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AI, Energy Justice, and Smart Grid Governance: A Review of Critical Debates, Conceptual Frameworks, and Future Directions

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Abstract

The integration of AI into smart grids raises profound questions about energy justice, including fairness, equity, participation, and accountability. These concerns are generating a growing, but fragmented, body of literature. No comprehensive scoping review maps the critical debates, conceptual frameworks, and future research directions at this intersection. The field lacks a systematic synthesis to guide research and policy. This scoping review maps the existing literature on AI, energy justice, and smart grid governance, identifies the main critical debates and conceptual frameworks, and outlines knowledge gaps and future directions. It aims to clarify how justice concerns are being framed in relation to AI-enabled energy systems. A scoping review methodology was applied to 33 peer-reviewed articles from 2017–2025. A structured search, eligibility screening, and thematic mapping were performed. The review maps the dominant critical debates, including efficiency versus democracy, digital exclusion, algorithmic bias, and data governance. It also catalogues conceptual frameworks around distributive, procedural, recognition, and responsible AI principles. The field is at an early stage but growing rapidly. Consolidating conceptual foundations and empirically testing the impact of AI on energy justice are urgent priorities.

Keywords Energy justice, AI, Smart grid governance, Scoping review, Critical debates, Conceptual frameworks

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Introduction

Artificial intelligence is increasingly embedded in smart grids through demand response, distributed energy coordination, predictive optimisation, smart metering, automated pricing, and grid-balancing decisions. This transformation raises justice concerns because smart energy systems may allocate benefits, burdens, risks, and decision authority unevenly across households, communities, and institutions [1]. Energy justice scholarship has long argued that technical transitions must be assessed through distributive, procedural, and recognition dimensions, but AI introduces new forms of opacity, automation, and data dependence into these debates [2]. As smart grid systems become more digitally mediated, questions of algorithmic accountability and democratic control become central to energy governance [3].

The literature is fragmented across energy justice, responsible AI, smart grid engineering, digitalisation, and socio-technical transition studies. Smart grid research has examined values, flexibility, automation, and demand-side response, while AI ethics research has focused on fairness, transparency, accountability, and human oversight [4]. However, these discussions often proceed separately, leaving unresolved how responsible AI principles should be translated into energy

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justice governance. This fragmentation motivates a scoping review that maps concepts, debates, and research gaps rather than testing a narrow causal hypothesis [5].

This article contributes by systematically mapping peer-reviewed scholarship from 2017–2025 on AI, energy justice, and smart grid governance. It first outlines the purpose, review questions, search strategy, eligibility criteria, and study selection process, then maps the literature and examines critical debates [6]. The review further evaluates conceptual frameworks in the literature and synthesises themes around distributive, procedural, and recognition justice in smart grid governance. By doing so, it provides a structured foundation for future interdisciplinary research at the intersection of AI ethics and energy transitions [7].

Purpose of the Scoping Review

The purpose of this scoping review is to chart the landscape of research rather than assess intervention effectiveness or estimate quantitative effects. A scoping approach is appropriate because the literature spans conceptual energy justice work, smart grid governance studies, responsible AI frameworks, and technology-specific analyses of demand response and smart energy automation [8]. The review maps how studies define justice problems, identify governance risks, and conceptualise AI-enabled smart grids as socio-technical systems. It therefore treats the field as emergent, interdisciplinary, and conceptually unsettled rather than as a mature evidence base suitable for meta-analysis [9].

The value of the review lies in clarifying how diverse literatures speak to one another. Energy justice provides normative categories for assessing fairness and vulnerability, while responsible AI offers principles for governing algorithmic systems [10]. Smart grid governance adds institutional concerns about regulation, data ownership, accountability, and participation [11]. By bringing these perspectives together, the review identifies where conceptual integration is developing and where gaps persist in empirical grounding, theory-building, and policy translation [12].

