Int. j. adv. multidisc. res. stud. 2025; 5(6):2380-2412

Received: 07-11-2025
Accepted: 17-12-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

When Universal Programs Deepen Inequality: A Critical Review of Intersectional Frameworks for Climate Justice and Energy Poverty

[1] Nenubari Marvin Komi, [2] Olaitan Shakirat Ganiu
[1] The City of Edinburgh Council, United Kingdom
[2] North Carolina A&T, State University, United States

DOI: https://doi.org/10.62225/2583049X.2025.5.6.6458
Corresponding Author: **Nenubari Marvin Komi**

Abstract
This paper presents a structured review of the scholarship on climate justice and energy poverty, read through a socio-technical lens that treats engineering performance and social outcomes as a single, interdependent concern rather than as separate questions to be addressed in sequence. The review organizes a fragmented body of work that spans engineering, economics, development studies, and energy justice, and it draws these traditions together around a common question, namely how technical capability and social legitimacy jointly determine whether interventions endure in resource-dependent and underserved regions. Particular attention is given to intersectional, quantitatively grounded targeting as the agenda for just transition, which the review identifies as a recurring but inadequately measured determinant of outcomes. The contribution is conceptual and synthetic: this paper clarifies the state of knowledge, exposes the gap between the recognized importance of social factors and the field's limited progress in measuring them, and sets out a conceptual agenda for integrated evaluation oriented toward inclusive and economically sustainable energy transition.

Keywords: Renewable Energy, Socio-Technical Systems, Conceptual Framework, Just Transition, Energy Equity, Sustainable Development, Inclusive Infrastructure

1. Introduction

Universal energy programs designed to expand access and reduce costs for all households have become a cornerstone of climate and energy policy in both developed and developing country contexts. Feed-in tariffs, net metering, subsidized connection fees, and carbon dividend schemes each promise benefits distributed broadly across the population. Yet a growing body of evidence documents that universal programs systematically deliver differential benefits, with higher-income and more institutionally connected households capturing disproportionate shares of program value while those in the deepest energy poverty receive least. The paradox of universal programs deepening inequality is not an accident of poor implementation but a structural feature of programs designed without intersectional analysis of who benefits and who does not (Basnet *et al*., 2023; Liadi, 2025a; Liadi, 2024a; Liadi, 2025b; Dada *et al*., 2021).

Intersectionality as an analytical framework entered energy policy discourse from feminist theory and critical race studies, where it was developed to describe how multiple axes of social disadvantage, including race, gender, class, disability, and immigration status, interact to produce outcomes that cannot be explained by any single axis alone. Applied to energy poverty, intersectionality reveals that the most severely affected households are not simply poor but multiply disadvantaged: they are simultaneously low-income, located in inadequate housing, lacking access to financial institutions, burdened by caregiving responsibilities, and excluded from civic participation processes in ways that compound each other. Programs designed around a single disadvantage axis, such as low income, fail to reach households whose energy poverty is rooted in a combination of overlapping exclusions (Lilian *et al*., 2024; Adelanwa *et al*., 2023a; Liadi, 2022; Liadi, 2023c; Liadi, 2024a; Basnet *et al*., 2021; Oghenemaiga *et al*., 2024; Isiekwu *et al*., 2021). (Dada *et al*., 2021a).

The critique of universalism in climate policy is analytically distinct from opposition to equity-oriented policy. The argument is not that universal programs are bad but that universalism without intersectional targeting is insufficient: universal baseline programs must be complemented by targeted interventions that reach the households for whom the universal program is structurally inaccessible. Making this argument requires both theoretical development of intersectional frameworks appropriate

to energy contexts and empirical evidence on the distributional outcomes of specific universal programs, evidence that is currently fragmented across literatures that rarely engage each other (Basnet *et al*., 2021; Liadi, 2023; Anene & Clement, 2022; Liadi, 2025b; Liadi, 2022; Liadi, 2023c; Liadi, 2024a; Lilian *et al*., 2024; Lilian *et al*., 2020).

