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Review

Limited Demand or Unreliable Supply? A Bibliometric Review and Computational Text Analysis of Research on Energy Policy in India

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Abstract: Although India has made significant progress towards the sustainable development goal on energy (SDG 7), further policy innovations are essential for closing the gap, addressing geographic disparities, and harnessing energy for transformative change. Research can support this process by creating policy-relevant knowledge regarding the energy transition, but there is no systematic account of the literature pertaining to energy policy in India to map the research area and suggest key avenues for future research. In this study, I conduct a bibliometric review and computational text analysis of over 2700 publications to identify the key themes, geographies, and public policy concepts (not) examined in the research on energy policy in India. I find that: (i) the literature is dominated by topics in energy supply and less attention is paid to demand-side management, energy efficiency, and electricity distribution; (ii) existing studies have hardly examined subnational policy (-making), especially in the case of eastern and north-eastern India; and (iii) research on both analysis for policy and analysis of policy is limited. I conclude that the current foci lack the breadth and depth necessary for supporting the Indian energy transition and urge scholars to diversify the thematic, geographic, and conceptual engagement in future research.

Keywords: bibliometric review; computational text analysis; energy policy; India; policy analysis; policy innovation; policy sciences; public policy; sustainable development goal on energy (SDG 7); sustainable energy transition



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1. Introduction

India has made significant progress on the three pillars of the sustainable development goal on energy (SDG 7): energy access, energy efficiency, and renewable energy. Residential electricity consumption in the country has increased over 50-fold in half a century [1] and nearly every household has received a connection to liquified petroleum gas, or LPG [2]. To enhance energy efficiency, governments have adopted numerous measures on demand-side management [3], and energy intensity of the economy has witnessed a reduction of approximately 15 percent in the previous decade [4]. Further, the country has been successful in increasing the capacity of solar and wind energy in its electricity generation mix in a cost-effective manner [5–7]. However, access to modern energy remains uneven [2,8] and nearly 35 percent of the country is still energy poor [9]; significant energy savings in end use [10–14], transmission and distribution [15], and generation [16] remain untapped; the dependence on imported technologies for solar energy [17], the slow deployment of wind energy [18,19], and the limited contribution of other renewable energy sources [20] continue to pose a challenge. Policy innovations will, therefore, be important in accelerating the sustainable energy transition in India.

The situation in energy access, energy efficiency, and renewable energy varies significantly at the subnational level. For instance, both the cost and the quality of electricity supply differ from state to state and from rural to urban India [21–23]. In combination with differences in cultural, geographic, and socioeconomic characteristics, these result

in heterogeneities in demand and consumption [9,24–26]. Further, there are leaders and laggards at the sectoral- and state-level in the case of energy efficiency [3,10,13]. Even for renewable energy, resource availability, policy activity, and achievement differ widely within the country [27]. Moreover, energy governance in the country is multi-level; the union government and the state governments are concurrently responsible for decision-making, implementation, and monitoring and evaluation. Therefore, policy innovations will be necessary not only across policy areas, but also at various levels of government.

Policy-relevant research can create knowledge on understanding, explaining, and promoting policy innovation for the Indian energy transition. In fact, the field of policy analysis gained prominence in the Global North after the Second World War to provide governments with a systematic, domain-agnostic approach for identifying societal issues [28], formulating policy alternatives, and choosing the “best” course of action [29,30]. The idea of policy sciences—a normative, multi-disciplinary, and contextual orientation to public policy emphasizing both analysis *for* policy (i.e., traditional policy analysis) and analysis *of* policy (i.e., policy studies)—was also born [31]. While the field of policy analysis continued to develop, scholars also began to study the processes of policy formulation, policy adoption, and policy implementation to explain policy outputs and outcomes on the ground [32–35]. Further, since the 1990s, scholars dissatisfied with the positivist or post-positivist orientation in public policy have expressed increasing interest in using a constructivist lens and studying public policy as a discursive or narrative contest, in what is known as the “argumentative turn” in public policy [36–38]. Consequently, a variety of approaches, theories, and methods are available for creating policy-relevant knowledge in any policy area, including energy policy.

The body of research pertaining to the energy policy in India is large and growing rapidly. Illustratively, the Elsevier Scopus database alone has indexed over 2500 publications in this research area, over half of which have been published within the last decade. Within this literature, one can find reviews of various subjects, such as business models [39], characteristics influencing energy behavior [40], indicators [28], policies [41–43], status and progress [44,45], and technologies [46,47]. In addition, a few reviews of the literature on topics such as the Electricity Act, 2003 [48] and the effect of local content requirements on the development of renewable energy [49] also exist. However, no study has conducted a comprehensive review to provide a systematic account of the scholarship. As a result, knowledge of the trends in the literature, the topics covered, the gaps in existing work, and broad directions for future research remain unclear.

The objective of this study is to provide an overview of the literature on energy policy in India and shed light on its thematic focus, geographic focus, and policy focus. It addresses the following research question: what are the key themes, geographies, and public policy concepts that have been examined in this research area. To answer this question, I conduct a bibliometric review and computational text analysis of over 2700 publications pertaining to energy policy in India. In doing so, I contribute to the literature by: (i) providing the first systematic account of the scholarship; (ii) identifying (gaps in) the thematic, geographic, and public policy focus of existing studies; (iii) thereby, proposing directions for future research in this area; and, (iv) demonstrating one application of computational text analysis to the research on energy policy in India.

This article is structured as follows. After this introduction, Section 2 describes the methods of this study. Subsequently, an overview of research pertaining to energy policy in India is presented in Section 3. Section 4 examines the thematic focus of the research based on the clusters identified in the co-occurrence analysis. Then, the geographic focus (Section 5) and the policy focus (Section 6) of the research are analyzed. Finally, Section 7 discusses the implications of the findings, proposes directions for future research, and concludes the study.

2. Materials and Methods

This study is based primarily on bibliometric analysis. Bibliometrics is “the collection, the handling, and the analysis of quantitative bibliographic data, derived from scientific publications” [50]. Thus, the unit of analysis is the record of a scientific publication, which comprises information on author names, publication title, publication year, source title, abstract, keywords, number of citations, and cited references. This information is coded to obtain quantifiable data regarding the volume of scientific activity, the authorship network, the source network, and the most cited publications in the dataset [50,51].