Review Questions

The review was guided by four questions that reflect the scope of the field. First, how has the literature conceptualised the relationship between AI, energy justice, and smart grid governance [3]? Second, what critical debates dominate scholarship on algorithmic decision-making, digital exclusion, energy democracy, and automated grid management [13]? Third, which conceptual frameworks are used or adapted to analyse justice in AI-enabled energy systems [14]? Fourth, what knowledge gaps and future research directions emerge from the mapped literature [15]?

These questions structure the subsequent mapping and synthesis. The literature was categorised according to publication characteristics, energy domain, AI dimension, justice dimension, and governance focus, drawing on prior scoping and review-oriented approaches in energy justice and digital energy systems [5]. The critical debate sections examine tensions between optimisation and participation, inclusion and exclusion, and data control and institutional accountability. The conceptual framework sections then evaluate whether existing frameworks are sufficiently AI-specific, energy-specific, and justice-sensitive [16].

Search Strategy

The search strategy targeted peer-reviewed journal articles published between 2017 and 2025 in fields relevant to energy justice, smart grid governance, AI ethics, digitalisation, and socio-technical energy transitions. Search terms combined justice-oriented language with AI and smart grid concepts, including “energy justice,” “artificial intelligence,” “smart grid,” “algorithmic fairness,” “governance,” “digital exclusion,” “energy democracy,” and “procedural justice” [17]. The review prioritised journals in energy policy, energy social science, sustainable energy systems, AI ethics, and digital society. The time window was selected to capture the period in which smart energy digitalisation and responsible AI debates became increasingly connected [18].

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The search was refined iteratively to avoid over-reliance on either technical smart grid studies or broad AI ethics literature. Initial searches identified foundational energy justice and smart grid governance studies, while subsequent searches added algorithmic fairness, AI ethics, digitalisation, and participation-focused terms [19]. The review also included studies on adjacent digital energy infrastructures, such as blockchain-enabled energy systems and smart contracts, where they raised governance, justice, or accountability issues relevant to AI-enabled smart grids [20]. This iterative approach allowed the review to capture conceptual bridges across fields rather than only studies using the exact phrase “AI and energy justice” [21].

Eligibility Criteria

Studies were included when they were peer-reviewed journal articles published in English between 2017 and 2025 and substantively addressed at least one component of the review topic. Eligible studies examined energy justice frameworks, smart grid governance, AI ethics, demand-side automation, digital energy participation, algorithmic fairness, data governance, or socio-technical implications of AI-enabled energy systems [22]. Both conceptual and empirical articles were eligible because the review maps an emerging field rather than judging only intervention outcomes. Reviews were also included when they synthesised energy justice, AI, smart technologies, or energy digitalisation in ways relevant to the review questions [5].

Studies were excluded when they focused only on technical grid optimisation without justice or governance implications. Articles were also excluded if they were conference papers, reports, book chapters, standards, theses, websites, or non-peer-reviewed publications, because the review sought a journal-based academic evidence map [23]. Purely general AI ethics papers were included only when their principles were directly relevant to algorithmic governance, fairness, transparency, or accountability in the energy context [4]. Similarly, smart energy studies were retained only when they offered insight into justice, participation, vulnerability, governance, or social impacts [24].

Study Selection

The study selection process proceeded in three stages. First, titles and abstracts were screened to identify records that connected energy systems, smart grid digitalisation, AI governance, justice, fairness, or participation [25]. Second, full texts were assessed to determine whether the article contributed conceptually, empirically, or methodologically to the intersection of AI, energy justice, and smart grid governance. Third, eligible studies were grouped according to their primary contribution, including energy justice theory, smart grid governance, AI ethics, digital inclusion, demand response, and socio-technical transition analysis [26].

The final corpus included 33 peer-reviewed journal articles. The selection reflects a deliberately broad scoping logic because the field is not yet organised around a single terminology or disciplinary canon [27]. Some articles address AI and smart grid systems directly, while others provide conceptual tools from energy justice, algorithmic accountability, or digital energy governance that are necessary for interpreting the field [28]. **Table 1** presents the PRISMA-style selection flow used to identify the included studies.