This paper reports a critical review of intersectional frameworks for climate justice and energy poverty, synthesizing evidence on the distributional outcomes of universal programs and the effectiveness of intersectionally targeted complements. The review finds that universal programs consistently exhibit regressive distributional patterns in their initial design and that intersectional targeting substantially improves distributional outcomes but requires analytical and administrative infrastructure that is underdeveloped in most program contexts. This paper concludes with recommendations for program design and research priorities (Anene & Clement, 2022; Basnet *et al*., 2021; Adelanwa *et al*., 2023b; Liadi, 2022; Liadi, 2025b).

Access to reliable, affordable, and clean energy underpins education, health, livelihoods, and full participation in economic life, yet dependable electricity remains out of reach for a large share of the population in low-income and resource-dependent regions (Agbabiaka *et al*., 2019). The scholarship bearing on climate justice and energy poverty has grown rapidly, but it has done so across several traditions that have developed in relative isolation from one another, with engineering work emphasizing performance, economic work emphasizing cost, and social-science work emphasizing acceptance, equity, and governance. This review takes as its task the drawing together of these strands, on the premise that the outcomes of interventions in climate justice and energy poverty are determined by all of them at once and cannot be understood from within any single tradition (Abolarin *et al*., 2024; Adeyemi, 2024). The overall logic relating these elements is summarized in Fig 1 (Basnet *et al*., 2021; Liadi, 2024d; Adelanwa *et al*., 2024b; Liadi, 2022; Liadi, 2023a).

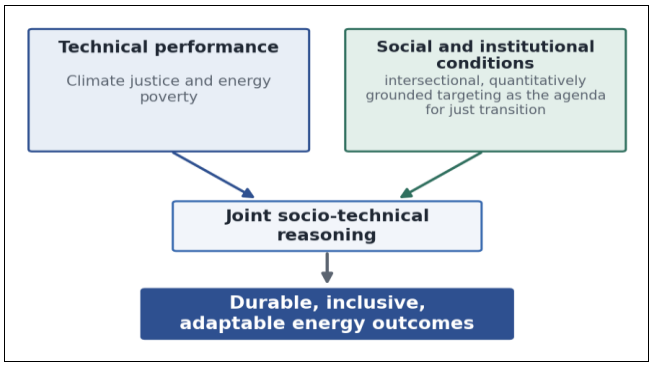

Fig 1: Technical performance and social conditions as jointly determining durable, inclusive outcomes

This review is organized around a socio-technical understanding of energy systems, in which technical artifacts and social arrangements are treated as mutually constitutive rather than as separate domains joined only at the point of deployment (Ahmed *et al*., 2020). From this vantage, a control scheme, a financing structure, or an algorithm is simultaneously a technical object and a social arrangement that distributes capability, cost, and risk (Ahmad *et al*., 2020). The review applies this lens to climate justice and energy poverty in order to clarify what is known, to expose where the prior literature has been thinnest, and to identify the conceptual moves needed to integrate technical and social analysis. The aim is synthesis and reframing rather than the reporting of new measurements, and the contribution lies in the organization and interpretation it offers (Adelanwa *et al*., 2023a; Basnet *et al*., 2024; Adelanwa *et al*., 2023; Dada *et al*., 2021). (Liadi, 2025b).

A recurring theme in the literature on climate justice and energy poverty is that interventions which appear similar in technical terms can produce markedly different outcomes across settings, a divergence that reflects the influence of social, institutional, and contextual factors that conventional technical evaluation leaves unmeasured (Aliliele *et al*., 2023). This review treats that divergence as the central puzzle to be explained, and it surveys how different bodies of work have approached it, from techno-economic analyses that emphasize cost to justice-oriented scholarship that emphasizes distribution and procedure. By placing these approaches alongside one another, the review seeks to show that each captures part of a larger picture and that an integrated account is both possible and necessary for understanding durability in resource-dependent regions (Akindeji & Ewim, 2023; Akindeji *et al*., 2024). (Adelanwa *et al*., 2024a). (Liadi, 2023a). (Dada *et al*., 2021b).