Further, the structure of enquiry in the research area is mapped through computational text analysis, specifically automated (term) co-occurrence analysis. This involves extracting terms from publication titles and abstracts, creating a thesaurus to harmonize them, and creating a co-occurrence network of frequently occurring, relevant terms. In a co-occurrence network, the weight of an edge between two nodes (terms) indicates the number of publications in which the terms co-occur in the keyword list or the title and abstract. Following van Eck and Waltman [52], I used binary counting for the creation of the co-occurrence network, i.e., counted the presence of a term rather than the number of times it occurred within the title or abstract.

Subsequently, I examined occurrences of countries, states, and cities in the dataset to understand the geographic focus of the research. Finally, the context in which the term “policy” is used was examined by counting occurrences of noun phrases containing the term, as these are likely to indicate the sectoral (for example, climate policy, energy policy, or urban policy) as well as conceptual (for example, policy change, policy design, or policy implementation) focus of the publications in the dataset. I then searched for the frequently occurring phrases in the dataset and reviewed titles and abstracts of publications matching them to understand the research focus and its analytical engagement with public policy.

The data for the bibliometric analysis were obtained from the Elsevier SCOPUS database. They consisted of publications whose titles, abstracts, or keywords matched the following search query: *India AND (electricity OR energy OR “power sector”) AND policy*. This search was conducted on 25 July 2019 and returned over 3200 publications. Amongst these, about 450 publications were excluded based on relevance after two rounds of screening based on publication content and type. Those excluded were, for instance, business reports pertaining to electricity, gas, or oil; research on energy pertaining to other geographies in which India was mentioned only cursorily; works on foreign policy in which energy was merely mentioned; or publications on nutrition in which energy was described in the context of metabolism.

The analyses were conducted using Microsoft Excel and VOSViewer [53,54].

3. Overview of the Research on Energy Policy in India

This dataset contains 2771 publications pertaining to energy policy and India. The earliest publication in this dataset was by Henderson [55] on “India: The energy sector”. Subsequently, Parikh and Parikh [56] published on the “Mobilization and impacts of bio-gas technologies” and Parikh [57] published on the “Scope for energy substitution in India”. The number of publications on the topic has grown steadily since then. The 1980s witnessed over 80 publications in this research area, in comparison to the 10 publications during the 1970s. By the turn of the millennium, scientific activity had increased to approximately 30 publications per year. It has risen severalfold since and after 2015 Scopus has indexed more than 200 publications annually.

Over 4700 authors have contributed to the 2771 publications in this dataset, indicating a fairly high degree of collaboration in this research area. This is further corroborated by the co-authorship network analysis: the largest connected co-authorship network in this dataset links over 1700 authors. A majority of the authors have, however, been involved in only a single publication on the topic and fewer than 150 authors have five or more publications in this dataset. A co-authorship network of scholars with five or more publications is shown in Figure 1.

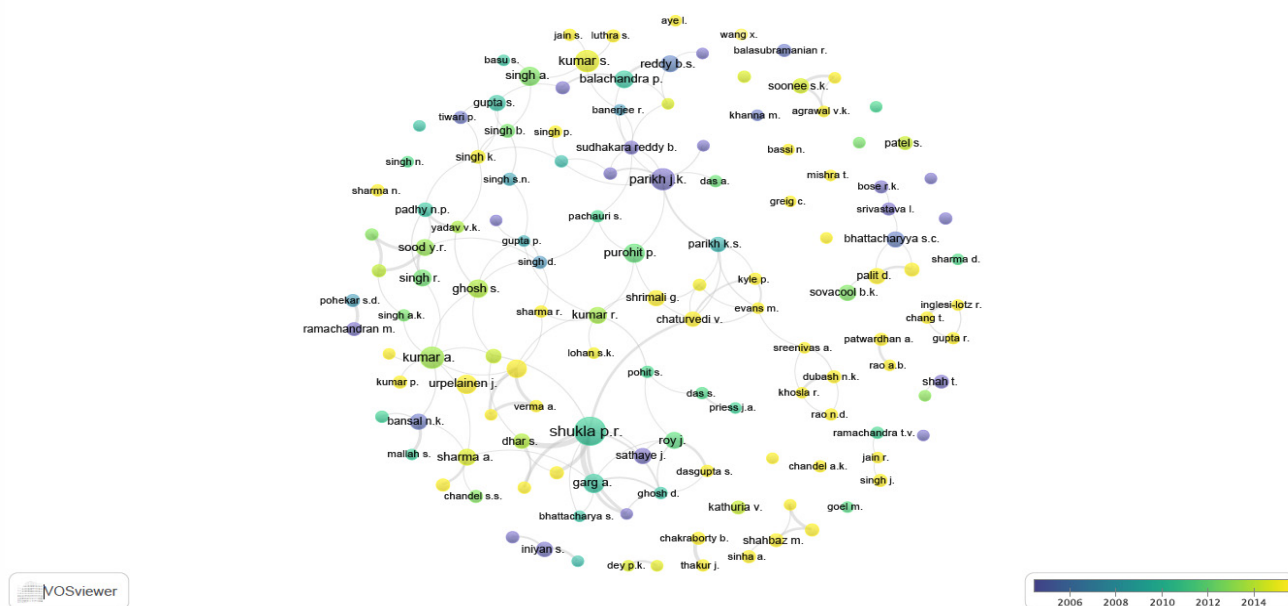


Figure 1. Co-authorship network of scholars with five or more publications pertaining to energy policy in India. A node depicts a scholar while a link between two nodes represents a co-authorship relation. The size of the node is indicative of the number of publications by the author in this dataset. The color of the node shows the average publication year of the author.