Table 1. Study Selection Flow Diagram

Selection Stage	Records or Studies	Number	Notes and Reasons
Records identified through database searching	Initial records	286	Records retrieved using combined search strings on energy justice, AI, smart grids, governance, digital exclusion, and algorithmic fairness

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Duplicate records removed	Duplicates	71	Duplicate journal records removed across databases and overlapping search strings
Records screened by title and abstract	Records screened	215	Screening focused on relevance to energy justice, smart grid governance, AI ethics, digital energy systems, or socio-technical governance
Records excluded at title and abstract stage	Excluded records	142	Excluded for purely technical optimisation focus, unrelated energy engineering topic, non-AI energy policy focus, or absence of justice/governance relevance
Full-text articles assessed for eligibility	Full-text assessed	73	Full texts assessed for peer-reviewed status, date range, conceptual relevance, and connection to the review questions
Full-text articles excluded	Excluded full texts	40	Excluded for non-peer-reviewed format, conference status, insufficient justice content, no smart energy relevance, or duplicate conceptual coverage
Studies included in scoping review	Included studies	33	Final corpus of peer-reviewed journal articles published between 2017 and 2025

Mapping the Literature

The included studies show a field that expanded from foundational energy justice and smart grid value debates toward AI governance, digitalisation, and algorithmic accountability. Early contributions foregrounded energy justice as a cross-disciplinary concept and framed smart grids as value-laden infrastructures rather than neutral technical systems [1]. Subsequent work examined smart meters, flexibility, demand response, smart homes, renewable energy communities, and digital energy participation as sites where social inclusion and exclusion are produced [3]. More recent contributions connect these concerns to AI governance, algorithmic decision-making, and the need for procedural fairness in automated systems [29].

The corpus includes conceptual articles, systematic and scoping reviews, socio-technical analyses, empirical studies, and technology-focused reviews. Conceptual energy justice studies provide the normative architecture for assessing distributive, procedural, recognition, and restorative dimensions [2]. Reviews of demand-side response, AI in sustainable energy, blockchain, and smart contracts provide insight into the technical systems through which algorithmic governance may enter energy infrastructures [18]. Empirical and stakeholder-oriented work adds evidence about smart grid acceptance, smart local energy systems, energy communities, and digital citizenship [30].

The main themes identified across the literature are justice in smart grid design, fairness in algorithmic decision-making, democratic participation in energy governance, digital exclusion from smart energy benefits, and accountability for data-intensive automation. A dominant theme is that AI-enabled smart grids may improve operational efficiency while simultaneously concentrating control in technical institutions and platform-based actors [31]. Another theme is that flexibility, automation, and smart home technologies can redistribute both benefits and risks in ways that require justice-sensitive governance [8]. **Table 2** summarises the mapped study characteristics in conceptual categories rather than as a reference-by-reference inventory.

Table 2. Characteristics of Included Studies

Study Cluster	Year Range	Geographic Focus	Energy Domain	AI Dimension	Justice Dimension Addressed

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Foundational energy justice scholarship	2017–2021	Global and cross-national	Energy transitions and policy	Indirect; provides normative basis for AI governance	Distributive, procedural, recognition, restorative
Smart grid values and social acceptance studies	2018–2022	Europe, especially Netherlands and United Kingdom	Smart grids, smart meters, smart local energy systems	Indirect; focuses on digital automation and system design	Procedural justice, value conflict, legitimacy
Demand response and flexibility studies	2019–2021	High-income smart grid contexts	Demand response, flexibility markets, automated energy management	Machine learning, reinforcement learning, automation	Distributive justice, flexibility justice, consumer vulnerability
Smart home and digital energy governance studies	2020–2023	Europe and broader developed-market contexts	Smart homes, digital energy services, energy citizenship	Data-driven platforms and connected devices	Recognition justice, privacy, digital inclusion
Responsible AI and algorithmic accountability studies	2018–2025	Global AI governance literature	Cross-sector algorithmic governance with energy relevance	Fairness, transparency, accountability, procedural algorithmic justice	Procedural justice, accountability, explainability
Sustainable energy AI reviews	2020–2021	Global	Sustainable energy industry and demand-side systems	AI, machine learning, optimisation, demand-side response	Equity implications discussed indirectly
Blockchain and smart contract energy governance studies	2019–2022	Global and decentralised energy systems	Energy trading, smart contracts, decentralised coordination	Algorithmic contracting and automated transactions	Procedural justice, data governance, accountability
Renewable energy community and participation studies	2021–2023	Europe	Community energy and citizen participation	Digital participation and platform mediation	Energy democracy, inclusion, recognition
AI-energy justice integration studies	2025	Global and conceptual	AI-enabled energy transition and smart grid governance	AI-driven decision-making, fairness, inclusive policy design	Integrated distributive, procedural, and recognition justice

