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Brown-out of policy ideas? A bibliometric review and computational text analysis of research on energy access

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Introduction: The target of universal access to affordable, reliable, and modern energy services—key for individual, social, and economic well-being—is unlikely to be achieved by 2030 based on the current trend. Public policy will likely need to play a key role in accelerating progress in this regard. Although perspectives from the field of policy studies can support this effort, to what extent they have been employed in the literature on energy access remains unclear.

Methods: This study analyzed nearly 7,500 publications on energy access through a combination of bibliometric review and computational text analysis of their titles and abstracts to examine whether and how they have engaged with public policy perspectives, specifically, policy process research, policy design studies, and the literature on policy evaluation.

Results: We discovered 27 themes in the literature on energy access, but public policy was not among them. Subsequently, we identified 23 themes in a new analysis of the 1,751 publications in our original dataset, mentioning "policy" in their title or abstract. However, few of them engaged with public policy, and even those that did comprised a rather small share of the literature. Finally, we extracted phrases pertaining to public policy in this reduced dataset, but found limited mention of terms related to the policy process, policy design, or policy evaluation.

Discussion: While to some extent this might reflect the multidisciplinary nature of the research on energy access, a manual review of the abstracts of select publications corroborated this finding. Also, it shed light on how the literature has engaged with public policy and helped identify opportunities for broadening and deepening policy relevant research on energy access. We conclude that, despite their relevance to energy access, public policy perspectives have infrequently and unevenly informed existing research on the topic, and call on scholars in both communities to address this gap in the future.

KEYWORDS

bibliometric review, energy access, natural language processing, policy design, policy evaluation, policy process, sustainable development goal on energy (SDG 7), topic modeling

1. Introduction

Access to energy is important for individual, social, and economic well-being. Affordable, clean, and modern energy, while probably not sufficient, is essential for—among other objectives—alleviating poverty, reducing hunger, improving public health, broadening education, and fostering economic development. To cite just one instance, it is estimated that replacement of open fires and outdated stoves with clean cooking technologies could save 800,000 children, who die due to hazardous indoor air pollution, annually (SEforALL, 2023). The significance of energy access has been duly noted by international organizations as well. Illustratively, in 2014/2015, the United Nations (UN) included universal access as part of its Sustainable Development Goal on Energy (SDG 7) (UN DESA, 2023a).

The first target of SDG 7 (i.e., SDG 7.1) is: "By 2030, ensure universal access to affordable, reliable, and modern energy services" (UN DESA, 2023b). The focus of this target is on both access to electricity as well as access to clean cooking. However, the progress thus far has been inadequate to reach this target, and shows signs of slowing down further. According to UN DESA (2023b), the number of people without access to electricity decreased significantly from 1.2 billion in 2010 to 733 million in 2020. However, based on the current rate of progress, nearly 650 million people will still lack access to electricity by 2030. Further, 2.4 billion people −31 percent of global population—continue to use inefficient and high pollution cooking fuel. Based on the current trend, the increase in clean cooking will barely keep up with population growth and only 72 percent of the world is likely to have access to clean cooking even by 2030 (IEA et al., 2021).

The problem of energy access has a strong regional dimension as it mostly concerns the Global South, especially South Asia and sub-Saharan Africa. Over 98 percent of the population of Eastern Asia, Southeastern Asia, and Latin America has access to electricity (IEA et al., 2021). While electrification was low even in South Asia at the start of the previous decade, the region has made rapid progress since then. Presently, three of four people without access to electricity live in sub-Saharan Africa and the number of people without electricity access has in fact been increasing recently (IEA et al., 2021). Further, more than half the people without access to clean cooking fuel and technology live in Asia, but low-income countries in Africa have amongst the lowest rate of access to clean cooking in the world (UN DESA, 2023b). The challenge has been worsened by the COVID-19 pandemic; the number of people without access to electricity and to clean cooking is estimated to have actually increased between 2019 and 2021 due to a pause in implementation, shift in government priorities, rise in energy prices, and increase in poverty (IEA, 2021).

1.1. Addressing energy access from a policy perspective

Various interventions are required in different parts of the energy system in order to address the energy access problem. The expansion of energy infrastructure (whether centralized or decentralized), for example, is key for providing energy access in the long-term. For communities situated close to the electricity grid or gas pipeline, extension of the infrastructure is a plausible solution. However, such an approach can be more challenging to implement in a short-term in areas with no or little infrastructure. In this case, decentralized or stand-alone infrastructure or technologies can be necessary. Countries such as Bangladesh, Kenya, and Uganda have—in fact—successfully integrated grid, minigrid, and off-grid electrification to significantly increase electricity access over the previous decade (IEA et al., 2021), but many others have not.

Financing is another key intervention necessary for improving energy access. It is estimated that an annual investment of approximately USD 50 billion is necessary in order to achieve universal electricity access and USD 4 billion to achieve universal access to clean cooking (Climate Policy Initiative, 2019). In contrast, only USD 13 billion was mobilized—approximately 25 percent of the requirement—to increase electricity access and only USD 32 million—less than one percent of the requirement—was raised to provide clean cooking access (Climate Policy Initiative, 2019). Further, India and Bangladesh accounted for over 60 percent of the total tracked financing on energy access (Climate Policy Initiative, 2019). More financing will be especially important for countries in sub-Saharan Africa, which witness low and, in some cases, even declining investment in energy access.

Public policy at different levels of government also can, and—in all likelihood—will need to, play a significant role in accelerating progress toward SDG 7.1. Broadly, the literature on public policy has identified four categories of policy instruments (Hood, 1983), each of which is relevant for the energy access problem. First, governments can collect and/or provide reliable information, for example, in order to shed light on the status of energy access and to increase willingness to adopt clean cooking fuels and technologies (IEA et al., 2022). Second, governments can create regulations and/or standards, for example, that ensure interoperability of off-grid, minigrid, and grid technologies, help phase-out of high polluting fuels in the medium- or long-term, and create a social safety net for marginalized or vulnerable communities in order to increase their purchasing power. Third, governments can use economic incentives, for example, to promote fuel switching through better targeting of fossil fuel subsidies and to stimulate private investment for energy access (Zinecker et al., 2018; IEA, 2021). Finally, governments can mobilize their organizational machinery to build infrastructure, create new partnerships, and provide new services to the public.

1.2. Analyzing research in the policy realm for energy access

The academic field of *policy sciences* or *policy studies* has shed light on various dimensions of public policy(-making) which can help advance energy access. Here, we highlight three perspectives that are applicable in this effort.

First, the achievement of universal energy access will likely require the mobilization of policy relevant knowledge in the policy process in order to alter policy priorities, introduce new policy alternatives, foster policy innovation, or enhance policy implementation. The research on policy process addresses questions such as why and how specific issues come on the policy agenda (Kingdon, 1995); why specific alternatives are considered or favored to solve policy issues (Voß and Simons, 2014) and how they are calibrated (Haelg et al., 2020); why and how policies change (Sabatier, 1988; Hall, 1993; Baumgartner et al., 2018); how and when policies spread from one polity to another (Marsh and Sharman, 2009; Graham et al., 2013; Goyal, 2021); and how policies are implemented on the ground (and why they often change in the process) (Pressman and Wildavsky, 1984; Grin and Loeber, 2007). It can, therefore, help in understanding geographic and temporal variation in the processes and substance of public policy regarding energy access.

Second, the policies adopted to increase energy access will need to be cognizant of, if not coordinated or integrated with, policies at different levels of government that address other—potentially even competing—objectives of the energy system, such as energy security or environmental sustainability. The literature on policy design can aid the formulation of effective, forward-looking policies by addressing questions such as what the likely effects of different types of policy instruments and their calibrations in accomplishing policy objectives are (Olejniczak et al., 2020); how the different instruments in the policy "mix" interact with one another; to what extent are the various objectives and instruments in the policy mix consistent, coherent, and congruent with one another (Howlett and Rayner, 2013); whether the policy mixes at different levels of government are synergistic, additive, or counterproductive (Howlett and How, 2015); how the policies use procedural policy instruments to steer the policy process (Howlett, 2000); and whether the policy design is in line with policy capacities of the jurisdiction (Mukherjee et al., 2021).