The authors with the most publications on the topic are: P. R. Shukla (n: 41), J. K. Parikh (n: 23), A. Singh (n: 17), and A. Garg, P. Purohit, and J. Urpelainen (n: 16 each). The results of this analysis also include A. Kumar and S. Kumar (n: 24 each). However, these names appear to match multiple authors who cannot be distinguished easily based on the bibliometric data. Among the prolific authors, while J. K. Parikh was actively involved in the early development of the research area (average publication year, y: 2000), P. R. Shukla, A. Singh, A. Garg, and P. Purohit have been more active since 2000 (y: 2010–12), and J. Urpelainen has been active more recently (y: 2016). As one might expect, a majority of the work on the topic (number of publications, $n > 1600$) has been published by scholars affiliated with an institution in India. In addition, scholars affiliated with institutions in the United States ($n > 400$) and the United Kingdom ($n > 150$) have also published frequently in this research area. Other countries with a substantial publication record on the topic ($n > 50$) include: Germany, China, Australia, France, the Netherlands, and Japan.

Although research in this area has been published in over 1000 sources, only 92 sources have five or more publications and 33 sources have 10 or more publications in this dataset (Figure 2; Table 1). The sources with the most publications in this dataset are: *Energy Policy*, *Renewable and Sustainable Energy Reviews*, *Energy*, *Energy Economics*, and *Energy for Sustainable Development*. Other prominent sources in this research area include: *Renewable Energy*, *The Journal of Cleaner Production*, *Energy Procedia*, *Economic and Political Weekly*, and *the International Journal of Global Energy Issues*. While sources such as *Energy Policy*, *Energy*, *Energy Economics*, and *Energy for Sustainable Development* have demonstrated an interest in the topic for a while (y: 2008–11), sources such as *Renewable and Sustainable Energy Reviews*, *The Journal of Cleaner Production*, and *Applied Energy* have paid attention to the research area more recently (y: 2014–17).

The most cited publications in this dataset provide a preview of the themes discussed in the research area (Table 2). Illustratively, Masih and Masih [58] examine unidirectional and bidirectional Granger causality between total energy consumption and real income in six Asian countries, including India. Relatedly, Pao and Tsai [59] and Ghosh [60] analyze the relationship between energy consumption and economic growth in the BRIC countries and India, respectively. In another highly cited study, Jebaraj and Iniyan [61] review a plethora of energy modelling techniques to inform the policy-making and scholarly communities.

Meanwhile, Nejat, Jomehzadeh [62] review the trends in residential energy consumption, carbon dioxide emissions, and energy policies in the 10 highest carbon-dioxide-emitting countries worldwide. With a focus on biofuels, Sorda, Banse [63] examine the national strategies of the leading producers and De Fraiture, Giordano [64] assess the implications of production on land and water use. Meanwhile, in broader analyses that also touch upon energy policy, Drèze and Sen [65], Leach, Scoones [66], and Ackerman [67] delve into India's development trajectory, the pathways approach to sustainability, and co-governance as a paradigm for effective public participation, respectively.

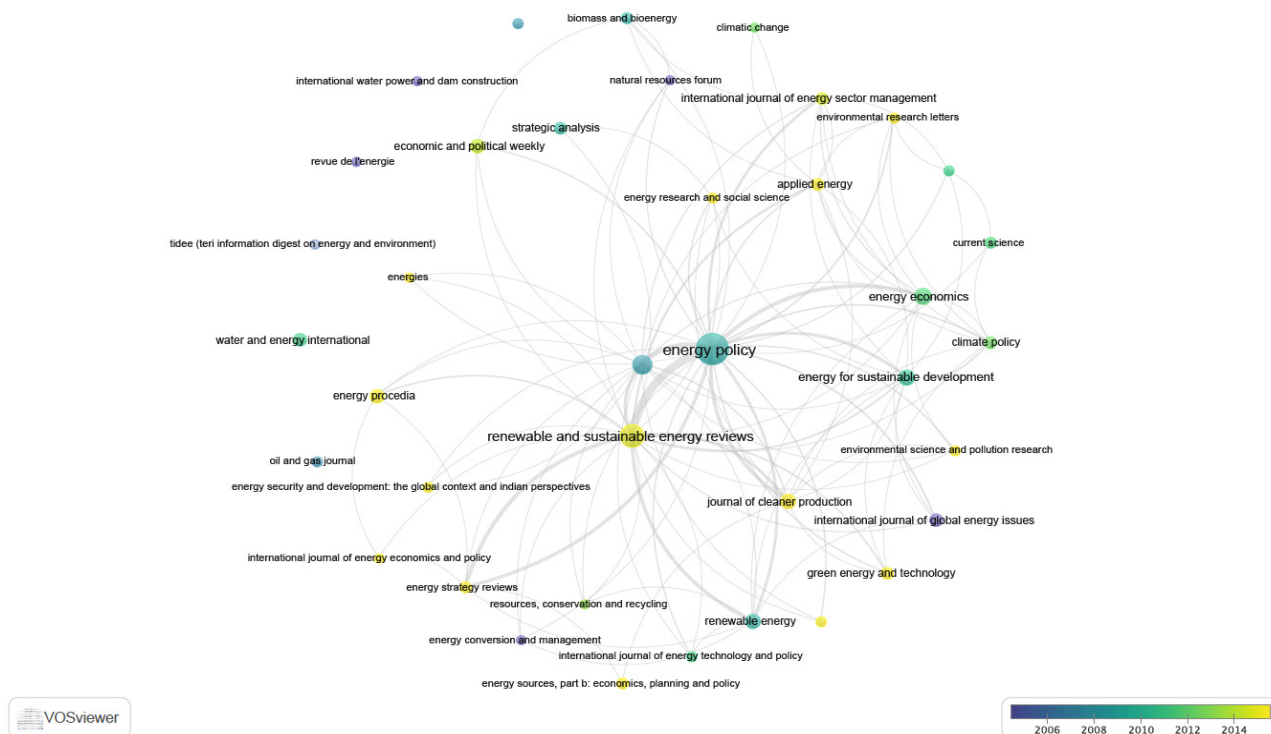


Figure 2. Citation network of sources with 10 or more publications pertaining to energy policy in India. A node depicts a source while a link between two nodes represents a citation relationship. The size of the node is indicative of the number of publications in the source in this dataset. The color of the node shows the average publication year for the source.

Table 1. Top sources publishing research pertaining to energy policy in India.