Critical Debates

Efficiency vs. democracy

A central debate concerns whether AI-enabled smart grids primarily advance efficiency or undermine democratic energy governance. Technical studies of reinforcement learning and demand response show how automation can optimise consumption, flexibility, and system balancing, but energy justice scholarship cautions that efficiency gains do not automatically translate into fair outcomes [23]. Smart local energy systems and flexibility markets may create new opportunities for participation, yet they may also privilege households with digital literacy, flexible appliances, and market

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access [12]. This debate therefore turns on whether smart grid AI is governed as a public-value infrastructure or as an optimisation layer serving system operators and market actors [9].

Digital exclusion and algorithmic bias

Digital exclusion and algorithmic bias form a second critical debate in the literature. Smart home and digital energy technologies may exclude vulnerable users who lack connectivity, trust, capital, time, or technical capacity, even when such technologies are presented as universally beneficial [6]. Responsible AI scholarship shows that algorithmic systems can reproduce unfairness when data, design objectives, or institutional assumptions encode existing inequalities [10]. In the energy sector, this concern becomes especially acute where automated pricing, demand response, or prioritisation systems shape access to affordability, reliability, and participation [17].

Data ownership and sovereignty

A third debate concerns data ownership, sovereignty, and accountability in increasingly automated energy systems. Smart grids depend on household, consumption, location, behavioural, and infrastructure data, which raises questions about who controls data, who benefits from its analysis, and who bears the risks of surveillance or misuse [21]. Blockchain and smart contract studies show that decentralised digital architectures may promise transparency and peer-to-peer coordination, but they also introduce new governance challenges around accountability, institutional oversight, and automated rule enforcement [19]. Algorithmic justice scholarship further suggests that procedural voice, transparency, and contestability are essential when data-driven systems make consequential decisions [27].

Conceptual Frameworks in the Literature

Energy justice frameworks adapted to AI

Energy justice frameworks provide the most developed conceptual foundation for analysing AI-enabled smart grids. The literature defines energy justice across distributional concerns, procedural participation, recognition of vulnerable groups, and broader normative commitments to fair transition governance [22]. Applied to smart grids, these frameworks shift attention from whether AI improves grid performance to who benefits, who is burdened, who participates, and whose needs are recognised [32]. The capability approach extends this analysis by asking whether digital energy systems expand or constrain people's substantive ability to live energy-secure lives [7].

AI governance and responsible AI frameworks

AI governance frameworks add principles of transparency, accountability, fairness, beneficence, and human oversight that are directly relevant to smart grid automation. The AI4People framework provides an influential ethical vocabulary for responsible AI, while later work warns that principles alone cannot guarantee ethical implementation without institutional mechanisms [4]. Algorithmic accountability studies deepen this concern by showing that automated decision-making requires clear responsibility, procedural safeguards, and mechanisms for contesting unfair outcomes [13]. Procedural fairness research further indicates that voice, transparency, and outcome control are central to public perceptions of algorithmic legitimacy [28].