Third, given the place of energy access on the international agenda, the evaluation of past policies or policies in other countries can facilitate lesson drawing and enable course correction through policy learning. The research on policy failure, policy success, and program evaluation has created useful knowledge in this regard. The key insights of this literature include: (i) a distinction among and appraisal of formal or government-driven, information or society-driven, and hybrid evaluation (Weiss, 1993; Hildén et al., 2014; Schoenefeld and Jordan, 2017); (ii) the need to distinguish among programmatic success, process success, and political success (Bovens et al., 2001; Vedung, 2006; Bovens, 2010; Marsh and McConnell, 2010a,b); (iii) criteria for assessing success (or failure) along each dimension (McConnell, 2010); (iv) the recognition that success along each dimension can vary over time (Goyal, 2021a); and (v) anticipation of policy success based on policy process or policy design characteristics (Bali et al., 2019; Goyal, 2021a).

While existing studies have conducted reviews of the research on energy access, to what extent and how the literature has engaged with public policy—specifically, perspectives on policy process, policy design, and policy evaluation—as a central theme is unclear. This study aims to address this gap through a review and computational text analysis of the bibliographic records of research on energy access.

2. Research methods

In this study, we combine bibliometric review and computational text analysis to examine whether and how scientific research has examined energy access and, within that area, to what extent policy questions have been pre-eminent.

Bibliometrics involves the—usually, quantitative—analysis of bibliographic records of scientific publications. A bibliographic record is an entry in a bibliographic database (such as Scopus or Web of Science) that contains identifying information as well as metadata of scientific publications. The fields in a bibliographic record include information on the authors, year, publication title, source, abstract, authors' keywords, and so on. A bibliometric review can shed light on the state of research on a topic and has previously been used in both energy research and policy studies (Goyal, 2017, 2021b; Goyal and Howlett, 2018; Goyal et al., 2022). We conducted the bibliometric analysis using the *bibliometrix* package in the R programming language (Aria and Cuccurullo, 2017). Bibliometrix is an open-source library with functions for mapping scientific activity and examining the relationships among different publications in a bibliographic dataset. Here, we focused on the following to obtain an overview of the dataset: (i) annual scientific production; (ii) most prolific authors, institutions, and countries; (iii) sources actively publishing in this research area; and (iv) publications with the most citations till date.

We use the following search query to identify publications relevant to energy access: "affordable energy" OR "clean cooking access" OR "electricity access" OR "energy access" OR "rural electrification" OR "SE4All" OR "sustainable energy for all" OR ["universal access" AND (cooking OR electricity OR energy OR fuel OR power)]. The search is conducted on both Scopus and the Web of Science, among the most widely used bibliographic databases, on 8 February 2023. On Scopus, it returned 6,541 publications while on the Web of Science it returned 5,432 publications. We used the Scopus of Science package (*version 0.0.4*) in Python (*version 3.10.10*) to combine publications from the two databases, resulting in 7,783 unique publications (4,190 publications were duplicated). After removing publications with no abstract, our complete dataset contains 7,498 publications. For analysis of policy-related research on energy access, we use a subset of 1,751 publications (hereafter, the policy subset) whose title or abstract mention the term "policy" (including its plural, "policies") in their title or abstract.

Subsequently, we conducted topic modeling—on publication titles and abstracts—to identify the key themes in the general literature (complete dataset) as well as the policy-related literature (policy subset). Fewer than 300 publications in the complete dataset were not in English, and even these contained a title and abstract in English. Topic modeling is a computational text analysis technique for "discovering" latent themes in a document collection based on mathematical/statistical analysis (Blei et al., 2003). While several topic modeling algorithms have been proposed over the past decade (Rosen-Zvi et al., 2004; Blei and Lafferty, 2007; Wang et al., 2007; Blei, 2012; Roberts et al., 2014), we use BERTopic for this study. BERTopic creates coherent topic representations using a novel approach based on state-of-the-art techniques in machine learning and natural language processing (Grootendorst, 2022). This involves document embedding using a pre-trained transformer model, dimensionality reduction, clustering, and identification of key terms within each cluster. The number of themes in the dataset is initially determined by the algorithm; we go through these manually and combine themes with over 80–85 percent similarity in order to obtain the final list of themes for our dataset. We repeated the bibliometric review and the topic modeling analysis for the policy subset to compare and contrast the findings in the general literature on energy access with the policy-related literature.

Subsequently, we examined the number of occurrences of key phrases pertaining to "policy" in order to delve deeper into the

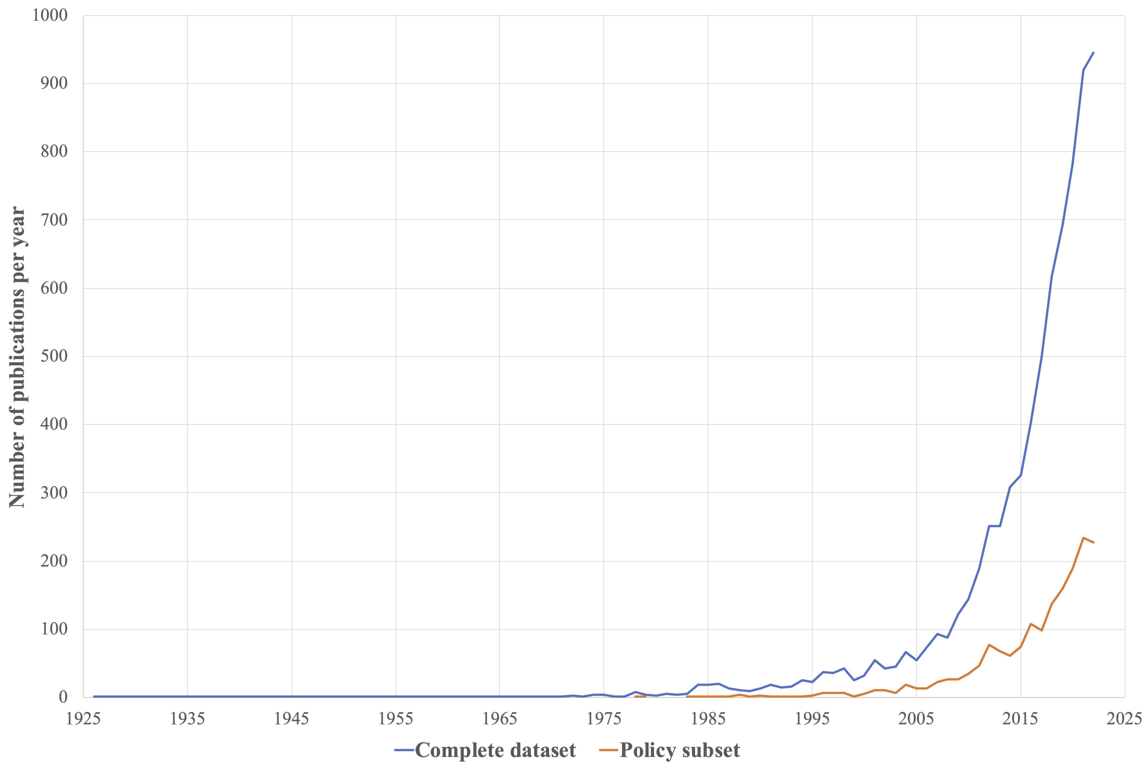

FIGURE 1
Number of publications on energy access per year.

mention of public policy within this dataset. This analysis of term occurrence used the KeyphraseVectorizer package in Python. KeyphraseVectorizer extracts key phrases matching specific parts of speech (in our case a noun phrase) in a document collection and counts their occurrences per document in the collection (Schopf et al., 2022). The phrases relevant to policy process, policy design, or policy evaluation were then identified and classified based on our knowledge of public policy. It is, of course, plausible that in a multidisciplinary research field—such as that of energy access—authors do not use the terminology of policy sciences or policy studies even though they engage with the notions of policy process, policy design, or policy evaluation (especially in the abstract). Therefore, we also reviewed abstracts of 10 percent of the policy subset, selected randomly, to check whether our findings regarding the volume of research on policy processes, policy design, and policy evaluation were robust. In addition, a close reading of abstracts of this randomly selected subset led to the inclusion of generic phrases that might also help identify work pertaining to the policy process (e.g., "coalition" or "policy direction"), policy design (e.g., "policy feature" or "policy scenario") or policy evaluation (e.g., "effective policy" or "policy lessons"). The abstracts of the publications selected through this process were reviewed manually to check to what extent and how the literature has delved into the policy process, policy design, or policy evaluation.

Our research design suffers from at least two limitations. First, while a manual review of select abstracts allows us to corroborate the centrality of policy process, policy design, or policy evaluation to the publication, it does not capture several other types of engagement with policy studies. These include, for example, a review of the research in policy sciences to inform the research question, the use of methods of policy analysis to design the study, and a discussion of policy relevant literature to inform recommendations for public policy and future research. Second, by limiting our search to Scopus and the Web of Science, we miss out on relevant publications not indexed by these. This is likely to be especially true for research on energy access that may have been published in more localized sources, for example, for higher policy impact.