Source	Publications	Citations
<i>Energy Policy</i>	317	9448
<i>Renewable and Sustainable Energy Reviews</i>	130	4479
<i>Energy</i>	73	1888
<i>Energy Economics</i>	45	1446
<i>Energy for Sustainable Development</i>	41	637
<i>Renewable Energy</i>	33	754
<i>The Journal of Cleaner Production</i>	33	472
<i>Energy Procedia</i>	29	123
<i>Economic and Political Weekly</i>	27	131
<i>International Journal of Global Energy Issues</i>	25	66

Table 2. The most cited publications pertaining to energy policy in India.

Authors	Title	Year	Source	Cites
Masih A.M.M., Masih R.	Energy consumption, real income and temporal causality: Results from a multi-country study based on cointegration and error-correction modelling techniques	1996	<i>Energy Economics</i>	419
Dreze J., Sen A.	An uncertain glory: India and its contradictions	2013	-	414
Jebaraj S., Iniyar S.	A review of energy models	2006	<i>Renewable and Sustainable Energy Reviews</i>	378
Nejat P., Jomehzadeh F., Taheri M.M., Gohari M., Abd. Majid M.Z.	A global review of energy consumption, CO ₂ emissions and policy in the residential sector (with an overview of the top ten CO ₂ emitting countries)	2015	<i>Renewable and Sustainable Energy Reviews</i>	347
Leach M., Scoones I., Stirling A.	Dynamic sustainabilities: Technology, environment, social justice	2010	-	335
Pao H.-T., Tsai C.-M.	CO ₂ emissions, energy consumption and economic growth in BRIC countries	2010	<i>Energy Policy</i>	283
Ghosh S.	Electricity consumption and economic growth in India	2002	<i>Energy Policy</i>	281
Sorda G., Banse M., Kemfert C.	An overview of biofuel policies across the world	2010	<i>Energy Policy</i>	279
De Fraiture C., Giordano M., Liao Y.	Biofuels and implications for agricultural water use: Blue impacts of green energy	2008	<i>Water Policy</i>	265
Ackerman J.	Co-governance for accountability: Beyond “exit” and “voice”	2004	<i>World Development</i>	223

4. The Thematic Foci of the Research

The most commonly occurring terms in publication titles and abstracts in this dataset are: India (number of publications, n: 2565), policy (n: 1203), country (n: 1166), energy (n: 932), development (n: 720), technology (n: 614), China (n: 559), government (n: 531), system (n: 530), use (n: 477), and model (n: 475). However, many of these have little discriminating power in identifying specific themes within this literature. To increase coherence of the analysis, only 60 percent of the most *relevant* terms were used for clustering the research. Indicatively, the most frequently occurring relevant terms in this dataset are: China (n: 559), emission (n: 419), carbon emission (n: 346), security (n: 325), economic development (n: 313), generation (n: 287), energy consumption (n: 268), oil (n: 204), carbon (n: 201), and United States (n: 188). Based on co-occurrence of frequently occurring relevant terms, this literature can be classified broadly into eight clusters (Figure 3).

The first cluster focuses on various aspects of the electricity sector. This is indicated by the terms frequently occurring in this theme, such as (energy/power) generation, renewable energy source, solar/wind energy, (electricity) grid, transmission, electricity demand, customer, competition, trading, and policy framework. The themes covered here include electricity generation [68], renewable energy [69], transmission and distribution [70,71], electricity demand [72], and governance [73–75]. Illustratively, Umamaheswaran and Seth [76] identify characteristics that facilitate or hinder financing for utility-scale solar and wind energy while Sahoo and Shrimali [77] evaluate the effectiveness of a requirement to source technology domestically in strengthening the local solar photovoltaic manufacturing base in India. In the context of electricity reform, Srivastava and Shahidehpour [78] and Sharma, Nair [79] critique the initial progress and draw lessons for restructuring the sector.

The second cluster is on energy geopolitics. Studies in this cluster engage with themes pertaining to energy security [80,81], fuel supply [82,83], nuclear energy [84,85], international trade [86,87], and resource extraction [88,89]. Consequently, the terms appearing often in this cluster include: security, geopolitics, oil, (liquified) natural gas, pipeline, nuclear (energy/power), (non-) proliferation, trade, agreement, supplier, import, domestic

production, reserve, and mining. In addition, other countries such as China, the United States, Japan, Russia, and Pakistan are mentioned frequently in this theme. Illustratively, Grover [90] reviews the policy initiatives of the Government of India on nuclear energy to develop a likely scenario for electricity generation capacity while Roy [91] calls for closer cooperation between India and Central Asia, especially Turkmenistan, to secure natural gas supply. In a study at the interface of energy and foreign policy, Jörgensen and Wagner [92] identify opportunities for strengthening the bilateral relationship between the European Union and India on climate change and energy.

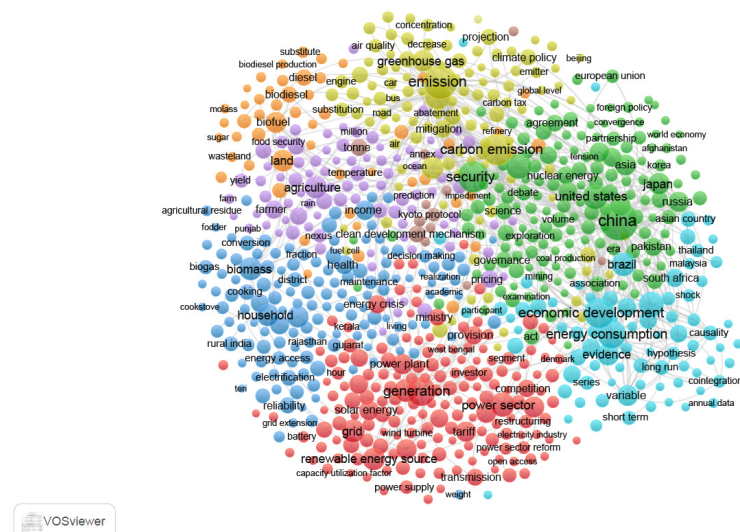


Figure 3. Co-occurrence network of terms in the titles and abstracts of at least 10 publications pertaining to energy policy in India. A node depicts a term in a publication title or abstract. A link between two nodes represents a frequent co-occurrence relationship. The size of the node is indicative of the number of occurrences of the node in this dataset. The color of the node shows the primary cluster of the node: the electricity sector (red), geopolitics (green), energy access (blue), climate change mitigation (yellow), the energy-food-water nexus (pink), the economy-energy nexus (aqua), oil and biofuel (orange), and the Kyoto protocol (brown).

