagen Protocol (2009).

Table 1 shows that the majority of the research comes from the U.S., followed by the UK, Canada, China, India and other significant EU (European Union) countries, representing both traditional and emerging energy actors in the world. Additionally, energy policy has strong multi-disciplinary

components, including materials science, economics, ecology, politics, engineering, geological resources, biology, environmental assessment and law, explaining why the decision-making in this area is always complex, complicated and controversial.

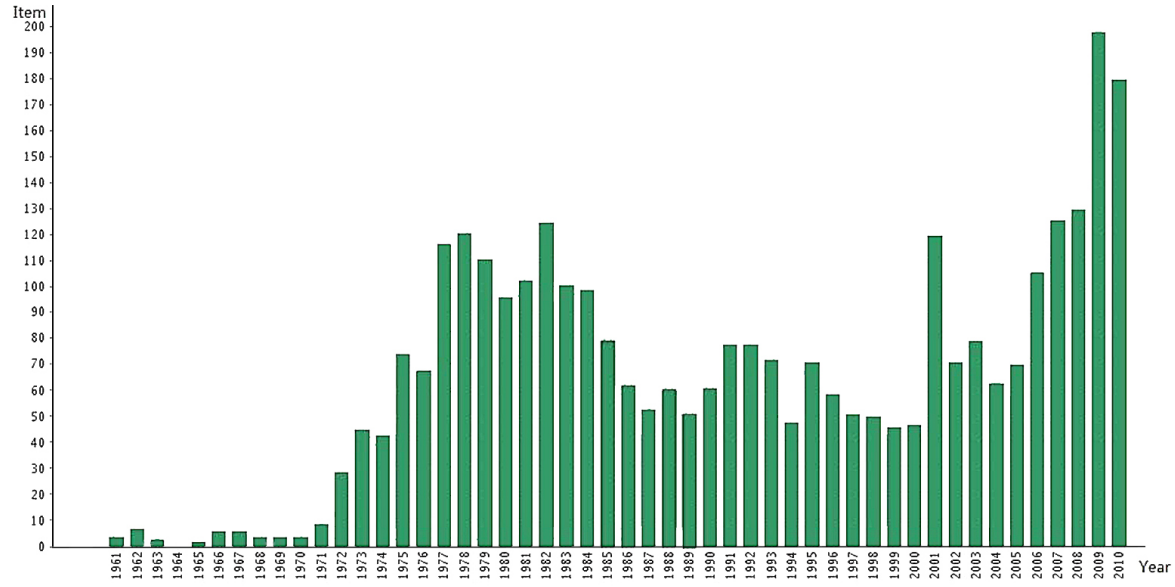

Figure 2. Time profile of energy policy literature (Source: ISI Web of Science).

Table 1. Distribution of countries and research fields (Top 10). Source: ISI Web of Science.

Rank	Countries	Records	Percentage	Fields	Records	Percentage
1	USA	1000	30.40	Energy fuels	1181	35.90
2	England	291	8.85	Environ. Sciences and Ecology	877	26.66
3	Canada	105	3.19	Engineering	712	21.64
4	China	99	3.01	Business Economics	475	14.44
5	Germany	95	2.89	Governmental Law	368	11.19
6	Netherlands	86	2.61	Public Administration	255	7.75
7	Australia	48	1.46	International Relations	173	5.26
8	France	48	1.46	Nuclear Science Tech	147	4.47
9	Sweden	45	1.37	Science Technology	118	3.59
10	India	40	1.22	Social Sciences	95	2.89

3. Experimental Section

3.1. Research Front Progress

In order to get a clear understanding of the significant changes in the energy policy arena, we employ the "burst-term-detecting" function of CiteSpace. Burst terms are derived from unit words, phrases and identifiers and are detected to reflect the research fronts during the past five decades. Using the algorithm embedded in the program, certain citation bursts were drawn based on the sample indicated earlier.

Table 2 displays the burst terms and their active "lifetimes". A citation burst reflects a sharp increase of interest in a specialty, which can last for multiple years or a single year. The results demonstrate the changes of research tendencies for energy policy studies and reveal various research frontiers in different eras. After looking at the results and our data (*i.e.*, the articles being retrieved), corresponding interpretations are summarized below.