3. Results

3.1. Overview of the datasets

As mentioned earlier, our complete dataset consists of nearly 7,500 bibliographic records. The earliest publications in this field are Post (1926), Keepper (1938), and Landis (1938), all focusing on rural electrification in the United States. However, the number of publications before 1970 was fewer than 10 and before 1980 was fewer than 50 (Figure 1). Energy access only started receiving more attention in the 1980s with over 100 publications in that decade alone. The field has grown exponentially since then, witnessing over 250 publications in the 1990s, nearly 700 publications in the 2000s, and over 3,500 publications in 2010s. This decade has seen even more activity; for example, in 2022 over 750 publications were published on the topic. Meanwhile, policy-related research has

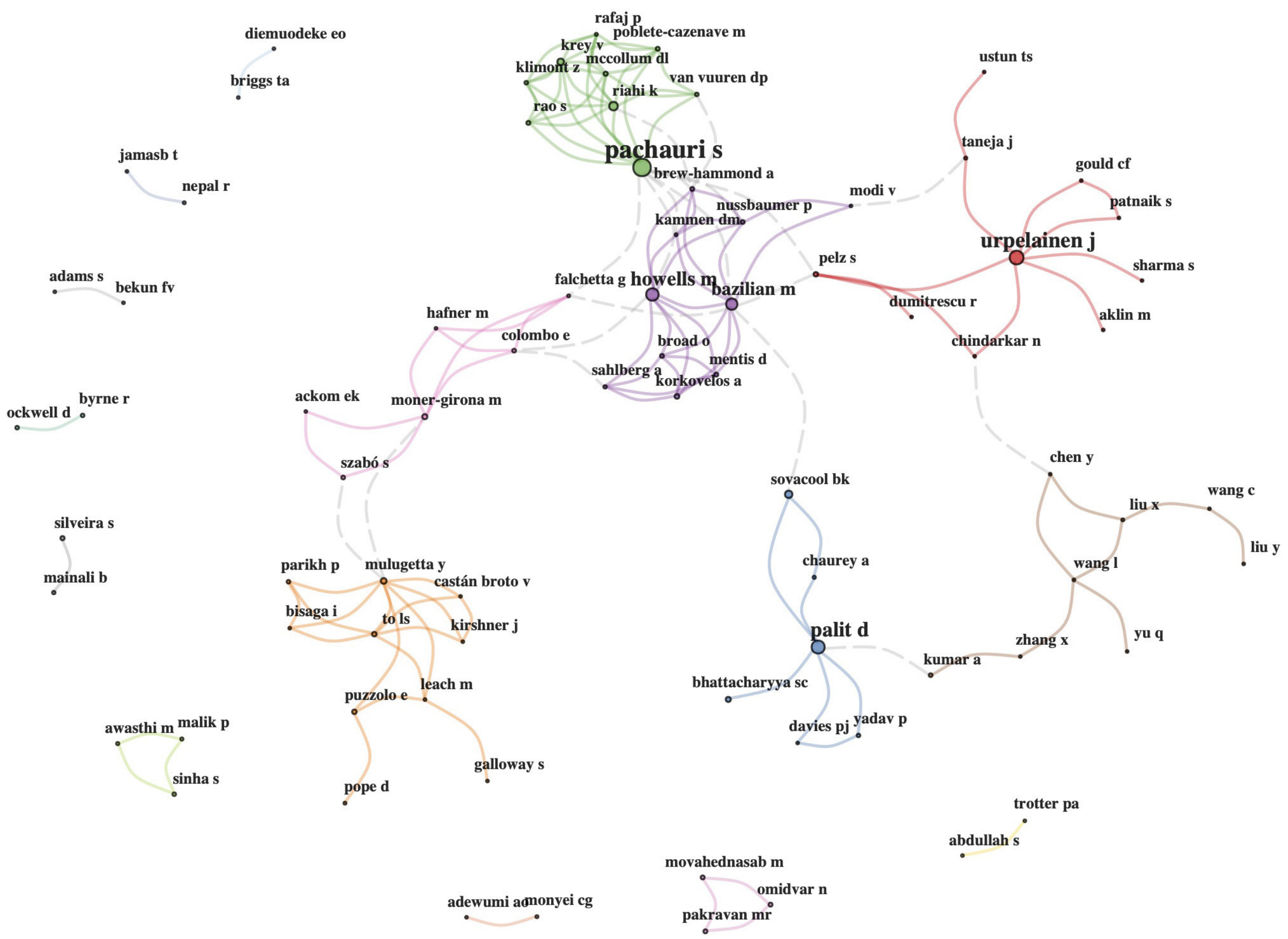

FIGURE 2
A co-authorship network of the 100 most prolific authors on energy access. A node in the graph depicts an author. The color of the node indicates its cluster, calculated based on the structure of the collaboration network. A link connecting two nodes indicates a co-authorship relationship. A link between nodes within the same cluster is depicted using a solid line while a link between nodes from different clusters is depicted using a dashed line. The size of the node as well as the label is indicative of the degree of the node (i.e., the number of co-authorship relationships).

grown significantly since around 2011, with over 100 publications in 2016 and more than 200 since 2021. The exponential growth in the volume of scientific research on energy access is possibly an indication of the increase in attention to the problem as well as the success of the Millennium Development Goals (MDGs) and the SDGs in raising its profile.

Research on energy access has involved over 15,000 authors, with an average of 3.4 co-authors per publication. About 600 authors have written five or more publications in this field while about 150 authors have 10 or more publications. A co-authorship network of the 100 most prolific scholars in this field is shown in Figure 2. J. Urpelainen is the most prolific author in this field with 67 publications on energy access (Table 1). Other authors who have published frequently in this field include A. Kumar (n: 45), D. Palit (n: 43), S. Pachauri (n: 41), and E. Colombo (n: 38). J. Urpelainen (n: 28), D. Palit (n: 27), and S. Pachauri (n: 25) appear in the list of the most prolific authors in the policy subset as well, along with M. Bazilian (n: 17) and B. Sovacool (n: 17).

Based on the institutional affiliation of the corresponding author, the countries with the most publications in the complete dataset are: the United States (n: 587), India (n: 416), the United Kingdom (n: 383), China (n: 382), Germany (n: 181), South Africa (n: 168), Spain (n: 141), Italy (n: 128), Sweden (n: 104), and Australia (n: 103). This suggests that the Global South has played a more prominent role in this research area than in areas such as the energy transition (Goyal et al., 2022). A comparison with the policy subset reveals that institutions in the United Kingdom, Australia, and Germany have a relatively high ratio of publications in the policy subset (38 percent, 34 percent, and 30 percent, respectively), while institutions in Spain and China have a relatively low ratio (15 percent and 19 percent, respectively).

A close look at institutional activity—based on the number of authorships—shows that Politecnico Di Milano (n: 157), KTH Royal Institute of Technology (n: 125), the University of California (n: 121), the International Institute for Applied Systems Analysis (n: 109), North China Electric Power University (n: 106), and the University of Cape Town (n: 103) have all published over 100 documents in this field (Table 2). Amongst the 15 most prolific institutions in this field, the International Institute for Applied Systems Analysis, University College London, the University of

TABLE 1 The most prolific authors on energy access.

Complete dataset		Policy subset	
Author	N	Author	N
J Urpelainen	67	J Urpelainen	28
A Kumar	45	D Palit	27
D Palit	43	S Pachauri	25
S Pachauri	41	M Bazilian	17
E Colombo	38	BK Sovacool	17
L Ferrer-Marti	35	M Howells	16
Y Li	35	SC Bhattacharyya	11
Y Liu	35	Y Mulugetta	9
M Bazilian	32	K Riahi	9
SC Bhattacharyya	31	A Kumar	8

TABLE 2 The institutions with the most authorships on energy access.

Institution	Complete dataset	Policy subset	Policy relevant ratio (%)
Politecnico Di Milano	157	25	16%
KTH Royal Institute of Technology	125	49	39%
University of California	121	25	21%
International Institute of Applied Systems Analysis	109	83	76%
North China Electric Power University	106	20	19%
University of Cape Town	103	19	18%
University of Oxford	81	9	11%
University College London	74	35	47%
Imperial College London	72	28	39%
Columbia University	70	29	41%
Delft University of Technology	70	6	9%
University of Cambridge	64	28	44%
Indian Institute of Technology	60	11	18%
Tsinghua University	57	15	26%
University of Strathclyde	57	12	21%

Cambridge, and Columbia University have a relatively high ratio of policy relevant publications (76 percent, 47 percent, 44 percent, and 41 percent, respectively).