The third cluster in this research area is on energy access. This literature covers themes spanning energy services, the choice of fuel, the availability and quality of electricity, the societal impact of energy access, and models for enhancing access. These are indicated by the terms used commonly in this cluster: energy access, energy requirement, cooking, lighting, biomass, liquified petroleum gas, kerosene, (rural) electrification, reliability, affordability, education, women, business model, microgrid, and public private partnership. Narula [93], for example, assesses sustainable energy security—in terms of availability, affordability, efficiency, and environmental acceptability—of several alternatives for households in India. Gupta and Ravindranath [94] conduct a financial analysis of household cooking energy alternatives, and Yap and Nixon [95] evaluate various waste-to-energy technologies based on a mix of qualitative and quantitative criteria. Focusing on the issue of energy access, Rao [96] examines the distributional benefit of the subsidy on kerosene in the state of Maharashtra while Jeuland, Bhojvaid [97] estimate the willingness to pay for improved cook stoves in rural India. In a more recent study, Malakar [98] examines the effect of rural electrification in enhancing capabilities in two villages in the state of Andhra Pradesh. Meanwhile, Sudhakara Reddy and Nathan [99] highlight the impact of the lack of access to modern energy services on women.

The fourth cluster focuses on climate change mitigation. The most frequently occurring terms within this cluster include (carbon) emission, greenhouse gas, (climate change) mitigation, policy scenario, co-benefit, carbon capture (and storage), air (pollution/quality), nitrogen dioxide, sulfur dioxide, United Nations Framework Convention on

Climate Change (UNFCCC), Paris Agreement, and Nationally Determined Contribution (NDCs). These show that studies in this cluster delve into themes surrounding greenhouse gas emissions, climate policy, low carbon technologies, and air pollution. Illustratively, in a scenario modelling analysis, Shukla [100] constructs the emissions trajectory for India under alternative specifications of a carbon tax. Subsequently, Ghosh, Shukla [101] examine the mitigation potential of various renewable energy technologies in the electricity sector in India. Moreover, Cohen, Blanco [102] explore the use of multi-criteria decision analysis in operationalizing the co-benefit approach by guiding policymaking at the climate-development interface. Another strand within this theme examines the issue of local air pollution in relation to energy use [103–105]. In addition, this cluster comprises terms that refer to energy demand, including demand-side, energy efficiency, rebound effect, buildings, transport (system), and industries such as cement and iron and steel [106–108].

The fifth cluster delves into the energy-food-water nexus. The key themes in this literature include water for energy [109,110], energy subsidies [111], agriculture [112], energy for water [113], and climate change adaptation [114]. This is reflected in the terms mentioned often in this cluster: hydroelectric power, energy subsidy, agriculture, farmer, food, groundwater, river, pricing, drought, livelihood, vulnerability, resilience, and adaptation. Illustratively, Devasenapathy, Senthilkumar [115] highlight the importance of a sustainable agricultural system in preventing the depletion of conventional energy sources, as agriculture consumes about 10 per cent of commercial energy in India. On the energy-water nexus, Bassi [116] argues that solar-powered irrigation is unviable in India from an economic and natural resources perspective, while Closas and Rap [117] also caution about the financial and economic cost of subsidizing solar photovoltaic technologies for groundwater pumping. Anand [118], in a focus on the energy-food nexus, emphasizes the dilemma in reducing energy subsidies in a low- or middle-income country, as a one-unit increase in the cost of input energy manifests as a multi-unit increase in the total cost of farming.

The sixth cluster concerns the economy-energy nexus. The most frequently mentioned terms in this cluster highlight its empirical foci and methodological preferences: economic development, gross domestic product, coal/electricity/energy consumption, foreign direct investment, price elasticity, environmental Kuznets curve, hypothesis, panel, time series data, co-integration, (Granger/unidirectional) causality, and vector error correction model. As these suggest, the prominent themes in this cluster are the relationship between energy consumption and economic growth, the influence of other economic variables—such as investment and trade—on the energy system, and price elasticities of energy demand. Illustratively, Ghosh [60] examines the presence and direction of causality between economic development and energy consumption in India (see also Paul and Bhattacharya [119]). In another example, Shahbaz, Mallick [120] study the effect of economic, social, and political globalization on energy consumption in India in the short-run as well as the long-run. Moreover, the mention of other countries—such as Brazil, Malaysia, South Africa, and Thailand—hints at cross-country analyses with a possible focus on BRICS and Asia. For instance, Abdouli, Kamoun [121] estimate the relationship of economic growth, foreign direct investment, and population density to carbon dioxide emissions in the BRICS economies.

The seventh cluster delves into issues related to oil and biofuel. This is indicated by the key terms in this cluster: crude oil, gasoline, petroleum, refinery, oil import/price, engine, transport fuel, alternative fuel, substitution, blending, biofuel, bioenergy, ethanol, lifecycle assessment, and wasteland. van Moerkerk and Crijns-Graus [122], for instance, analyze oil supply risk under different scenarios in large economies around the world and Li and Xiaowen Lin [123] estimate the effect of demand from emerging countries, such as China and India, on global oil prices. In another strand, Murali and Hari [124] examine the trends in demand and supply of biofuels in India, while Kumar Biswas and Pohit [125] identify the characteristics that hinder progress on the policy target of 20 percent bioethanol

and biodiesel blending in petrol and diesel, respectively. Meanwhile, Gmünder, Zah [126] conduct a lifecycle assessment of an electricity generation plant running on Jatropha oil.

The final cluster, closely related to the cluster on climate change mitigation, focuses on the Kyoto protocol and related topics. This is reflected in the terms associated with this cluster: clean development mechanism (project), Kyoto protocol, annex, host/industrialized country, certified emissions reduction, Latin America, tonne, and transparency. Illustratively, den Elzen, Lucas [127] identify geographic regions with similar mitigation costs in the post-Kyoto world. Meanwhile, Rahman and Kirkman [128] analyze variation in the cost structure of certified emissions reduction based on project and geographic characteristics. With an interest in the impact of the Kyoto protocol on low- and middle-income countries, Pathak, Gupta [129] model the effect of carbon tax in the United States on its trade with India.