Energy diplomacy appeared as a new tendency when the Age of Oil came in the 1960s. Fears of peak oil and dependence on suppliers from the Middle East have been key factors shaping western

domestic and foreign energy policy until recently. Energy policy is a matter of concern within individual countries and has been the subject of extensive discussions at the intergovernmental level aimed at establishing a European energy policy [19]. Conversely, abundant resources reserves, especially oil, provided not only energy security but also drawing power for the Soviet Union (USSR) in the global energy market. In the mid-1980s', guided by Gorbachev's "new thinking", the USSR's energy policy emphasized system development and technological innovation to gain high economic profit rather than political security which was over-estimated during the cold war.

Table 2. Burst terms with time span during 1960–2010.

Begin	End	Burst Term	Begin	End	Burst Term
1961	1974	international control	1978	1980	western energy policy
1962	1977	US foreign policy	1979	1988	energy policy modeling
1964	1967	4th-republic	1980	2000	energy economics
1964	1980	atomic energy policy	1980	1987	energy-issues
1971	1990	national energy policy	1980	1983	Soviet energy system
1972	1990	national policy	1981	1984	Soviet energy technology
1975	1983	government policy	1985	1986	business-gov relation
1975	1986	Canadian energy policy	1985	1989	international perspective
1975	1996	nuclear energy policy	1987	1988	forming economic policy
1975	1976	policy execution	1987	1990	fossil fuel policy
1975	1978	policy making	1993	1994	energy policy act
1975	1992	US energy policy	1993	1993	energy technology policy
1975	1982	world energy policy	1993	1997	market failure
1976	1990	policy analysis	1994	1998	developing countries
1977	1992	energy planning	1995	2004	environmental policy
1977	1988	energy policy analysis	1997	2005	energy source
1977	1994	Swedish energy policy	2000	2001	energy policy
1978	1995	energy conser. policy	2006	-	climate policy
1978	1980	new dimension	2009	-	energy security
1978	1978	Carter adm. approach	2009	-	Chinese government
1978	1993	UK energy policy	2009	-	climate change

A strong connection between domestic energy policy and international conditions emerged when The Control of Oil [20] was manipulated by a dozen members of the Organization of Petroleum Exporting Countries (OPEC) to fix the world oil prices. This triggered the 1970s' global energy crisis. Even though the Carter-administration-approach was relatively successful for energy security by abolishing the powerful Joint Committee on Atomic Energy and issuing the Crude Oil Windfall Profits Tax, the relationship between government and markets never reached a definite conclusion [21].

It was in the U.S. that the theoretical analytical methods, consisting of operational research, combinatorial optimization, simulation analysis, decision analysis and econometrics, were modeled to resolve energy-related issues in policy decision-making processes after the energy crisis. Among all the models, the mathematical modeling is the most conventional way to address the crisis followed by the historic insight method [22]. Energy economics appeared in the early 1980s and lasted for 20 years as one of the research frontiers.

The definition of energy conservation was broadly used from the 1960s' through the 1980s' as a choice of energy policy to improve energy security. In addition to fossil fuels, atomic and nuclear materials were policy makers' favorites and formed a "hard" path to meet national energy security and independence [23]. However, controversy around the operation of nuclear power plants has not stopped as several accidents have happened [24].

The widespread construction and application of nuclear power between the late 1960s and early 1970s raised significant social concerns in Sweden. The heated debate forced the government to switch its policy from nuclear-focused to a "diversified renewables scenario" from 1977–1994 [25]. Nowadays, Sweden is among the leading IEA (International Energy Agency) members in terms of low-carbon

intensity and high share of renewables in its energy supply, with strong growth coming from solid biofuels and onshore wind [26].

Energy technology research reached its peak with the advent of the Stabilization Wedges Theory [27] and other related studies [28,29]. Such studies provided key options—including low carbon technology, energy efficiency management, fuel shifting, carbon capture and storage, nuclear power,and power from renewable sources—to keep emissions on a stable and acceptable level to address climate change.

In the late 1990s, energy policy making became complex, complicated and comprehensive, especially as climate change issues became serious and urgent. Energy growth nowadays is predominantly driven by population and economic growth and a high level of consumption in emerging countries, especially the BRICS (Brazil, Russia, India, China, and South Africa), who have brought a great deal of attention towards energy issues.

3.2. Intellectual Basis and Evolution

According to the analytical framework described in Figure 1, a specific mode is set (*i.e.*, time slice = 5; citation threshold (c), co-citation threshold (cc), and co-citation coefficient threshold (ccv) = (2, 3, 15), (3, 3, 20), (3, 3, 20); the rest of the time value is determined by linear interpolation) and operated to get the visualized distribution of the co-citation network using the data collected in Section 2 (*i.e.*, 10,222 records/articles from the WOS) (Figure 3).