The diversity of the contexts in which climate justice and energy poverty is deployed, spanning climate, institutional maturity, and economic circumstance, means that lessons drawn in one setting do not transfer automatically to another, and the review attends throughout to this problem of generalization (Arumosoye & Obriki, 2018). Much of the literature is grounded in particular cases, and while such studies are valuable, their findings are difficult to combine into cumulative knowledge without a framework for distinguishing what is general from what is context-specific. The review treats this difficulty as one of the central obstacles to progress in the field, and its synthesis is organized so as to separate the regularities that recur across settings from the particulars that vary (Aliliele *et al*., 2025; Ambali *et al*., 2021; Lilian *et al*., 2020; Liadi, 2024d; Liadi, 2025b; Lilian *et al*., 2025).

A further concern of the review is the geography of scholarly attention, which does not match the geography of need, since research effort has concentrated in well-resourced settings while the regions where energy poverty is most acute remain comparatively understudied (Arumosoye & Obriki, 2021). The review is positioned deliberately against this imbalance, drawing its questions and its framing from the conditions of the underserved and resource-dependent regions that are its concern. In doing so it seeks to ensure that the synthesis it offers is relevant to the settings that need it most, rather than reproducing a body of knowledge calibrated to contexts whose conditions differ fundamentally from those in which climate justice and energy poverty must actually perform (Arumosoye & Obriki, 2019; Arumosoye & Obriki, 2020).

The review is also attentive to the way the indicators used to judge success shape the interventions that get designed, since what is measured tends to be what is optimized (Arumosoye & Obriki, 2024). The predominance of technical and unit-cost metrics in the literature has, on this reasoning, steered a generation of interventions toward those dimensions while leaving the conditions governing durability comparatively neglected. The review treats this as a consequential observation rather than a methodological

aside, arguing that broadening the set of measured outcomes is a precondition for broadening what design seeks to achieve, and it returns to this theme in setting out the conceptual directions it proposes for climate justice and energy poverty (Arumosoye & Obriki, 2022; Arumosoye & Obriki, 2023; Anene & Clement, 2022).

The review treats climate justice and energy poverty as a field whose central difficulty is integration rather than discovery, since the constituent insights largely exist but remain dispersed across traditions that do not communicate (Babawurun *et al*., 2023). The task it sets itself is therefore to assemble these insights into a coherent account, identifying where they reinforce one another and where they conflict, so that the field can move from a collection of partial perspectives toward a shared understanding of how technical capability and social legitimacy jointly govern outcomes (Arumosoye *et al*., 2025). This orientation shapes the selection and organization of the literature the review goes on to examine. The review carries this concern through its synthesis of the technical and social scholarship that follows. (Liadi, 2025a).

The review is concerned less with adjudicating between technical and social explanations than with showing why both are necessary and how they fit together (Bhattacharyya *et al*., 2021). It argues that explanations confined to either dimension are incomplete, and that the durability of interventions can be understood only by attending to the interaction of the two (Bednar *et al*., 2017). This integrative ambition shapes the organization of the review, which is structured to bring technical and social scholarship into sustained dialogue rather than to treat them in separate compartments. This consideration informs the themes the review treats as central and the gaps it regards as most consequential. Acknowledging this, at the outset frames the integrative reading the review develops in subsequent sections (Lilian *et al*., 2020).

The review takes the divergence of outcomes across similar interventions as the puzzle that motivates its synthesis, treating that divergence as evidence that unmeasured social and institutional factors are at work (Dagodzo, 2018a). By surveying how different literatures have approached this puzzle, it builds toward an account in which the divergence is explained rather than merely noted, and it uses that account to identify the conceptual tools the field would need to anticipate, rather than merely observe, the conditions under which interventions succeed or fail (Collath, 2021). This premise distinguishes the review from surveys that treat technical and social scholarship in isolation. This concern guides the way the review weighs and combines the studies it surveys (Basnet *et al*., 2024; Liadi, 2024d).

The review situates climate justice and energy poverty within the larger project of inclusive energy transition, arguing that the questions it raises are not peripheral but central to whether that transition succeeds (Dagodzo & Patrick, 2020). The regions where the field operates are those where the transition is most consequential and most fraught, and the review treats the durability and inclusiveness of interventions there as bearing directly on the prospects for a transition that is both rapid and fair, which is the wider purpose its synthesis is ultimately meant to serve (Dagodzo, 2018b). The review keeps this consideration in view as it moves from technical to socio-technical scholarship. This orientation explains the emphasis the review places on integration over enumeration (Liadi, 2023b).