While publications on energy access thus far have appeared in over 2,500 sources, there is a relatively low average of approximately three publications per source. Indeed, a majority of these sources have only one publication in this research area and 100 sources have 10 or more documents published. The sources with the most publications include: Energy Policy (n: 302), Renewable and Sustainable Energy Reviews (n: 298), Energy for Sustainable Development (n: 224), Renewable Energy (n: 222), Energies (n: 177), Energy Research and Social Science (n: 172), Energy (158), Applied Energy (n: 89), Sustainability (Switzerland) (n: 77), and the Journal of Clean Production and Sustainable Energy Technologies and Assessments (n: 63 each). The prominent presence of these sources even in the policy subset—with only a slightly different ranking in some cases—indicates that the importance of public policy for addressing energy access is acknowledged by the key avenues and communities in this field. It is, however, striking to note the absence of journals focusing on public policy broadly in this literature. Among prominent journals in public policy, only Global Policy (n: 3), the Review of Policy Research (n: 3), the Journal of Asian Public Policy (n: 2), the Journal of Public Policy (n: 1), and Policy and Society (n: 1) have a presence in the complete dataset.

3.2. Themes in the research on energy access

A list of the globally most cited publications within this dataset provides a preview of the themes that have been discussed in this research area (Table 3). Here, we observe significant emphasis on different technological alternatives in the context of energy access. Owusu and Asumadu-Sarkodie (2016), for example, highlight energy access as an opportunity associated with renewable energy. Similarly, other studies emphasize the potential of small hydropower (Paish, 2002), sustainable hydrogen production (Navarro Yerga et al., 2009), waste sludge (Tyagi et al., 2013), bioenergy (Creutzig et al., 2015), and DC microgrid technology (Kumar et al., 2017) in providing affordable and clean energy for all. Meanwhile, Zarfl et al. (2015) caution that significant increase in hydropower capacity alone will be insufficient for closing the electricity gap. In contrast, Shiu and Lam (Shiu et al., 2004) show that electricity consumption has a positive effect on economic growth and call for accelerating rural electrification in China. Two studies mention energy access in the context of the ongoing energy transition: Newell and Mulvaney (2013) contend that energy access is a key aspect of a just transition to a low carbon economy while Pachauri and Jiang (2008) note a significant difference in the share of households with electricity access between China and India.

While total citation count is one measure of the broad impact of a publication, it does not necessarily indicate the impact of the publication within the research area of energy access. The local citation count of a publication (i.e., the number of documents within this dataset that cite the publication) can shed some light here (Table 4). In general, we observe three broad strands of research that have high local citation count. The first includes studies that delve into the economic or social impact of energy access, for example, in the form of a gain in labor productivity (Kirubi et al., 2009), increase in female employment (Dinkelman, 2011), and higher literacy rate (Kanagawa and Nakata, 2008). The second, once again, focuses on alternatives—often based on renewable energy—for increasing energy access, spanning off-grid, micro- or mini-grid, and grid extension (Deichmann et al., 2011; Palit and Chaurey, 2011; Szab et al., 2011; Alstone et al., 2015;

TABLE 3 The globally most cited publications on energy access.

Study	Citations	Citations per year
Owusu and Asumadu-Sarkodie (2016)	1179	147
Zarfl et al. (2015)	1155	128
Paish (2002)	657	30
Shiu et al. (2004)	542	27
Navarro Yerga et al. (2009)	463	31
Tyagi et al. (2013)	421	38
Creutzig et al. (2015)	414	46
Kumar et al. (2017)	411	59
Newell and Mulvaney (2013)	401	36
Pachauri and Jiang (2008)	360	23

TABLE 4 The locally most cited publications on energy access.

Study	Local citations	Global citations	LC/GC ratio (%)
Kirubi et al. (2009)	140	258	54.26
Dinkelman (2011)	122	356	34.27
Kanagawa and Nakata (2008)	112	286	39.16
Szab et al. (2011)	103	196	52.55
Mandelli et al. (2016)	102	252	40.48
Palit and Chaurey (2011)	101	194	52.06
Alstone et al. (2015)	94	242	38.84
Cook (2011)	83	163	50.92
Deichmann et al. (2011)	81	203	39.9
Bhattacharyya (2006)	78	193	40.41

Mandelli et al., 2016). The third includes studies with a more explicit message for public policy: Cook (2011) highlights the need to focus on livelihoods rather than on cost recovery in order to increase rural electrification while Bhattacharyya (2006) stresses the importance of looking beyond rural electrification (in India) due to the low share of electricity in the rural energy mix.

To obtain a more systematic account of the literature, we identify 27 key themes in the research on energy access based on a topic modeling analysis (Table 5). The theme on "rural electrification" focuses on issues such as off-grid vs. grid extension, the role of local communities and cooperatives, and providing electricity to remote areas (Santiago and Roxas, 2012; Yosiyana and Simarangkir, 2015). Some themes also pertain to other policy objectives related to energy access. For example, the theme on "energy security" delves into topics around geopolitics, price dynamics, and providing energy in a changing climate (Kemfert, 2010; Panpuek and Teetong, 2016). Similarly, the theme on "energy poverty" focuses on issues surrounding the measurement of energy poverty, the relationship between poverty and energy access, and energy poverty and climate vulnerability (Bartiaux et al., 2018; Awan et al., 2022; Yadava and Sinha, 2022). Closely related to this, the theme on "energy justice" situates energy access in different settings such as low carbon development, post capitalism and post liberalism, and in the aftermath of crises or disasters (Luque-Ayala, 2018; Lacey-Barnacle et al., 2020; Hesselman et al., 2021). In a different vein, the criticality of energy access has also been discussed in the case of a "wireless network" (Xing et al., 2016; Zhou et al., 2020; An and Park, 2022).

As anticipated previously, various themes in the literature focus on technology alternatives for energy production. The theme on "solar energy", for example, discusses the technical and economic potential of solar energy, the different solar energy technologies, and the impact they can create on society (Diniz et al., 2006; Al-Shetwi et al., 2016; Kadri and Hadj Abdallah, 2016). Closely related to this, the theme on "solar home system" sheds light on aspects such as the financing, adoption, and evaluation of solar energy for household energy services (Ondraczek, 2011; Pode, 2013; Hellqvist and Heubaum, 2023). Similarly, the theme on "hydropower" delves into whether and how small-, micro-, and pico- hydropower can play a role in electrification (Koirala et al., 2017; Bhandari et al., 2018; Ariyabandu, 2020). Meanwhile, the theme on "bioenergy" examines the potential of different fuel sources and technologies in supplying energy (Okure et al., 2018; Andriatoavina et al., 2021; Kamalimeera and Kirubakaran, 2021). In addition, the literature has studied the production of hydrogen and other materials for energy in the theme on "energy materials" (Navarro et al., 2009; Nawaz et al., 2021) as well as the manufacturing, performance, and life cycle assessment of small "wind energy" (Masud, 1998; Mukulo et al., 2014; Rama Prabha et al., 2017).

Several themes are centered around the role of standalone alternatives for improving energy access. The most prevalent theme, that of "hybrid energy", focuses largely on the feasibility and performance of systems that combine renewable energy, fossil fuel-based energy, and/or storage (Nigussie et al., 2017; Rehman et al., 2020; Thirunavukkarasu and Sawle, 2021). The theme on "minigrid", for example, discusses the role of microgrids and minigrids in providing electricity in remote, low-density areas in an adjustable and expandable manner (Moner-Girona et al., 2018; Adefarati and Bansal, 2019; Mudaheranwa et al., 2023). With a more specific focus on system design, the theme on "system optimization" explores the balance among parameters such as the net present cost, the cost of electricity, the share of renewable energy, and the reliability of supply within a (hybrid) microgrid or minigrid system, and the role of an energy management strategy therein (Das et al., 2021; Mustafa Kamal et al., 2022; Sharma et al., 2023). Rather than prioritizing technical optimization, the theme on "multicriteria analysis" uses techniques such as analytic hierarchical process, the best worst method, and multi-objective optimization to also consider environmental and social objectives in microgrid design (Kumar et al., 2019; Juanpera et al., 2020; Elkadeem et al., 2021). In contrast, the theme on "DC microgrid" is primarily concerned with the technological design and feasibility of a direct current microgrid or nanogrid system in providing sustainable energy (Nasir et al., 2019; Kothari et al., 2022; Kumar and Bhat, 2022). Relatedly, the theme on "energy storage" studies different battery technologies in hybrid, microgrid, or more general stationary energy systems (Dhundhara et al., 2018; Jing et al., 2019; Kebede et al., 2021).