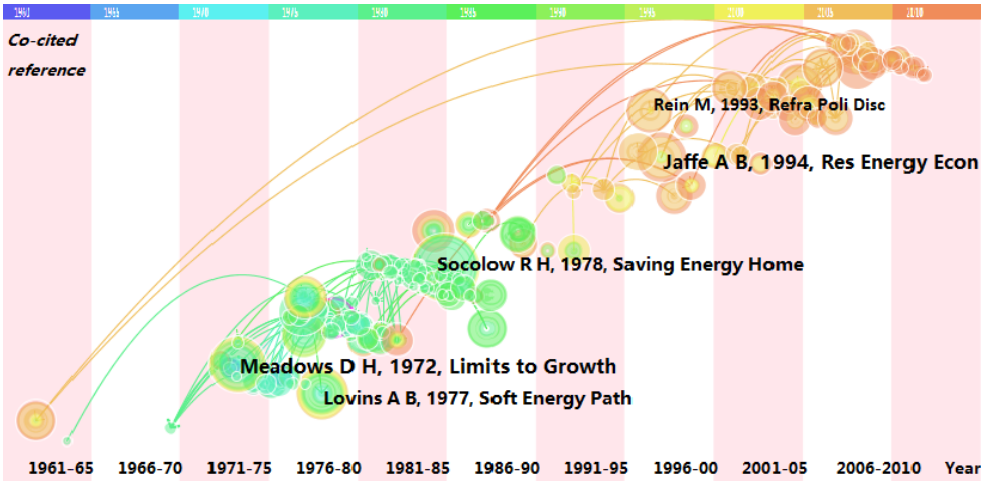

Figure 3. Time period view of the co-citation network.

Figure 3 demonstrates a visualized co-citation network for the literature. Visually salient nodes in the network with long half-lives represent the most important literature in the field, which has formed the research basis of energy policy studies over time. Each node in the picture represents one citation (*i.e.*, a co-cited reference). The location and color of a node denote its publication year and the year of being co-cited by different articles, respectively. The colors of links denote when a particular connection was made for the first time. Blue colors indicate the earliest citations, whereas orange colors indicate the most recently made citations. The thickness of a ring is proportional to the number of citations in a given time slice (*i.e.*, each five years in this study).

As shown in the figure, two main groups (*i.e.*, clusters) have formed during the 1960s to the 1980s and the 1990s–2010s, respectively. Compared to the network before the mid-1990s, the co-cited literature after the mid-1990s gets higher centrality with more notable clusters. To find out the main intellectual base, we pay attention to notable co-cited references (*i.e.*, the statistically significant nodes in the network) with long half-life to identify the major strands of theoretical and empirical research in the field (Table 3).

Table 3. Selected notable/representative citations from network.

Author	Year	Source	Half-Life (Years)	Author	Year	Source	Half-Life (Years)
1960s–1980s				**1990s–2010s**			
Sundquist	1969	Making Federalism Work	11	Arrow	1962	Rev Econ Stud	47
Meadows	1972	Limits to Growth	7	Hausman	1979	Bell J Econ	31
Schurr	1972	Johns Hopkins Univ	6	Jaffe	1994	Res Energy Econ	16
Lovins	1977	Soft Energy Path	6	Rein	1993	Reframing Policy Discourse	16
Craig	1978	J Consum Res	6	Jaffe	1994	Energy Policy	15
Christensen	1973	Rev Econ Stat	5	Hajer	1995	Clarendon Press	14
Light	1976	Publius	4	Kaygusuz	2002	Renew Energy	8
Landsberg	1979	Energy Next 20 Years	4	Popp	2002	Am Econ Rev	8
Yokell	1979	AM Econ Rev	4	Mitchell	2000	Annu Rev Energy Env	7
Stobaugh	1979	Energy Future	4	Kaygusuz	2003	Energy Convers Manag	7
Berndt	1975	Rev Econ Stat	4	Greening	2004	Energy Policy	6
Blair	1976	Control Oil	4	Kingdon	2003	Agen Altern	6
Koreisha	1979	Energy Future	4	Abrahamse	2005	J Environ Psych	5
Lovins	1976	Foreign Affairs	3	Lauber	2004	Energy Policy	5
Socolow	1978	Saving Energy Home	3	Liu	2002	Energy Policy	5
Griffin	1976	AM Econ Rev	3	Jaffe	2005	Ecol Econ	4
Willrich	1974	Nuclear Theft Risks	3	Mitchell	2006	Energy Policy	3
Joskow	1976	Bell J Econ	3	Lewis	2007	Energy Policy	3
Nikamp	1977	Theory Appl	3	IPCC	2007	IPCC	3

(1) 1960s–1980s: Theoretical research was mainly focused on marginal analysis, operation research, development economics, consumer theory, system theory, exhaustible resources economics, electricity market theory, international trade theory, sustainable development concept and public economics.