Integrated frameworks and their limitations

Integrated frameworks are emerging but remain underdeveloped. Studies linking AI to just energy transitions suggest that artificial intelligence may become either a driver of justice or a mechanism of exclusion depending on governance design, institutional accountability, and social context [29]. AI-driven smart grid justice frameworks explicitly attempt to connect technical efficiency with inclusive welfare policy, but such work remains at an early stage and requires stronger empirical validation [33].

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Figure 1 synthesises the reviewed frameworks into a justice-sensitive governance model for AI-enabled smart grids, showing how AI applications generate distributive, procedural, and recognition justice risks that can be addressed through accountability, participation, transparency, and data governance safeguards.

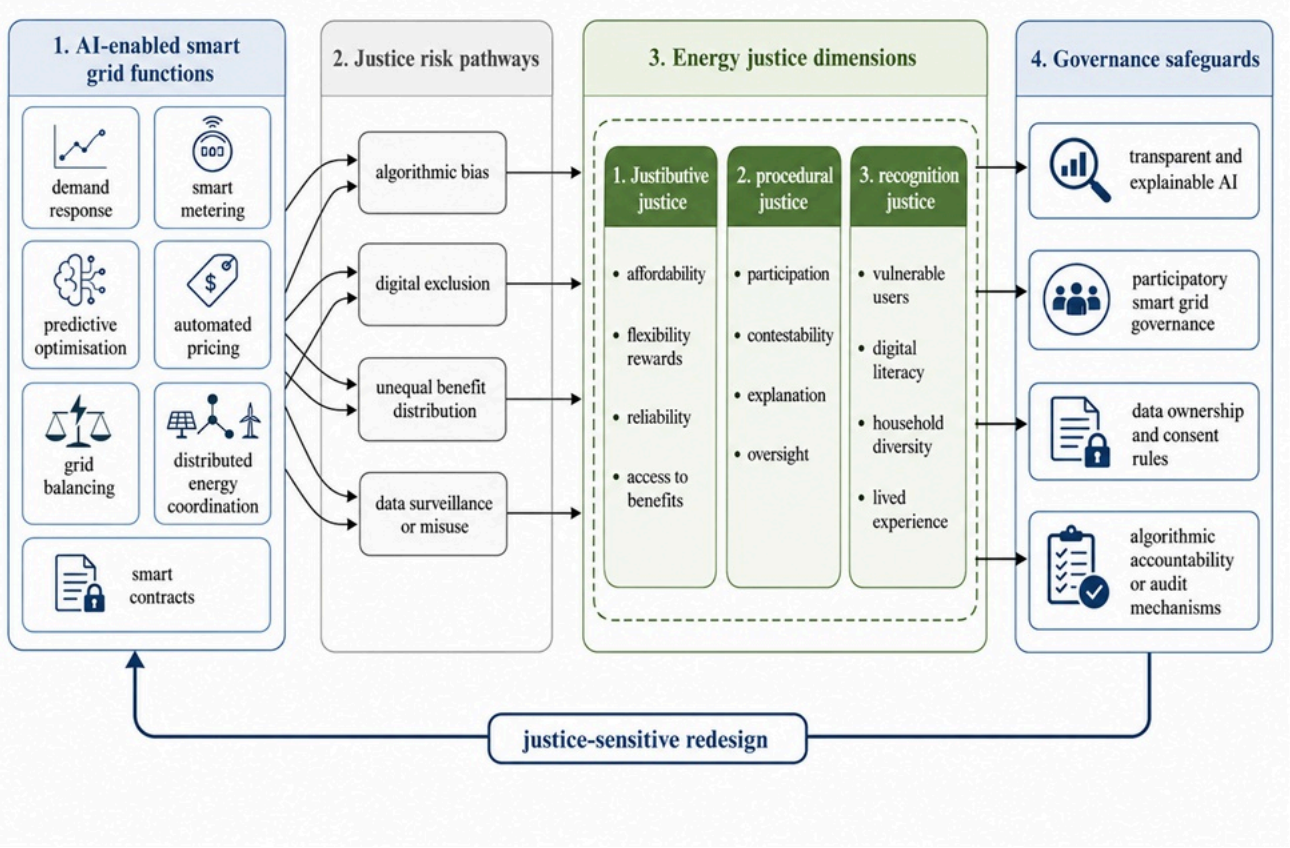

Figure 1. Justice-Sensitive Governance Framework for AI-Enabled Smart Grids

Table 3 compares the main conceptual frameworks identified in the literature and highlights their limits for analysing AI, energy justice, and smart grid governance together.