This analysis shows that electricity generation has received far more attention than transmission and distribution in the literature. Even without counting variations such as (renewable) energy generation, the terms “generation” and “power generation” occur in over 275 publications and 150 publications, respectively. In contrast, the terms “distribution”, “transmission”, and “DISCOM” (or “distribution utility”) feature in about 125, 70, and 30 publications, respectively. In addition, although the term energy efficiency or its variants occurs in approximately 260 publications, energy efficiency does not feature as a separate cluster and is often discussed as one umbrella of measures in the context of climate change mitigation. Further, terms associated with energy conservation and demand side management also appear in only about 110 and 30 publications, respectively.

5. The Geographies in the Research

Apart from India, several other countries are mentioned often in publication titles and abstracts in the dataset. Most prominent amongst these are: China ($n > 500$), the United States ($n > 200$), Brazil ($n > 150$), Japan ($n > 130$), and Russia ($n: 116$). Other countries mentioned in a significant number of publications ($n > 50$) include South Africa, Pakistan, Australia, Bangladesh, and Mexico. The literature spans large- n econometric analyses [130], studies on countries prominent from an energy consumption or greenhouse gas emissions perspective [131–133], regional analyses on Asia [134] or the Indian subcontinent [135], research on emerging economies such as the BRICS countries [136], small- n comparative work, for example, on China and India [137], and investigation of issues involving geopolitically strategic countries for India, such as Iran [138].

The states in India are not mentioned often in this dataset. The ones mentioned most frequently are: Gujarat, Tamil Nadu, Maharashtra, Karnataka, Uttar Pradesh, Andhra Pradesh, Rajasthan, Odisha, and Kerala (Table 3). Numerous state-level studies focus on various aspects of renewable energy, such as solar energy resource potential [139,140], public acceptance of small hydroelectric power [141], diffusion of renewable energy [142–144], policy implementation [145], or the management of biomass energy [146]. Research has also delved into the energy-food or the energy-water nexus, for example, in the case of Gujarat [147], Karnataka [148], Tamil Nadu [149], or West Bengal [150]. The issue of energy pricing is another key challenge that has received attention in state-level analysis, illustratively, in the case of kerosene subsidy in Maharashtra [96] or cross-subsidization and residential pricing of electricity in Uttar Pradesh [151,152].

Research at the city level is even more limited. As one might expect, Delhi (or New Delhi) is the most frequently mentioned among the cities. The other cities featuring in the literature are: Mumbai, Bengaluru, Chennai, Hyderabad, Ahmedabad, Vishakhapatnam, Pune, and Kolkata (Table 4). A key topic at the city level is that of local air pollution. Illustratively, Gurjar, Ravindra [104] examine local air pollution in Indian megacities; Garg, Kapshe [153] focus on point sources of pollution; and Guttikunda, Goel [154] zoom in on particulate emissions in coastal cities such as Chennai and Vishakhapatnam. Carbon footprint and greenhouse gas emissions of the city or for specific categories of consumers (such as residential buildings) have also received attention, both in the international context

and the domestic one [155–157]. Other issues studied at the city level include cooking fuel use [158], community microgrids [159], slum electrification [160], decentralized renewable energy [161], transportation scenarios [162], and energy conservation/optimization in industries [163].

Table 3. The states mentioned in research on energy policy in India.

State	Occurrences
Gujarat	44
Tamil Nadu	37
Maharashtra	30
Karnataka	28
Uttar Pradesh	27
Andhra Pradesh	25
Rajasthan	25
Odisha	22
Kerala	20

Table 4. The cities mentioned in research on energy policy in India.

City	Occurrences
(New) Delhi	90
Mumbai	31
Bengaluru	18
Chennai	9
Hyderabad	9
Ahmedabad	7
Vishakhapatnam	6
Pune	5
Kolkata	5

This analysis indicates that a majority of the research pertaining to energy policy in India has focused on the international or national level. The fact that terms such as state, district, city, or village do not occur commonly in the dataset further corroborates this inference. Moreover, studies that conduct state-level analysis often delve into themes such as resource availability or techno-economic assessment. Energy governance, in which Indian states play a key role, has been relatively under-studied at the subnational level. Further, the literature also demonstrates a bias towards western and southern states, which benefit from higher (renewable) resource potential and a better standard of living. North-eastern, eastern, and northern states have received far less attention. Finally, city-level analyses have been mainly limited to large or metropolitan cities with a preference for themes such as air pollution and energy access or supply; end-use in buildings and transportation are hardly examined at this level.

6. The Locus of Public Policy

An examination of the terms mentioning policy provides a glimpse into the policy areas covered in this literature (Table 5). As one might expect, energy policy is the most commonly discussed domain in this dataset. The terms associated with it include energy policy, bioenergy/biofuel policy, energy conservation/efficiency policy, electricity policy, new (gas) exploration licensing policy, solar power policy, and oil policy. Climate policy is

another area receiving much attention in the literature, as corroborated by the presence of terms such as climate (change) policy, climate change mitigation policy, emissions reduction policy, and low carbon policy. Numerous studies also refer to energy in the context of economic policy as seen by the mention of the following: economic policy, development policy, fiscal policy, industrial policy, and trade policy. Other policy areas discussed in the literature include environmental policy, foreign policy, science, technology, and innovation policy, social policy, urban policy, and agricultural policy.

Table 5. Policy areas mentioned in the research on energy policy in India.