TABLE 5 Themes in the literature on energy access.

#	Theme	Key terms	*N*
1	Hybrid energy	Hybrid, diesel, system, wind, homer, battery, pv, kwh, techno, cost	487
2	Rural electrification	Electrification, rural, projects, electricity, local, countries, social, program, programs, communities	415
3	Minigrid	Microgrid, microgrids, minigrids, minigrid, load, grid, demand, design, off_grid, cost	307
4	Financing	Finance, sector, ssa, african, access, financing, continent, region, development, investment	290
5	Solar energy	Photovoltaic, solar, pv, pumping, cells, solar_photovoltaic, systems, program, water, modules	284
6	Solar home system	Solar, home, shs, lighting, bangladesh, households, products, kerosene, systems, lamps	264
7	Hydropower	Hydropower, hydro, turbine, micro, river, pico, water, head, plants, flow	260
8	Household energy	Cooking, lpg, household, households, charcoal, fuels, fuel, use, wood, firewood	215
9	Grid stability	Distribution_network, method, new, power, operation, scheduling, planning, model, multi, voltage	208
10	Bioenergy	Biomass, engine, waste, biogas, production, gas, crop, wood, fuel, agricultural	194
11	DC microgrid	Dc, voltage, control, microgrid, converter, architecture, power, microgrids, distribution_network, bus	178
12	Energy security	Energy_security, global, oil, affordable, climate_change, security, emissions, supplies, policy, gas	178
13	Energy planning	Gis, planning, data, spatial, satellite, geospatial, electrification, demand, information, electricity	178
14	Energy impact	Agricultural, irrigation, employment, farmers, labor, household, farm, households, rural, electrification	173
15	Energy poverty	Energy_poverty, household, multidimensional, income, households, poor, modern, poverty, access, indicators	149
16	Multicriteria analysis	Multicriteria, criteria, decisionmaking, decision, evaluation, alternatives, hierarchy, design, best, microgrids	133
17	Electricity distribution	Voltage, distribution, lines, phase, line, transmission, single, carrier, earth, return	117
18	Smart grid	Internet, smart, smart_grid, things, intelligent, monitoring, computing, networks, data, network	108
19	Wireless network	Information, harvesting, transfer, channel, sensor, transmission, radio, communication, network, powered	98
20	Energy materials	Hydrogen, materials, density, water, ion, synthesis, affordable, properties, high, promising	97
21	System optimization	Optimization, swarm, sizing, objective, optimal, hybrid, technique, algorithms, genetic, multi	87
22	Energy storage	Energy_storage, battery, batteries, charge, acid, ion, lead, storage, life, controller	84
23	Wind energy	Wind, wind_turbine, speed, small, speeds, manufacturing, resource, design, turbine, coastal	80
24	Economy and environment	Growth, long_run, consumption, emissions, panel, gdp, co2, sdg, economic, carbon	74
25	Energy justice	Energy_justice, justice, post, right, social, low_carbon, rights, energy_poverty, law, climate	63
26	Energy and gender	Women, gender, empowerment, energy_justice, entrepreneurs, equality, productive, access, equity, social	61
27	Energy Union	European, european_union, prices, decarbonization, policy, targets, affordable, security, consumers, markets	50

N denotes the number of publications clustered within the theme.

While much of the research focuses on energy production alternatives, some themes also address distribution and end-use. The theme on "grid stability" discusses topics linked to the integration of distributed energy and renewable sources with the electricity grid, such as intermittency, scheduling, and dispatch (Dou et al., 2014; Li et al., 2022; Wang, 2022). Meanwhile, the theme on "smart grid" highlights the role of a dynamic, interactive grid for building an electricity network of the future and tapping into the potential of demand response, real-time monitoring, and short-term forecasting through big data and machine learning (Nizar et al., 2008; El-Hawary, 2014; Zhang et al., 2017). Relatedly, the theme on "electricity distribution" examines technological challenges as well as solutions—such as the single-wire earth return system—in the distribution network for reducing the cost of electricity (van Niekerk and Hofsajer, 2000; Hosseinzadeh et al., 2011). In a different vein, the theme on "household energy" delves into barriers to clean energy adoption at the household level, with an emphasis on cooking. Studies within this theme emphasize alternatives such as income generation—for example, through off-farm employment—provision of social security, and targeted subsidization for influencing household behavior (He et al., 2016; Puzzolo et al., 2016; Sharma and Dash, 2022).

Some themes pertain to a more macro-level discussion on energy access. For example, the theme on "financing" underlines the need to mobilize financing, including climate financing and development financing—especially in Sub-Saharan Africa—in order to promote sustainable energy for all (Chirambo, 2018; Michaelowa et al., 2021). A key issue here is the strengthening of institutions in order to tap into diverse sources of investment (Sheba and Bello, 2020). The theme on "energy planning", meanwhile, delves into topics such as the use of satellite data to measure electrification, the estimation of electricity demand, and geospatial planning of transmission and supply infrastructure (Mentis et al., 2015, 2016; Dominguez et al., 2018). With a regional

TABLE 6 Themes in the policy-related literature on energy access.

#	Theme	Key terms	N
1	Energy behavior	Energy_poverty, income, household, multidimensional, inequality, households, modern, access, urban, poor	128
2	Solar energy	Solar, home, photovoltaic, solar_photovoltaic, systems, shs, off_grid, rural, market, diffusion	120
3	Hybrid energy	Hybrid, optimal, system, microgrid, optimization, power, techno, wind, battery, diesel	98
4	Household energy	Cooking, lpg, fuel, charcoal, household, firewood, fuels, fuelwood, households, use	72
5	Bioenergy	Biomass, biogas, food, rice, waste, materials, fast, potential, production, oil	68
6	Minigrid	Minigrids, minigrid, grid, electrification, off_grid, microgrids, rural, remote, villages, distribution	62
7	Energy transition	Coal, bangladesh, wind, indian, country, renewable, power, growth, generation, primary_energy	60
8	Energy Union	European, affordable, commission, european_union, gas, new, natural_gas, heating, external, federal	60
9	Economy and environment	Growth, asian, long_run, consumption, carbon, trade, economic, sdg, environmental, co2	59
10	Community electrification	Electrification, rural, electric, local, infrastructure, program, institutional, public, communities, social	59
11	Financing	Finance, climate, financing, financial, ssa, investment, capital, risks, private, power	57
12	Energy and sustainability	Renewable, nigerian, african, development, sustainable, potentials, review, sector, hydro, potential	45
13	Energy security	Oil, energy_security, global, foreign, international, strategic, supplies, secure, affordable, security	43
14	Governing electrification	Electrification, projects, sustainability, rural, project, communities, framework, program, programs, resilience	43
15	Energy and gender	Gender, women, men, firm, labor, gendered, enterprise, enterprises, entrepreneurial, empowerment	38
16	Hydropower	Hydropower, hydro, small, development, schemes, installled_capacity, stations, small_scale, plants, micro	38
17	Energy justice	Justice, housing, social, energy_justice, energy_poverty, community, rights, transport, material, socio	37
18	Energy for agriculture	Agricultural, irrigation, farmers, food, water, livelihood, crop, production, farm, security	30
19	Slum electrification	Water, pandemic, covid, healthcare, slum, facilities, space, health, sanitation, people	28
20	Energy governance	Governance, hydrogen, political, actors, communities, african, policy_making, initiatives, sector, recent	24
21	Energy planning	Satellite, planning, settlement, geographic, grid, burkina_faso, tool, data, electrification, spatial	24
22	Measuring access	Regular, farm, evidence, households, household, electricity, likely, supply, points, availability	22
23	Politics of access	Energy_justice, urban, democratic, uneven, political, change, infrastructural, spatial, local, relations	21

N denotes the number of documents clustered within the theme.

focus, the theme on "Energy Union" focuses on topics such as the role of renewable energy in providing affordable energy; EU level policies on energy, including the fuel quality directive and the renewable energy directive; and the requirements and implications of a resilient Energy Union (Zhang et al., 2017; Mexhuani et al., 2022).

The remaining themes engage with energy access in the wider context of the economy, environment, and society. The theme on "economy and environment" examines the influence of energy access on characteristics such as economic growth, ecological footprint, and greenhouse gas emissions (Vidyarthi, 2015; Balsalobre-Lorente et al., 2021; Arnaut and Dada, 2022). The theme on "energy and gender", meanwhile, studies the linkages among climate change, energy access, and renewable energy development on the one hand and entrepreneurship, gender (in)equality, and social inclusion on the other hand (Mohideen, 2012, 2021; Pueyo et al., 2020). Finally, the theme on energy impact analyzes the relationship between electrification and various socio-economic indicators, such as those pertaining to agriculture, child nutrition, household labor supply, and reproductive behavior (Saha, 1994; Lahiri, 2005; Rolland et al., 2013). Nearly 2700 documents are classified as miscellaneous as they do not distinctly match any of these themes.