Many studies were conducted regarding the substitution and complementary effects between energy and non-energy elements to understand the impact of tax or price on macro-economy fluctuations [30,31]. Appropriate energy policy choices were proposed by using elastic analysis methods such as Allen-Uzawa Partial Elasticity of Substitution, Morishima Elasticity of Substitution and Cross Price Elasticity theory of neo-classicism.

Based on the business cycle concept, Christensen's Translog Production Function [32] has been an important pillar of technology improvement measurement and Return to Scale analyses. It also contributed to further research such as Endogenous Growth Model [33] in development economics theory that provides useful tools for policy effective evaluation and basis for energy policy making.

Craig's work provoked discussion about the relationship between consumer behavior and energy conservation through the lens of communication effectiveness [34]. How to use information to persuade public conservation manners by influencing consumer behavior has become a key topic in the energy policy discipline.

As a fundamental of exhaustible theory, Hotelling's law [35] drew public attention to indefinite fossil fuel consumption. However, the ceiling price of energy and a shortage of electricity generating capacity formed by unreasonable policy approaches caused difficulties in national energy security. Therefore, intensive examinations of policies affecting energy markets were undertaken to identify and eliminate distortions by stressing the importance of systematic economic analysis [36].

Electricity market theory emerged with research of real-time prices in the 1980s. This theory uses economic means, especially marginal cost analysis, to regulate participants where the electricity pricing is the body of management concepts [37]. As one of the representative experts in this area, Joskow has contributed to electricity market theory with his studies on electricity market capacity mechanisms, power system reliability, generation capacity regulation mechanism, industry performance related to plants scale [38], competition mechanism's impact on market [39], electricity peak valley pricing theory [40] and Demand Side Management (DSM) effectiveness discussion.

After Sundquist [41] proposed to establish single "unified" federalism guided by the executive office of the president, which ignored the "potential losses in efficiency, effectiveness or responsiveness inherent in the performance of large-scale bureaucracies", Light [42] discussed the evolution of the state role in the 1973–1974 energy crisis and the new responsibilities that states assumed during that period, which they continue to exercise from the lens of federalism. This gives rise to further discussion on the game between federal agencies and states in the energy regulation arena.

While many researchers examined the possibilities of various alternatives to fossil fuels, and made certain recommendations, including the decontrol of oil and gas prices, reform of public utility prices, retention of the nuclear option, strong support for conservation and solar energy and more sharply focused roles for government and industry in the R&D process [43], Stobaugh and Koreisha [44] revealed the critical roles of policies in affecting energy technology assessments, and how those assessments impact the application scope and scale.

Lovins [45] initially presented a soft energy path to solve America's high dependency on fossil fuel and environmental risk [46] by providing distributed energy resources, improvement of energy efficiency and application of renewable energy (solar photovoltaic and wind).

Resources, especially nature resources, were seen as a key constraint condition of economic growth. Limits to Growth [47], a milestone of sustainable development theory that has influenced policy-making decisions to varying degrees, created the significant limit theory of economic growth based on a global models analysis. Resource depletion and environmental degradation caused by economic indexation growth were discussed deliberately and broadly after the book was published. Around the same time, systematic thinking emerged when Schurr [48] considered society as a living organism as well as a system including energy, economics and environment, in which trade-offs are needed to balance both future energy supplies and protecting the natural environment for economic growth.

From the perspective of conventional international trade theory, an optimum tariff would be in order. Yet, taking a political view, the editors wisely reject the optimum tariff argument in favor of subsidization and regulation of domestic energy production and consumption, promotion of renewable energy and implementation of conservation measures to guarantee a prosperous energy future for the United States [49].

Yokell [50] discussed the economic rationale for energy subsidy programs, methods for determining the proper funding level for each program and designing optimal subsidy policies and programs that require several phases. Fiscal subsidy research of energy projects, especially renewable energy projects, has subsequently formed and expanded its territory since the 1970s.

In addition to national and industrial level analyses, Socolow's study [51] represents another dimension in relating to residents' energy conservation issues with the help of field experiment means; in terms of measurement of energy consumption, cost effective strategies of retrofitting houses, data processing for houses diagnoses and finally, the policy enlightenment for improving energy efficiency of households.