Policy Area	Occurrences
Energy policy	217
Bioenergy/biofuel policy	37
Energy conservation/efficiency policy	28
Electricity policy	17
New (gas) exploration licensing policy	10
Solar power policy	3
Oil policy	3
Climate (change) policy	96
Climate change mitigation policy	26
Emissions reduction policy	7
Low carbon policy	4
Economic policy	22
Development policy	18
Fiscal policy	8
Industrial policy	7
Trade policy	5
Environmental policy	36
Foreign policy	24
Science, technology, and innovation policy	5
Social policy	5
Urban policy	5
Agricultural policy	4

Apart from policy areas, terms mentioning policy also reveal how the literature engages with concepts in public policy (Figure 4; Table 6). Several publications in the dataset use terms that indicate policy relevance. For instance, terms such as policy implication, policy recommendation, policy relevance, policy prescription, policy perspective, and policy suggestion are used in several publications. In addition, policy analysis has received attention in the scholarship, demonstrated by terms such as policy option, policy analysis, policy scenario, policy choice, policy alternative, and policy modelling.

A large number of studies refer to policy instruments in some form. This is indicated by the use of the following terms: policy measure, policy initiative, policy intervention, policy instrument, policy mechanism, policy tool, and policy action. These are frequently mentioned cursorily or descriptively, for instance, in the context of the need for policy measures [164], an acknowledgement of their adoption [165,166], or a reference to state-level variation [167]. Some studies focus more explicitly on creating knowledge regarding policy instruments. Illustratively, Dulal and Akbar [168] propose policy instruments for cities to address local priorities while also reducing greenhouse gas emissions. The research

examining whether and how policy instruments work in practice is, however, limited. In an example of this type of work, Kathuria [103] assesses the impact of the mandate for the use of compressed natural gas as the fuel for public transport on air pollution in Delhi. In another example, Quitzow [169] proposes an analytical framework of policy strategy to account for the presence of multiple policy instruments in a typical policy package and applies it to study the performance of the national solar mission in India.



Figure 4. A word cloud representing public policy concepts occurring in three or more publications. The figure is created using WordArt. Available online: <https://wordart.com> (accessed on 20 September 2021).

Table 6. Public policy concepts mentioned in the research on energy policy in India.

Term	Occurrences
<i>Pertaining to policy relevance</i>	
Policy implication	83
Policy recommendation	38
Policy relevance	9
Policy prescription	8
Policy perspective	12
Policy suggestion	7
<i>Pertaining to policy analysis</i>	
Policy option	39
Policy analysis	23
Policy scenario	20
Policy choice	7
Policy alternative	6
Policy modelling	3
<i>Pertaining to policy instruments</i>	
Policy measure	49
Policy initiative	41

Table 6. Cont.

Term	Occurrences
Policy intervention	41
Policy instrument	36
Policy mechanism	10
Policy tool	9
Policy action	7
<i>Pertaining to policy objectives</i>	
Policy issue	32
Policy challenge	4
Policy formulation	17
Policy goal	15
Policy objective	15
Policy priority	6
Policy framework	43
Policy approach	9
Policy strategy	8
Policy design	7
<i>Pertaining to the policy process</i>	
Policy-making	40
Policy change	29
Policy decision	18
Policy reform	11
Policy process	4
<i>Pertaining to implementation</i>	
Implementation	266
Policy implementation	10
Implementation strategy	8
Project implementation	4
<i>Pertaining to evaluation</i>	
Evaluation	120
Outcome	80
Effectiveness	64
Efficacy	14
Impact assessment	11
Policy failure	5

Closely related to the topic of policy instruments is that of policy objectives and the match (or mismatch) between the two. Some terms indicate the possibility of such engagement in policy analysis: policy issue, policy challenge, policy formulation, policy goal, policy objective, policy priority, policy framework, policy approach, policy strategy, and policy design. Thakur, Deshmukh [170], for example, highlight the issue of inefficiency in the performance of state electricity utilities in India based on a country-wide comparative assessment. Meanwhile, Halsnæs and Garg [171] propose the integration of various policy goals pertaining to energy access, sustainable development, and climate

change in the case of emerging low- and middle-income countries such as India. Karma-charya and De Vries [172] evaluate the viability of several supply-side and demand-side alternatives in meeting the policy objectives of the energy system in India. Moreover, Rohankar, Jain [173] assess the policy framework for solar energy in India, comprising multiple policy instruments such as feed-in tariff, renewable purchase obligation, and accelerated depreciation.

Another set of terms refers to the policy process: policy-making, policy change, policy decision, policy reform, and policy process. Numerous scholars use the terms policy-making or policy change while highlighting the evidentiary value of their study for policy design [174–176]. For instance, Khosla, Dukkipati [177] propose multi-criteria decision analysis as a procedural tool for analytically rigorous, participative, and transparent policy-making. Some research has, however, examined these concepts empirically. Kale [178], for example, highlights how the interplay of domestic interests and prevailing global economic ideologies resulted in two historical policy changes in the electricity sector. Chaliganti and Müller [179] employ a critical discourse approach to explain the emergence of the national biofuel policy in India despite significant opposition from civil society, while Pradhan and Ruysenaar [180] delve into the role of specific actors and (global and local) narratives in the legitimizing of the adoption of the same policy. Further, Gupta [181] and Olofsson, Katz [182] apply the advocacy coalition framework to the case of nuclear energy and shale gas in India, respectively.

While the term policy implementation has not been used often in the literature, the concept as a whole has received attention: implementation, implementation strategy, and project implementation. This attention does not necessarily translate into systematic investigation of policy implementation itself though. Several studies that mention the term conduct policy analysis to make a case for policy implementation [183–185]. For instance, Balachandra [186] emphasizes implementation in proposing an integrated strategy for provision of universal energy access in rural India. Few scholars have studied the policy implementation phase analytically. Illustratively, Sindhu, Nehra [187] identify barriers to the implementation of solar energy in India and examine their interdependencies. In another example, Raha, Mahanta [188] analyze the implementation of the national biogas and manure management program in the state of Assam.

Concepts one might associate with policy evaluation—such as policy effectiveness, policy evaluation, policy outcome, policy performance, or policy success—find almost no mention in the dataset (policy failure being a limited exception). However, the mention of several other terms—such as evaluation, outcome, effectiveness, efficacy, and impact assessment—suggests that some studies have focused on ex-post evaluation. While many of these studies focus on technical or technological evaluation, a small number have conducted evaluations of policy. Schmid [74], for example, evaluates the effectiveness of major legislations and policies in increasing the penetration of renewable energy in nine states in India during 2001–09. Similarly, Thapar, Sharma [189] assess the economic and environmental efficacy of innovative policy practices that have contributed to the deployment of renewable energy in India. In another instance, Ghosh and Kathuria [190] examine the impact of independent state-level regulation on the efficiency of thermal-electricity-generating stations in India.