3.3. Themes in the policy-related research on energy access

A topic modeling analysis of this subset results in 23 themes in the policy relevant literature on energy access (Table 6).

An examination of these themes shows that many of them correspond to the themes in the complete dataset. Even in the policy relevant literature, several themes delve into technological alternatives for generating energy, including "solar energy", "bioenergy", and "hydropower." Similarly, the prospect of "hybrid energy" and "minigrid" is also advanced in this research area. Further, the demand or end-use perspective on energy has been has been discussed in the theme on "household energy." In terms of policy objectives, the focus on "energy security" is retained in this subset. Meanwhile, the themes on "financing", "energy planning", and "Energy Union" capture energy access at a more macro level. In addition, two of the themes study the relationship of energy to the economy, the environment, and the society: "economy and environment" and "energy and gender."

A comparison of the themes prominent in the complete dataset and those prominent in the policy subset is shown in Table 7. As one might expect, the more technologically oriented themes in the complete dataset are not prominent in the policy relevant literature. These span energy generation ("wind energy" and "energy materials"), system configuration ("DC microgrid", "system optimization", "multicriteria analysis", and "energy storage"), energy distribution ("grid stability", "smart grid", "electricity distribution") and application area ("wireless network").

On the other hand, several themes pertaining to policy objectives are more prominent in this subset. The theme on energy poverty, for example, is captured partially by the theme on "energy behavior" and partially by the theme on "measuring access." While the theme on "energy behavior" examines the energy preferences of households for cooking, lighting, and other energy services (Klasen et al., 2005; Louw et al., 2008; Olang et al., 2018), the theme on "measuring access" establishes the status of energy access among households, communities, or public facilities such as primary health centers (Pelz and Urpelainen, 2020; Mani et al., 2021; Pelz et al., 2021). Similarly, the objective of rural electrification is discussed in the themes on "community electrification" and "governing electrification"; while the former focuses more on the role of civil society organizations and remote communities in improving energy access (Torero, 2016), especially in the case of last mile connectivity in Latin America, the latter focuses more on the role of the government in electrifying villages, especially in the context of Asia (Zomers and Gaunt, 2010; Derks and Romijn, 2019; Pandyaswargo et al., 2022). Even energy justice is covered by two themes in this subset, with one more inclined toward geographies in the Global North and concerns of affordability (Bartiaux et al., 2018; Evensen et al., 2018; Ozarisoy and Altan, 2021) and the other toward geographies in the Global South and issues of inequity and "politics of access" (Castán Broto et al., 2018; Cotton et al., 2021; Smith et al., 2022).

The policy relevant literature also delves into themes that are less prominent in the complete dataset. The theme on "energy transition", for example, discusses the challenge of transitioning away from fossil fuels as much as the opportunity of deploying renewable energy (Ghose, 2009). In addition, it emphasizes the need for effective governance in promoting a sustainable energy transition (Karim et al., 2019). Closely related to the theme on "energy transition", the theme on "energy and sustainability" highlights the role of the (renewable) energy system in promoting sustainable development—mainly in the context of Africa—and the need for effective governance therein (Kenfack et al., 2014; Sheba and Bello, 2020; Yetano Roche et al., 2020). The theme on "energy for agriculture", meanwhile, examines issues such as the role of energy access in facilitating access to groundwater for irrigation, the influence of different electricity pricing mechanisms on groundwater conservation, and the impact of tubewell irrigation on crop production (Bhandari, 2001; Evans et al., 2012; Sidhu et al., 2020). The lack of access to amenities (including electricity) in urban slums—often despite their proximity to the electricity grid—are highlighted in the theme on "slum electrification" (van Leeuwen et al., 2017; Yaguma et al., 2022). Finally, the theme on "energy governance" addresses issues such as the lack of local level capacity for the devolution of energy governance, the role of energy communities in energy governance, and the influence of politics on electricity access reform in low- and middle-income countries (Gore et al., 2019; Gebreslassie et al., 2022; Volkert and Klagge, 2022).

The themes in this subset can be broadly classified as mainstream, emerging, marginal, and declining in the context of energy access based on their relative importance over time (Figure 3). Themes with a high number of publications as well as a large share of publications in the past 5 years, for example, can be considered as mainstream and growing in importance (i.e., top right quadrant of Figure 3). These include the themes on "hybrid energy", "household energy", "energy behavior", and "solar energy." Further, themes such as "bioenergy", electrification, "energy transition", "Energy Union", and "minigrid" appear to be mainstream, but steady. Meanwhile, the themes with fewer publications but a high share of publications in the recent past are more likely to be emerging: "economy and environment", "energy and gender", "energy justice", "financing", "energy and sustainability" and—to some extent–"slum electrification", "energy planning", "measuring access", "energy governance", and the "politics of access." In contrast, the themes on "energy security", "hydropower", and "energy for agriculture" appear to be declining in their relative importance in the recent past.

While the themes in this subset are more policy relevant, whether even this strand of the literature has paid sufficient attention to public policy remains unclear. First, as noted above, several themes in this subset are common to the broader literature on energy access. On the one hand, this indicates that different themes in the broader literature have been addressed from a policy perspective; however, on the other hand, it raises the question whether their treatment of public policy has been cursory rather than in-depth. Second, although various themes address policy objectives, none of the themes are centered around public policy, with the possible exception of "energy governance" and "politics of access" to some extent. This is also reflected in the terms associated with the themes, which are predominantly domain-specific and terms such as governance, institution, law, policy making, politics, and program are prominent in only five of the 23 themes. Third, the themes that, prima facie, signal the most engagement with public policy—such as "energy governance" and "politics of access"—constitute a rather small share (less than five percent) of the policy relevant literature on energy access, as seen in Figure 3.

In the next section, we examine the use of terms related to public policy in further detail to understand whether and how the policy relevant literature has engaged with public policy.

4. Analysis: where is the policy?

The term policy (including its plural, policies) has been mentioned more than 2,800 times in the titles or abstracts of the policy relevant literature on energy access. However, as noted above, the mentions of phrases involving policy are relatively few. Apart from the phrase "energy policy" (n: 413), only the phrase "policy maker(s)" (n: 318) has over 100 occurrences in this dataset. Even phrases such as "policy implication(s)" (n: 75) or "policy recommendation(s)" (n: 51) are mentioned infrequently. In addition, "policy analysis" occurs on only 14 occasions in this dataset. We analyze the occurrence of phrases related to the policy process, policy design, and policy evaluation in more detail (Table 8). In total, 429 of the 1,751 policy-related studies mention any of these phrases, indicating that less than 6 percent of the

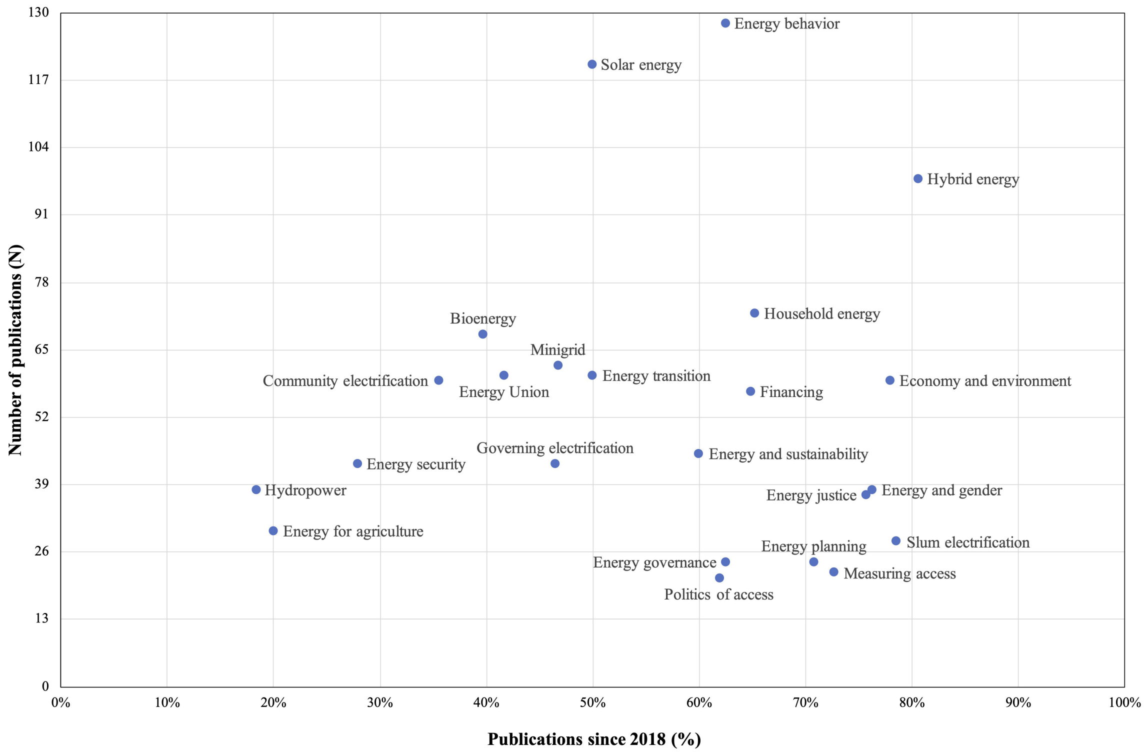

FIGURE 3
Theme-wise volume and recency of activity in policy-related literature on energy access.

overall literature and less than 25 percent of the policy-related literature has delved into policy processes, policy designs, or policy evaluation concerning energy access.