It bears emphasis at the outset that this review is concerned with climate justice and energy poverty as it operates in resource-dependent and underserved regions specifically, rather than in the well-resourced settings where much of the literature has been produced (Dagodzo & Patrick, 2022). This focus shapes which questions the review treats as central and which findings it regards as most relevant, since conditions that can be assumed in better-resourced contexts cannot be assumed in the settings of concern here. The review is explicit about this orientation because it bears directly on the external validity of the literature it surveys, and it reads that literature throughout with attention to whether its conclusions are likely to hold where they matter most (Dagodzo & Patrick, 2021a; Dagodzo & Patrick, 2021b; Adelanwa *et al*., 2023a).

The review proceeds on the understanding that a synthesis is valuable precisely when a field has accumulated substantial but fragmented knowledge, which is the situation it finds in climate justice and energy poverty (Dagodzo & Patrick, 2025). Rather than adding new findings, the review's contribution lies in organizing existing ones into a coherent account that reveals patterns, tensions, and gaps not visible from within any single study or tradition. This understanding of the purpose of review shapes this paper throughout, orienting it toward interpretation and integration rather than enumeration, and it explains why the review is structured around themes and arguments rather than around a catalogue of the works it considers (Dagodzo & Patrick, 2023a; Dagodzo & Patrick, 2023b).

A premise of the review is that the apparent disagreements in the literature on climate justice and energy poverty often reflect differences in the conditions studied rather than genuine contradictions, so that findings which appear to conflict can frequently be reconciled once their contexts are taken into account (El-Rashidy *et al*., 2025). The review treats the reconciliation of such apparent conflicts as part of its task, since doing so reveals the conditions under which particular findings hold and thereby contributes to the transferable understanding the field requires. This premise informs the review's interpretive stance, which seeks to make sense of the literature as a whole rather than to adjudicate isolated disputes within it (Dagodzo *et al*., 2022; Dioha *et al*., 2021).

This review attends throughout to the gendered dimension of climate justice and energy poverty, since the literature increasingly documents that energy poverty and energy access affect women and men differently, and that interventions can either narrow or widen these disparities (Ewim *et al*., 2023b). The review treats gender not as a separate topic but as a dimension cutting across the conditions it examines, on the premise that an account of inclusive transition that overlooks gender would be incomplete. By foregrounding this dimension where the literature addresses it, the review aims to ensure that its synthesis reflects the distributional realities within communities and not only the aggregate outcomes that obscure them (Ewim & Dosunmu, 2025; Ewim *et al*., 2023a; Lilian *et al*., 2024).

The review is attentive to the environmental context of climate justice and energy poverty, since the regions it concerns frequently combine demanding operating

conditions with heightened exposure to climate change, making environmental resilience integral to the durability it examines (Ewim *et al*., 2024). The review reads the literature with attention to how interventions perform under these conditions and to whether their durability accounts for environmental stress (Ewim *et al*., 2021). This attention reflects the review's broader argument that durability cannot be assessed apart from the conditions of deployment, of which the environmental conditions are among the most demanding in the settings the review addresses. This consideration shapes which findings the review treats as most relevant to durability.

A concern running through the review is the lifecycle perspective on cost and affordability, since the literature documents that interventions affordable to build can prove unaffordable to operate and maintain, undermining the durability they were meant to secure (Eyetsemitan *et al*., 2023a). The review treats affordability as a condition extending over the full life of a system rather than as a matter settled at installation, and it reads the literature with attention to whether it accounts for ongoing costs. This lifecycle concern reflects the review's emphasis on durability, and it identifies the neglect of operating and maintenance costs as a recurring limitation in the literature on climate justice and energy poverty (Eyetsemitan *et al*., 2020; Eyetsemitan *et al*., 2021; Basnet *et al*., 2023).