Table 3. Comparison of Conceptual Frameworks

Framework	Core Components	Justice Dimensions Covered	AI Specificity	Key Limitation
Energy justice framework	Distribution of benefits and burdens, participation, recognition, responsibility	Distributive, procedural, recognition, restorative	Low to moderate; adaptable to AI but not originally AI-specific	Requires translation into data, automation, and algorithmic decision contexts
Smart grid values framework	Value conflicts, social acceptance, institutional legitimacy, infrastructure design	Procedural justice, legitimacy, fairness, trust	Moderate; addresses digital energy systems but often not AI directly	May understate algorithmic opacity and automated decision-making risks

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Flexibility justice framework	Access to flexibility markets, burden shifting, household capacity, demand response participation	Distributive and recognition justice	Moderate; relevant to automated demand response	Often focused on flexibility participation rather than broader AI governance
Responsible AI framework	Transparency, accountability, fairness, beneficence, non-maleficence, human oversight	Procedural fairness and accountability	High; developed specifically for AI governance	Often too general to capture energy-sector vulnerabilities and grid-specific harms
Algorithmic justice framework	Voice, contestability, explainability, procedural safeguards, outcome control	Procedural justice and recognition	High; focuses on automated decisions	Needs stronger integration with energy affordability, reliability, and access concerns
Capability approach to digital energy	Substantive freedoms, agency, lived experience, unequal capabilities	Recognition, distributive, procedural	Moderate; captures digitalisation more than AI specificity	Requires operationalisation for smart grid AI assessment
Energy democracy framework	Public participation, decentralised authority, community benefit, citizen agency	Procedural, distributive, recognition	Low to moderate; relevant to AI governance by extension	May lack technical detail on algorithmic systems and data infrastructures
Integrated AI-energy justice framework	AI efficiency, inclusive welfare, fairness, governance safeguards, accountability	Distributive, procedural, recognition	High; explicitly connects AI and energy justice	Still emergent and insufficiently validated across contexts

Energy Justice and Smart Grid Governance Themes

Distributive justice and access to benefits

Distributive justice concerns arise when AI-enabled smart grids allocate energy savings, flexibility rewards, reliability improvements, or exposure to risks unevenly. Clean energy transition scholarship shows that even low-carbon and digital innovations may produce unequal outcomes when benefits accrue to already advantaged users [17]. Demand-side response and smart home systems may reward households with flexible devices, stable housing, and digital capacity while leaving low-income or vulnerable households with fewer benefits and greater exposure to dynamic pricing [18]. Renewable energy communities offer a potential corrective by linking local participation with shared benefits, but their justice outcomes depend on inclusive governance and access conditions [16].

Procedural justice and participation

Procedural justice focuses on who participates in smart grid decisions and whether affected communities can influence algorithmic governance. Smart grid value studies show that public acceptance depends not only on technical functionality but also on whether systems reflect moral values, trust, autonomy, and transparency [30]. Energy democracy debates further suggest that AI-enabled governance should not reduce citizens to data sources or passive consumers, but should enable meaningful participation in rule-setting and oversight [26]. In algorithmic systems, procedural justice also requires mechanisms for explanation, appeal, and accountability when automated decisions affect households or communities [31].