(2) 1990s–2010s: Research development combined with global changes after the 1990s forced new insights that helped to update and enrich the theoretical basis of energy policy studies in many ways: environment psychology, ecological modernization theory, consumer behavior theory, policy intervention analysis, externality theory, utility theory, energy paradox, renewable energy analysis, modern government theory, strategic niche management, political system theory, political transition theory, environmental regulation theory, policy instrument analysis, policy discourse analysis and public participation theory.

Abrahamse [52] divided intervention policies into two categories: one is antecedent strategies including goal setting, commitment, information and modeling, the other is consequent strategies, including feedback, reward and punishment. His work contributes to effectiveness research of energy policy interventions from the lens of social and environment psychology in addition to economic analysis in this area.

Combining social theory with detailed empirical analysis, Martin Hajer [53] identified the emergence and increasing political importance of "ecological modernization" as a new concept in the language of environmental politics and provided relative policy instruments. Not only does his study give a better understanding of environmental conflict, it also triggers discourse analysis in the study of policy process.

From the traditional industry's point of view, competition and agglomeration contradict each other, as it is unclear whether the increase in agglomeration damages profit from competition or gives rise to monopolistic behavior that could earn more by setting price beyond marginal cost. Nevertheless, Arrow [54] suspected this and brought new insights to industry organization theory by arguing that workers could gain more experiences and become efficient thanks to "learning by doing" as product volume increased. Additionally, agglomerating of industry in specific spaces helps with technique diffusion due to technological externality effect. Based on Arrow's work, the accumulative effect of knowledge has become one of the hot topics that has been absorbed and developed by endogenous growth theory while his external theory has become a significant branch of economic development theory.

The phenomenon that some cost-effective energy technologies are overlooked or abandoned in energy markets has confused energy economists and energy experts, and has subsequently brought the "energy efficiency paradox" [55] issue into public view. Individuals' decision-making being impeded by market barriers [56], various technique preferences caused by users' heterogeneity [57,58] and inefficient allocation of energy capital as well as technologies caused by market failure [59] are the main reasons accounting for the existence of an "energy efficiency gap" that requires public policy to address.

Studies of renewable energy started after the energy crisis in the 1970s and became popular when "Renewable Energy: The Power to Choose" [60] was published in 1983. There are four main branches in the field of renewable energy studies: renewable energy policies analysis [61], the relationship between renewable application and sustainable development [62], economic explanation for renewable energy and economic system design for renewable development [63].

To tackle the difficulties of promising emerging technologies' diffusion, Kemp [64] placed emphasis on niche market research and considered it as a significant method to cultivate emerging industries. Triggered by approaches and foundation of strategic niche management (SNM) provided by Kemp, more studies have been done to enrich this field.

System theory in policy analysis first appeared in 1953 before being expanded by Kingdon [65], who elaborated on agendas' analysis of policy process based on the Garbage Can Model and proposes multiple-streams framework as one of the key theories of policy transition. Moreover, definitions of policy entrepreneur and policy discourse [66] have been discussed broadly as additions to input-output policy system analysis to provide a way to select, organize, interpret and make sense of public policy.

The prominent synthesis report listed in Table 2 identifies that a comprehensive, science-based assessment of the global energy system is needed if these challenges are to be realistically addressed [67]. The IPCC (Intergovernmental Panel on Climate Change) work indicates that, for one thing, carbon and climate problems have become one of the most serious worldwide energy-related issues in the early 21st century; for another, the multi-stakeholder and multi-level governance perspective has been widely accepted among scientists, business and governments during the process of policy decision-making.

3.3. Research Hot Spot Evolution

In order to get an impression of the evolution of research focus in energy policy studies, key terms with high frequency and centrality during a number of five-year periods are detected and listed using CiteSpace. In so doing, research focuses in different time-spans as well as on the significant transitions of energy policy research can be identified to a great extent. A summary of the results are shown below.

Table 4 shows that the research foci evolved from initially narrow to much broader analyses; in view of background, research focus has changed from narrow analysis to a more comprehensive

view. Early focus was on single energy-related economic analysis and connection of energy and the nation's economic growth, influence of price on energy supply and demand sides, as well as the national medium and long-term development strategy to a more comprehensive scenario including CO_2 mitigation, climate change and environmental sustainability. The focus on research has also shifted from fossil energy (oil) dependency and energy conservation to energy efficiency, energy systems, electrical generation industry, and sustainable energy resources. In view of content, research spots have transited from policy executive and policy analysis to public policy and policy instruments studies, especially the implementation effectiveness measurement. In view of objects, research has transited from developed countries like France, European Nations, and the U.S. to developing countries and worldwide analysis.