We observe that concepts related to the policy process have been mentioned in approximately 150 publications in the policy-related literature on energy access. These can approximately be classified based on the likely stage of the policy process in which they could be the most relevant. The phrases pertaining to agenda setting ("policy agenda(s)", "policy attention", "policy discourse", and "policy issues") have been mentioned approximately 30 times in this dataset. Meanwhile, phrases relevant to policy formulation ("policy development", "policy discussion", "policy formulation", and "policy planning") occur approximately 35 times. The phrases related to decision-making ("policy change(s)", "policy decision(s)", "policy initiatives", and "policy reform"), meanwhile, are mentioned about 50 times in this literature. Finally, the phrase "policy implementation" occurs only 14 times in this subset.

A closer look at publications that mention some of these phrases indicates that they are largely used in a descriptive or normative sense. For example, the term policy agenda is most commonly used to state that energy poverty is not on, or is only beginning to appear on, the policy agenda (Sareen et al., 2020; Castaño-Rosa and Okushima, 2021), or to propose a policy agenda for the issue (Amin et al., 2022; Thomson et al., 2022). An analysis of variation in energy access on the policy agenda—illustratively, over time or across geographies—is rarely done. Similarly, policy change is typically used in a descriptive manner in existing research (Kelkar and Nathan, 2021; Patel et al., 2021). Studies that examine the policy process have created insights on various dynamics in this area, such as the consensus and conflict among different discourses or narratives—including energy access or energy for all—in the energy transition (Mohan and Topp, 2018; Shukla and Swarnakar, 2022; Wibisono et al., 2023); the importance of domestic and international politics in influencing policy activity on energy access (Byrne et al., 2018; Gore et al., 2019; Dye, 2021; Newell and Daley, 2022); the role of policy entrepreneurship in placing the issue on the agenda (Goyal et al., 2020); the challenges that access policies face during implementation, including complexities, corruption, discrimination, and resource logistics (Geall and Shen, 2018; Zaman and Brudermann, 2018; Aklin et al., 2021); and the potential of social movements in changing policy (Delina, 2022).

Terms that might be relevant for policy design are more frequent, and have received attention in about 250 publications on energy access. Broadly, these can in turn be viewed as terms indicating policy means, policy ends, or combinations of means and ends. The various phrases that could describe policy means (such as "policy instrument", "policy intervention", "policy measure", and "policy option") have been mentioned about 110 times in this dataset. Conservatively, the phrases that could describe policy ends ("policy focus", "policy goal", "policy objective", and "policy priority") have about 60 occurrences in this dataset. Meanwhile, phrases that could describe a combination of means and ends ("policy design", "policy framework", "policy mix", "policy scenario", and "policy strategy") collectively occur about 80 times in this dataset.

TABLE 7 A comparison of themes in the literature on energy access vs. those in the policy-related literature on energy access.

Theme	Complete literature	Policy-related literature
Hybrid energy	Yes	Yes
Rural electrification	Yes	Yes, split across “Community electrification” and “Governing electrification”
Minigrid	Yes	Yes
Financing	Yes	Yes
Solar energy	Yes	Yes
Solar home system	Yes	Yes, captured within “Solar energy”
Hydropower	Yes	Yes
Household energy	Yes	Yes
Grid stability	Yes	No
Bioenergy	Yes	Yes
DC microgrid	Yes	No
Energy security	Yes	Yes
Energy planning	Yes	Yes
Energy impact	Yes	No
Energy poverty	Yes	Yes, split across “Energy behavior” and “Measuring access”
Multicriteria analysis	Yes	No
Electricity distribution	Yes	No
Smart grid	Yes	No
Wireless network	Yes	No
Energy materials	Yes	No
System optimization	Yes	No
Energy storage	Yes	No
Wind energy	Yes	No
Economy and environment	Yes	Yes
Energy justice	Yes	Yes, split across “Energy justice” and “Politics of access”
Energy and gender	Yes	Yes
Energy Union	Yes	Yes
Energy transition	No	Yes
Energy and sustainability	No	Yes
Energy for agriculture	No	Yes
Slum electrification	No	Yes
Energy governance	No	Yes

As in the case of the policy process, mention of policy design is often in a descriptive context (Trotter et al., 2017; Ndiritu and Engola, 2020). Yet, several (types of) studies in the policy-related literature have clear relevance for policy design. First, some studies assess economic, social, or technological viability of alternatives and shed light on feasible policy designs for promoting energy access (Thapar, 2022). Second, studies also model energy systems and create knowledge on possible policy pathways for achieving medium- or long-term objectives, typically, in a dynamic environment (Gebremeskel et al., 2023). Third, other studies examine the synergies and trade-offs among different policy objectives, such as energy access, climate change mitigation, and gender (Antwi, 2022).

Research incorporating a policy studies perspective shows how the above work can be enriched to make it more policy relevant. For example, Minogue (2013) and Chindarkar (2017) emphasize the need to address not only the technological but also the political and the social context through policy design and also ensure administrative, financial, and technical capacity for implementation of the design. Similarly, Kern et al. (2017) and Malhotra (2022) underscore the importance of considering the interaction among various objectives and instruments in a policy “mix” for effective policy design, especially as various energy policies often address potentially competing policy objectives (see also Trotter and Brophy, 2022). Finally, Barnett et al. (2020) exhibit the necessity of accounting for path dependence and the existing policy landscape for policy designing by showing that a policy mix can, paradoxically, weaken due to internal contradictions created by layering or patching policy through the addition of new policy instruments over time.

The number of publications that matched the phrases for policy evaluation was about 50. The phrase “policy evaluation” (or even associated phrases such as “policy failure”, “policy success”, “program evaluation”, “program failure”, or “program success”) have been mentioned on less than five occasions in the policy relevant literature on energy access. The terms closest to evaluation in this subset are “successful implementation” (n: 14), “effective policy” (n: 13), “policy lesson(s)” (n: 7). However, successful implementation or effective policy have been generally used to refer to technical implementation (Kirchhoff et al., 2016) or to make a case for a specific policy recommendation (Landi et al., 2013; Khan et al., 2022) rather than to an empirical evaluation of policy.

Research that has undertaken some form of policy evaluation has shed light on different dimensions of policy-making for energy access. These include the role of public policy in reducing multidimensional energy poverty in Ghana (Crentsil et al., 2019), the influence of deregulation on the electricity system in low- and middle-income countries (Mutale and Mensah-Bonsu, 2009), and the positive effect of renewable energy policy in the Economic Community of West African States (ECOWAS) on energy access, primary energy supply, and energy intensity (Moustapha, 2022). In one example of the potential of lesson drawing in this area, Soyemi et al. (2021) assess the implementation of energy access policies in several countries to provide policy recommendations for Nigeria. Meanwhile, some studies have highlighted the several challenge(s) of providing universal energy access: the potential trade-offs among different policy objectives associated with energy access (Kansakar et al., 2009), the need for technical expertise in policy designing and policy implementation (Ndiritu and Engola, 2020), the necessity of close collaboration between the private sector and the public sector (Landi et al., 2013), the limitations of economic competition in “small” electricity systems (Nepal et al., 2018), and the continued need for subsidization as well as the “competition” between off-grid

TABLE 8 Occurrence of terms pertaining to public policy in the policy-related literature on energy access.