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Recognition justice and vulnerability

Recognition justice requires smart grid governance to account for the specific needs, vulnerabilities, and lived experiences of different users. Vulnerability studies of smart meter transitions show that digital energy systems may generate resistance when they are experienced as intrusive, confusing, or misaligned with household circumstances [3]. Digital citizenship research similarly indicates that participation in smart energy systems depends on identity, social practice, communication channels, and trust rather than on technology access alone [21]. A recognition-oriented approach therefore asks whether AI-enabled smart grids are designed around diverse users or around a narrow model of the rational, digitally literate, flexible consumer [6].

Knowledge Gaps

Empirical evidence gap

A major gap is the limited empirical evidence on how AI-enabled smart grid governance affects energy justice in real-world settings. Much of the literature identifies plausible justice risks, such as unequal access to smart home benefits, unfair demand response burdens, and vulnerability in smart meter transitions, but fewer studies trace actual consequences for households and communities over time [3]. Demand-side response reviews demonstrate that AI and machine learning are technically mature enough to influence energy behaviour and grid flexibility, yet justice impacts are often discussed indirectly rather than measured or observed in lived contexts [18]. Future research should therefore examine how algorithmic energy decisions affect affordability, reliability, comfort, participation, and trust among differently positioned users.

Theoretical under-development

Theoretical integration remains under-developed because energy justice, responsible AI, smart grid governance, and energy democracy often operate with different assumptions about technology, institutions, and agency. Energy justice frameworks provide strong normative categories, but they were not originally designed to address automated decision-making, model opacity, or data-driven optimisation [2]. Responsible AI frameworks offer principles for fairness and accountability, yet scholars warn that such principles can remain abstract unless embedded in sector-specific governance arrangements [14]. A stronger theory of AI-enabled energy justice is needed to connect algorithmic design choices, institutional accountability, and socio-technical energy transitions.

Geographic and contextual imbalances

The mapped literature is weighted toward European and high-income smart energy contexts, with less attention to low-income, rural, Global South, and infrastructurally constrained settings. Studies of smart grid values, local energy systems, and renewable energy communities provide important insights, but their institutional assumptions may not transfer easily to contexts with weaker regulatory capacity, lower digital access, or more severe energy insecurity [32]. Clean energy justice scholarship shows that transition benefits and burdens vary sharply across social and geographic contexts, making contextual imbalance a significant limitation in current AI-energy justice debates [17]. **Table 4** maps the principal knowledge gaps to future research directions, methodological approaches, and policy relevance.

Table 4. Knowledge Gaps and Corresponding Future Research Directions

Identified Gap	Illustrative Research Question	Suggested Methodological Approach	Policy Relevance
Limited empirical evidence on justice	How do AI-enabled demand response systems affect	Longitudinal qualitative studies, mixed-method case studies,	Supports safeguards for automated pricing,

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impacts	affordability, comfort, and participation among vulnerable households?	household interviews, participatory evaluation	flexibility markets, and consumer protection
Weak integration of energy justice and responsible AI	How can distributive, procedural, and recognition justice be translated into AI design and governance requirements?	Conceptual framework development, Delphi studies, expert workshops, design justice methods	Guides sector-specific responsible AI standards for smart grid governance
Insufficient attention to algorithmic bias	Which data and modelling practices create unfair outcomes in smart grid allocation, pricing, or load management?	Algorithm audits, fairness assessment, model documentation, scenario analysis	Informs regulatory requirements for transparency, explainability, and bias mitigation
Limited research on data ownership and sovereignty	Who should control household energy data in AI-enabled smart grid systems?	Legal analysis, governance mapping, comparative policy analysis, stakeholder consultation	Supports data rights, consent frameworks, and accountability rules
Geographic concentration in high-income contexts	How do AI and smart grid justice concerns differ in low-income, rural, or Global South energy systems?	Comparative case studies, community-based participatory research, regional policy analysis	Prevents one-size-fits-all governance models and supports context-sensitive energy policy
Under-theorised recognition justice	How are vulnerable users represented or misrepresented in AI-enabled smart grid design?	Ethnography, user-centred design studies, vulnerability mapping, social practice analysis	Improves inclusive technology design and recognition of diverse household needs
Weak linkage between energy democracy and AI governance	How can citizens participate meaningfully in the design and oversight of algorithmic grid systems?	Participatory governance experiments, deliberative workshops, institutional design studies	Strengthens democratic legitimacy, public trust, and accountability
Limited policy translation	What governance instruments can align AI optimisation with justice, reliability, and public value?	Regulatory impact analysis, policy prototyping, comparative governance studies	Helps regulators design enforceable rules for AI-enabled energy systems