The review also attends to the measurement problem that has limited the integration of social factors into the analysis of climate justice and energy poverty, since the difficulty of quantifying conditions such as intersectional, quantitatively grounded targeting as the agenda for just transition has often been treated as grounds for their exclusion (Eyetsemitan *et al*., 2025). The review surveys how the literature has handled this difficulty, and it treats the development of means to characterize social conditions systematically as a central need (Eyetsemitan *et al*., 2023b). This concern with measurement reflects the review's broader argument that the field's difficulty with social factors is methodological rather than evidence of their unimportance, and it anticipates the conceptual directions the review proposes. The review carries this premise into the critical assessment it develops later (Liadi, 2025b; Lilian *et al*., 2025). (Adelanwa *et al*., 2024b).

It is useful to state what a review of this kind can and cannot achieve, since its contribution lies in synthesis and interpretation rather than in the generation of new data (Eyetsemitan *et al*., 2024b). By drawing together a literature on climate justice and energy poverty that has developed across several traditions, the review aims to reveal patterns, tensions, and gaps that are not visible from within any single study, and to advance a reading of what the literature collectively implies. Its value is to be judged by the coherence and usefulness of the account it constructs, and the review is explicit that the integration it offers involves interpretive judgment, which it sets out transparently so that readers can assess the synthesis on its merits (Eyetsemitan *et al*., 2022; Eyetsemitan *et al*., 2024a).

The review proceeds from the observation that the literature on climate justice and energy poverty contains a recurring disjunction between the criteria emphasized in research and the criteria that determine outcomes in deployment (Hamdan *et al*., 2023). Studies tend to foreground technical performance and cost, while field experience points to durability and inclusion as the decisive considerations, and the review treats this disjunction as a central object of analysis. By tracing how it arises and what it implies, the review builds toward an argument that the field's prevailing criteria are too narrow, and that an integrated account attentive to the social determinants of durability is needed to close the gap between what is studied and what matters (Fawole *et al*., 2023; Guerrero *et al*., 2013).

2. Scope and Review Approach

The review covers theoretical and empirical literature on intersectionality as applied to energy poverty, climate justice, and energy program evaluation, published through 2025. Search terms combined intersectionality and its conceptual synonyms with energy poverty, energy access, climate policy, and program evaluation, yielding a broad initial corpus subsequently narrowed by relevance screening. The review also draws on literature from adjacent fields, including health disparities research, where intersectional methods are more developed, and housing policy research, where regressive effects of universal programs have been extensively documented (Liadi, 2025b; Basnet *et al*., 2024).

Empirical evidence quality varies substantially across the reviewed literature. Studies using individual-level microdata with explicit distributional analysis receive the strongest evidence ratings. Studies relying on aggregate administrative data with limited ability to distinguish outcomes across social categories receive moderate ratings. Qualitative studies documenting lived experiences of multiply disadvantaged households without quantitative distributional estimates receive lower ratings for generalizability while providing essential descriptive richness. The review synthesizes across these evidence quality levels, clearly signaling where conclusions rest on stronger versus weaker evidentiary foundations.

The review is organized around the question of how intersecting social categories shape both energy poverty exposure and access to programs designed to address it. This framing differs from standard distributional analysis in two ways: it attends to the interaction of multiple social categories rather than treating each separately, and it analyzes access barriers as well as outcome distributions, recognizing that programs may formally be available to all while being practically inaccessible to the most disadvantaged. The access barrier dimension is particularly important for evaluating why universal programs fail to reach the most vulnerable even when eligibility criteria are formally inclusive (Lilian *et al*., 2020).

Geographic scope of the reviewed literature is broader than most energy reviews, intentionally including evidence from sub-Saharan Africa, South Asia, and Latin America alongside the OECD-country evidence that dominates energy poverty scholarship. This breadth is necessary because intersectionality operates differently across different institutional, cultural, and structural contexts: the intersection of gender and poverty in energy access in rural sub-Saharan Africa produces different vulnerability patterns than the intersection of race and income in urban energy poverty in the United States, and a review that addresses only one context will miss the contextual specificity of intersectional dynamics. (Liadi, 2024d).