Policy concept	Term: frequency			
Policy process	Policy making: 37	Policy formulation: 15	Policy decisions: 15	Policy initiatives: 15
	Policy implementation: 14	Policy development: 10	Policy reform: 10	Policy agenda: 8
	Coalitions: 7	Policy issues: 7	Policy attention: 6	Policy changes: 6
	Policy planning: 6	Policy discussion: 5	Policy agendas: 5	Policy change: 5
	Policy discourse: 5	Policy decision: 5		
Policy design	Policy framework: 40	Policy measures: 33	Policy interventions: 29	Policy frameworks: 21
	Policy options: 21	Policy goals: 21	Policy objectives: 18	Policy design: 18
	Policy instruments: 17	Policy mix: 12	Policy scenarios: 11	Policy intervention: 9
	Policy barriers: 9	Policy strategy: 9	Policy priority: 8	Policy scenario: 6
	Policy focus: 6			
Policy evaluation	Successful implementation: 14	Effective policy: 13	Policy lessons: 7	Effective policies: 6

and on-grid energy for furthering access (Hellqvist and Heubaum, 2023).

A review of the abstracts of 176 randomly selected publications—i.e., 10 percent of the policy-related literature—corroborated the findings of the computational text analysis. We found that approximately 25 percent of this subset engaged with the policy process, policy design, or policy evaluation. Only three publications in this subset focused on some aspect of the policy processes, and none of them engaged with the literature on policy studies explicitly. Further, 34 publications paid attention to policy design in their problematization, analysis, or recommendations. Finally, 10 publications evaluated policy, program, or process in some form.

5. Discussion

To ensure universal access to affordable, reliable, and modern energy services by 2030 is a key target (SDG 7.1) for the sustainable development goal on energy (SDG 7). Despite the significant progress on increasing access to clean cooking and electricity over the past decade, the COVID-19 pandemic—among other reasons—has caused a slowdown and even backsliding in this effort. At the current pace, SDG 7.1 will not be achieved for either clean cooking (likely attainment: approximately 70 percent of the global population) or electricity (likely attainment: approximately 90 percent of the global population). As public policy can help accelerate the progress toward universal energy access, this study examined whether and how perspectives from *policy sciences* or *policy studies*—specifically, policy process research, policy design studies, and the literature on policy evaluation—have been used in nearly 7,500 publications on energy access indexed either by Scopus or the Web of Science.

Using topic modeling, we identified 27 themes in the literature on energy access. While some of these focused on policy objectives—such as "rural electrification", "energy security", "energy poverty", and "energy justice"—many focused on technological alternatives for increasing access—such as "solar energy", "solar home system", "hydropower", "bioenergy", "wind energy", and "energy materials"—or configuration of the energy system, such as "hybrid energy", "minigrid", "DC microgrid", "multicriteria analysis", "system optimization", and "energy storage." In addition, some themes discussed energy distribution or end-use ("grid stability", "electricity distribution", "smart grid", "household energy") while others emphasized more macro-level themes ("financing", "energy planning", "Energy Union") or the relationship of energy to the economy, environment, and society ("energy impact", "economy and environment", "energy and gender"). This analysis revealed public policy was not a key theme in the literature on energy access.

Subsequently, we examined the themes in the more policy-related literature on energy access (i.e., publications mentioning policy in their title or abstract) to see whether the situation in this literature was different. The themes discovered in this analysis were quite similar to those in the broader literature on energy access. However, some of the more technologically oriented themes spanning energy generation ("wind energy" and "energy materials"), system configuration ("DC microgrid", "system optimization", "multicriteria analysis", and "energy storage"), energy distribution ("grid stability", "smart grid", "electricity distribution") and application area ("wireless network") were not prominent here. Instead, themes pertaining to policy objectives stood out more clearly, with "energy behavior" and "measuring access" addressing energy poverty, "community electrification" and "governing electrification" speaking to rural electrification, and "energy justice" and "politics of access" engaging with energy justice in different geographies. In addition, themes surrounding "energy for agriculture", "slum electrification", "energy transition", "energy and sustainability", and "energy governance" were also discovered. Yet, with the possible exception of "energy governance" and "politics of access"—which were a small part of the literature—the themes in this literature also showed limited engagement with public policy.

We analyzed the occurrence of terms related to policy process, policy design, and policy evaluation in the policy-related literature on energy access. We found hardly any mentions of phrases pertaining to policy, with even phrases such as "policy implication(s)", "policy recommendation(s)", and "policy analysis" receiving much fewer than 100 mentions in our dataset. Further, phrases pertaining to the policy process (such as "policy agenda", "policy change", "policy implementation"), policy design (such as "policy design", "policy mix", "policy objective", "policy instrument"), or policy evaluation (such as "policy evaluation", "policy failure", "policy success") were hardly mentioned or mentioned in a cursory or descriptive manner. Sophisticated research based on the *policy sciences* or *policy studies* was uncommon despite its relevance for energy access.

It is plausible that a larger volume of the literature has, in fact, engaged with topics concerning the policy process, policy design, and policy evaluation, but used generic phrasing and terminology for a multidisciplinary audience. Although we cannot rule this possibility out completely, our manual review of randomly selected abstracts of 10 percent of policy-related literature too indicated that only 25 percent of the studied engaged with the policy process, policy design, or policy evaluation in some form. Most of these, too, focused on policy design, few on policy evaluation, and almost none on the policy process. Further, even among these, hardly any engaged explicitly with the policy studies literature. This could inhibit knowledge cumulation or energy access and instead create fragmentation among different bodies of research.

A manual review of publications mentioning terms relevant to the policy process, policy design, or policy evaluation revealed uneven treatment of these perspectives. While several studies had clear relevance to policy design, this strand of research on energy access could benefit further from insights from policy studies such as (i) the importance of accounting for the political and social context as well as policy capacity in policy design(ing); (ii) the potential interaction among different policy objectives and policy instruments that could be synergistic or conflicting; and (iii) the need to account for path dependence and the existing policy landscape in policy analysis. On the other hand, policy evaluation has received much less attention in the field of energy access. Here, there is scope for much more breadth as well as depth, shedding light on policy failures and successes around the world, incorporating process and political assessment of public policy in evaluation, and studying when and how policies help achievement of universal access to energy. Finally, the policy process has received the least attention in this literature even though policy design is affected significantly by policy-making dynamics. Research examining why some governments adopt policies concerning energy access, whether and how vested interests influence policy design, and how energy access policies are implemented can create useful knowledge for explaining and altering the status quo.

The reasons for the observed structure of knowledge in this research area could be several. First, publications on technological and economic assessment seem to dominate research on energy access and other social science perspectives may have received less attention within this scholarly community. Second, the *policy sciences* or *policy studies* community has likely focused primarily on the Global North (especially North America) and concerns of the Global South (such as energy access) have not found traction among scholars in this field. Third, there might be limited opportunities for scholarly exchange between the two communities of researchers. Fourth, public policy education—although growing rapidly—is still not mainstream in the Global South with most degree programs, departments, and schools being less than two decades old (El-Taliawi et al., 2021). Fifth, such research requires access to fine-grained socioeconomic indicators (including metrics for energy access), policy documents, and people involved in the policy process, all of which might pose a high barrier.

An examination of the dataset—and, especially, the publications that have engaged with the policy process, policy design, and policy evaluation—reveals how these factors might be at play. First, many of the studies that engage with the policy process, for example, are published in just one source: *Energy Research and Social Science*. At the same time, journals focusing on public policy have published little on the topic of energy access, possibly resulting in a dearth of avenues for this kind of research. Second, studies that engage with the policy design literature appear to have been written by scholars who have co-authored with researchers in the policy studies community, indicating that more opportunities for an exchange of perspectives is likely to be fruitful. Third, several studies on policy evaluation, for example, are based on countries where English is an official or semi-official language, suggesting that the ability to access or interpret data might indeed pose a challenge to diversify the policy-relevant research on energy access. Future research could investigate whether these findings are specific to the literature on energy access and whether the findings differ in the case of research on energy justice or energy poverty, for example. If so, these research areas could serve as a bridge between the literature on energy access and the research on public policy.

To conclude, future research activity on public policy in and for energy access is much needed if the backsliding on SDG 7.1 is to be reversed and progress toward the achievement of the SDGs is to be made. This study proposes different perspectives through which this can be done and demonstrates how the few studies that have done so have created useful scholarly knowledge for addressing the energy access challenge.

Data availability statement

The raw data from Scopus and Web of Science is subject to license. The authors will share the processed data used for the analysis upon request.

Author contributions

NG and MH contributed to conception of the study. NG designed the study, organized the database, conducted the analysis, and wrote the first draft of the manuscript. MH wrote sections of the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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