Future Directions

Priority research areas

Future research should prioritise empirical studies of AI-enabled smart grids as lived socio-technical systems rather than only as optimisation infrastructures. Studies should examine how smart contracts, decentralised platforms, and algorithmic demand response reshape accountability, participation, and benefit-sharing in practice [20]. Research on AI-driven energy justice should also test whether integrated frameworks can identify harms before they become embedded in grid operations, pricing systems, or automated service allocation [33]. Priority areas include algorithmic fairness in flexibility markets, justice-sensitive data governance, inclusive smart grid participation, and the role of public institutions in supervising automated energy decisions.

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Methodological recommendations

Methodologically, future work should combine conceptual analysis with participatory, comparative, and audit-based approaches. Stakeholder mapping can clarify whose values are embedded in smart grid governance, while algorithmic audits can assess whether automated systems produce unequal outcomes or reduce procedural voice [28]. Comparative research should examine how justice risks differ across regulatory systems, community energy models, and digital infrastructure contexts [16]. Scoping and systematic reviews should also continue to track the field as AI-energy justice scholarship grows, especially as new studies move from conceptual debate toward empirical assessment [5].

Limitations of the Scoping Review

Methodological limitations

This scoping review is limited by the breadth of its interdisciplinary search strategy. Because relevant studies are distributed across energy justice, AI ethics, smart grid governance, and digital energy systems, some articles may use different terminology and therefore remain difficult to identify [10]. The review also prioritised peer-reviewed journal articles, which strengthens academic quality control but may exclude policy debates, regulatory guidance, technical standards, and practitioner knowledge that shape AI-enabled energy governance [13]. As with other scoping reviews, the goal was to map the field rather than formally assess study quality or produce statistical evidence.

Scope boundaries

The scope was intentionally limited to studies relevant to AI, energy justice, and smart grid governance between 2017 and 2025. Articles focused only on technical optimisation, engineering performance, or general energy modelling were excluded unless they contributed to governance or justice debates [23]. Conversely, general AI ethics studies were included only when they offered concepts directly applicable to algorithmic fairness, accountability, or procedural justice in energy systems [4]. This boundary means that the review captures the conceptual and governance landscape rather than the full technical literature on AI in power systems.

Conclusion

This scoping review mapped the emerging literature at the intersection of AI, energy justice, and smart grid governance. It showed that the field is growing but remains fragmented across energy justice theory, responsible AI, digital energy systems, smart grid governance, and socio-technical transition studies. The review clarifies how these literatures can be brought together to understand automated energy systems as justice-sensitive infrastructures. Its main contribution is to organise a dispersed body of scholarship into a structured research agenda.

The critical debates identified in the review show that AI-enabled smart grids are not merely technical innovations. They raise contested questions about democratic control, digital exclusion, data ownership, algorithmic bias, accountability, and recognition of vulnerable users. Conceptual frameworks are available, but they often remain either too general, too energy-specific without AI detail, or too AI-specific without sufficient attention to energy justice. The next stage of scholarship must therefore move toward integrated, sector-sensitive, and empirically grounded frameworks.

Future progress requires collaboration among energy justice scholars, AI ethicists, smart grid engineers, regulators, social scientists, and affected communities. Research should move beyond abstract commitments to fairness and test how algorithmic energy governance operates in practice. Smart grids should be evaluated not only by efficiency, flexibility, or reliability, but also by their contribution to just, inclusive, accountable, and democratic energy futures. The review therefore calls for empirically grounded justice research that can guide both AI design and smart grid governance.

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