Table 4. High frequency and centrality terms during each five years.

Time Span	High-Frequency & Centrality Terms
1961–1965	international control; European industrial-policy; Atlantic energy policy
1966–1970	4th republic; energy policy; economic policy; common European energy policy; atomic era; economic comparison
1971–1975	energy policy; national energy policy; national policy; atomic energy; Americas energy future; policy execution; policy making; energy policy project
1976–1980	national energy policy; Carter administration approach; policy execution; policy making; United States energy policy; energy policy; world energy policy; new dimension; western energy policy; United States foreign policy; Soviet foreign policy; energy planning
1981–1985	United States energy policy; energy policy; national energy policy; policy analysis; today's problems; Soviet energy technology; yesterday's solution; energy issues; energy economics; business-government relation
1986–1990	fossil fuel policy; forming economic policy; development policy; coal technology; national energy policy; United States energy policy; energy policy analysis; energy conservation policy
1991–1995	energy policy; environmental policy; energy efficiency; energy policy act; nuclear power; developing countries; CO_2 emissions; energy conservation policy; energy technology policy; postwar Japan; developing countries; market failure; energy markets; policy implications
1996–2000	energy policy; energy efficiency; renewable energy; European union; energy consumption; energy sector; developing countries; climate change; economic growth; renewable energy source; renewable energy technology; electricity generation; energy system
2001–2005	energy policy; renewable energy; energy efficiency; natural gas; energy sector; sustainable development; environmental policy; nuclear power; national energy policy; energy source; climate change; energy consumption
2006–2010	energy policy; renewable energy; energy efficiency; climate change; renewable energy source; energy consumption; energy security; energy resources; sustainable energy; renewable energy policy; public policy; policy instruments; energy supply; climate policy; European union; electricity generation; natural gas

4. Conclusions

Energy policy studies comprise a comprehensive field of research. The studies reflect sensitivity to the changes of external situations, concerns around national security and geopolitics of energy access, involvement of multi stakeholders and their impacts at multiple levels in the decision-making calculus and influence on climate as well as environmental policies. Accordingly, the body of relevant literature is growing rapidly in the field of energy policy studies. In order to identify core publications related to energy policy, the "topic search" and the "citation expansion" approach were utilized to

retrieve the raw data (*i.e.*, the articles and their citations) by following [12,18,68–71]. The former technique is used to select articles with specific terms in their titles, keywords, keywords plus, abstract content, or identifiers, while the latter one identifies references of the selected articles to "remedy" and expand the dataset with closely related studies of a topic. The combination of the two approaches is valid to support bibliometric analyses in judging research fronts, focuses, and bases [72]. Further, a visualization tool and analysis of the vast body of literature provides an effective method for gaining insights about trends in the directions of research. Conclusions drawn from the above analyses are:

(1) Energy policy research is a multi-disciplinary endeavor, with many actors and stakeholders operating at different levels in national and international contexts. The onus is on policymakers and energy policy professionals to better understand how to leverage the combined resources and talents of the academic, public, private and nonprofit organizations to resolve complex problems related to energy issues.
(2) Several disciplines including economics, sociology, geography, political science, philosophy, engineering, urban planning and environmental studies have contributed to, and formed the backbone of, energy policy research. Development of theoretical concepts in each field and fusion of research disciplines provide a useful means to interpret, estimate, adjust, predict and plan the evolution of energy policies and their impacts.
(3) Recent trends show energy policy studies have broken through boundaries of energy economics into a more comprehensive arena including climate change, ecological protection and environmental impact. Moreover, the picture of international energy policies is undergoing rapid change in light of the emergence of developing countries' growing influence driven by the high demand for energy and the imperative to reduce environmental impacts for balanced outcomes.
(4) Recent studies on energy policy focus on several terms such as evaluation and prediction of energy policy, governments' role in energy market or energy projects, path to improving renewable energy application, coordination of energy consumption, economic growth and climate change, and synergy of domestic and foreign policies.
(5) The data-retrieving method used in the paper still has limitations as some relevant references may be excluded when specific terms do not explicitly appear in the "topic" section. In this case, further studies should incorporate articles from critically acknowledged journals in the field, such as the journal of Energy Policy. In so doing, the updated work would help to provide additional insights on the subject.

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