Thus, while policy-relevant research on energy policy in India is voluminous, policy analysis and policy studies constitute a small share of the research. Concepts from public policy—such as policy analysis, policy instruments, policy design—even when mentioned, are often used superficially or descriptively. Further, research examining the policy process empirically to shed light on agenda setting, decision-making, or policy implementation—through a (post-) positivist or an interpretive lens—is also limited. Finally, even the relationship between policy adoption (or design) and policy outcomes has been studied on few occasions, leading to paucity of evidence in the peer-reviewed literature on what works and why.

7. Discussion and Conclusions

In this study, I conducted a bibliometric review and computational text analysis of (the bibliographic data of) over 2700 publications pertaining to energy policy in India. The scholarship in this research area can be clustered broadly into the following themes, in descending order of prominence: (i) the electricity sector; (ii) geopolitics; (iii) energy access; (iv) climate change mitigation; (v) the energy-food-water nexus; (vi) the economy-energy nexus; (vii) oil and biofuel; and (viii) the Kyoto protocol. While demand-side management or energy efficiency has been discussed, primarily in the context of climate change mitigation, it does not constitute a distinct cluster. Further, the scholarship has focused mainly on the international level—with a keen interest in China, the United States, Japan, the BRICS economies, and the Indian subcontinent—and the national level. States and cities, towns, or villages have received less attention. In addition, while much of the research has policy relevance, relatively few publications have engaged with the scholarship on policy analysis or policy studies. These findings suggest that the thematic, geographic, and conceptual depth and diversity—necessary for supporting policy innovations for the Indian energy transition—are currently lacking in the literature.

To the best of my knowledge, this is the first large bibliometric analysis of the research pertaining to energy policy in India. The findings are, however, comparable to other reviews of climate and energy research. Creutzig, Roy [191], for instance, rue the overemphasis on supply-side technologies in the research on climate change mitigation and propose a multi-disciplinary demand-side assessment framework to address this gap. In an exploratory literature review of research on energy policy in the Netherlands, Hoppe, Coenen [192] find that policy studies' concepts were used only in about a quarter of the publications in the sample and illustrate the different ways in which policy studies can inform energy research.

The analysis emphasizes several avenues for future research. First, scholars should pursue different types of policy analysis to shed light on the various aspects of the energy transition. These go beyond research on policy or technology alternatives and include studies that explore the design of new governance arrangements, clarify values of different stakeholders in the system, promote democratization of policy-making, create knowledge or methodologies to mediate conflicts, and offer strategic advice to specific actors [193]. The field of policy studies, in particular, provides frameworks, theories, and models to do so by addressing questions on topics such as the framing of energy issues, the factors influencing policy-making, the role of advocacy coalitions, the structure and dynamics of policy networks, the prevalence of policy innovation and diffusion, and effectiveness of policy implementation [192]. It is especially important to create systematic knowledge on policy processes as these can inform the actions necessary for policy innovation in a given context [194] and influence policy success or failure [195]. Further, such an effort can also contribute to addressing “Western bias” in policy studies and spur the advancement of that field [196].

Second, while the focus of current research on the international or national level is understandable, more studies at the state and local level are imperative [197]. This is the case as several challenges associated with the Indian energy transition, such as energy distribution, residential and commercial demand-side management, urban transport, and local air pollution require policy innovations from local and state governments as well. Moreover, with ongoing technological developments in renewable energy and energy storage, small “energy regions” can spur the transition by altering power dynamics and infrastructure ownership to facilitate economic development and promote energy justice [198,199]. In addition, such a decentralized setup has been conceived as a fertile ground for experimentation and learning; studies that examine diffusion and lesson-drawing at the subnational level can also help identify mechanisms through which policy innovations can scale up and catalyze the energy transition [200–202]. Importantly, an effort in this direction should cover states and cities, towns, or villages in eastern and north-eastern India too.

Third, the theme of demand-side management deserves more attention. The key questions in this context pertain to the social, economic, and environmental implications of various technology alternatives; the attitudes, norms, and values that shape energy behavior; the adoption and implementation of appropriate policy instruments; the impact of demand-side management on individual well-being; and the potential contribution of demand-side management to sustainable development [191]. A focused review of the literature on demand-side management and energy efficiency in India based on this framework can help elucidate the coverage of existing studies and facilitate the creation of a more specific research agenda on this aspect of energy policy.

Fourth, this study demonstrates one application of computational text analysis for research on energy policy in India. Computational text analysis is an emerging approach that allows the user to interact with unstructured text data through diverse techniques, such as frequency analysis, co-occurrence analysis, sentiment analysis, topic modelling, and those in natural language processing [203–208]. This approach has been used in research on public policy, for example, to study issue framing and agenda setting [209,210], map the relationship between policy discourse and public opinion [211], examine priorities of public agencies [212], “measure” policy design [213,214], and examine program evaluations [215]. In addition, it has been employed in research on energy and environment policy, illustratively, to understand stakeholder opinions regarding air pollution in Hong Kong [216], analyze 70 years of German parliamentary debate on coal [217], and identify various dimensions of electric vehicles’ adoption in the United States using Facebook posts [218]. The use of such an approach can tap into existing and new data sources for research on energy policy in India in a scalable and systematic manner.

As with any research, this study has numerous limitations that should be considered while interpreting its findings. First, the analysis is based on bibliographic data and did not take the complete text of the publications into account. Second, the search was conducted in 2019 and, as a result, recent literature is not covered by the bibliometric review and computational text analysis. Third, this analysis focused only on academic publications on the topic; future research should examine whether “gray” literature on energy policy in India addresses some of the shortcomings. These limitations notwithstanding, in this study, I reviewed over 2700 publications on energy policy in India to present the first systematic account of this research area, identify the key themes, geographies, and public policy concepts used in the literature, and recommend areas that deserve more attention in the future in order to foster policy innovations to accelerate the Indian energy transition.

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