The scope of this review encompasses the scholarship bearing on climate justice and energy poverty across the engineering, economic, development, and energy-justice

literatures, selected and organized so as to bring these traditions into dialogue rather than to catalogue them separately (IEEFA, 2024). The review approach is interpretive and synthetic: rather than enumerating studies, it identifies the themes that recur across them, the assumptions that underpin them, and the gaps that separate them, with the aim of constructing an integrated account. This approach is suited to a field whose central difficulty is precisely the separation of its constituent literatures, and it reflects the review's purpose, which is to clarify and reframe rather than to measure (Hichri *et al*., 2024; Idoko *et al*., 2023). (Liadi, 2023b).

In organizing the literature, the review distinguishes between work that addresses the technical dimensions of climate justice and energy poverty and work that addresses its social and institutional dimensions, while treating this distinction as a convenience to be transcended rather than a fundamental division (International Energy Agency, n.d.). The two bodies of work are read against one another throughout, on the premise that their separation is the source of the field's central limitation. The review pays particular attention to studies that attempt to bridge the divide, since these point toward the integrated approach it advocates, and it treats the relative scarcity and the limitations of such studies as evidence of the gap it seeks to characterize (Ikemba *et al*., 2024; International Energy Agency, 2023; Adelanwa *et al*., 2023b).

The review approach also attends explicitly to the conditions under which findings were obtained, distinguishing results drawn from controlled or simulated settings from those grounded in field experience, since this distinction bears directly on the external validity of the conclusions (Kou *et al*., 2024). By foregrounding the realism of the conditions behind each strand of work, the review is able to assess not only what the literature claims but how far those claims are likely to hold in the resource-constrained settings that are its concern. This attention to conditions is a deliberate feature of the approach, reflecting the review's broader argument that the value of a finding cannot be assessed apart from the context in which it was produced within climate justice and energy poverty (Jalal *et al*., 2024; Jessel *et al*., 2019).

A further aspect of the review approach concerns its synthetic rather than enumerative character, since the aim is not to provide an exhaustive catalogue of studies but to construct an integrated interpretation of what the literature, taken together, reveals about climate justice and energy poverty (Liu *et al*., 2014). This approach involves identifying the assumptions, themes, and gaps that characterize the field, and reading individual contributions in light of the larger picture they collectively compose. It is suited to the review's purpose, which is to clarify and reframe a fragmented body of work, and it reflects the judgment that the field's central need is not more catalogues of what has been done but a coherent account of what it all amounts to and where it must go next (Liao *et al*., 2023; Lilian *et al*., 2024).

An additional aspect of the review approach concerns the breadth of literatures it brings into dialogue, since understanding climate justice and energy poverty as a socio-technical concern requires drawing on engineering, economics, development studies, and energy justice, among others (Mbonu *et al*., 2020). The review treats this breadth as necessary rather than incidental, on the premise that the determinants of durability span all of these fields and cannot be apprehended from within any one. Bringing such varied literatures into a single synthesis is demanding, but the review argues that it is precisely the integration of these perspectives that the field most needs, and that the value of the review lies in the connections it draws across them (Mbasso, 2025; Mbonu *et al*., 2018). (Liadi, 2024a).

The review approach is also explicitly interpretive, in that it does not merely report what the literature contains but advances a reading of what it collectively reveals about climate justice and energy poverty (Michael & Ogunsola, 2021b). This interpretive stance is appropriate to the review's purpose, which is to reframe a fragmented field rather than to catalogue it, and it is reflected in the organization of the synthesis around themes and gaps rather than around individual studies. The review is transparent that this involves judgment, and it sets out the reasoning behind its interpretation so that readers can assess it, in keeping with the standards of rigor appropriate to a conceptual contribution (Mbonu *et al*., 2022; Michael & Ogunsola, 2021a).

The review approach is interpretive and synthetic rather than enumerative, aiming to construct a coherent account of what the literature collectively reveals about climate justice and energy poverty rather than to catalogue individual studies (Michael & Ogunsola, 2022a). This approach is suited to a field whose central need is integration, and it involves identifying the themes, assumptions, and gaps that characterize the literature as a whole (Michael & Ogunsola, 2021c). The review is transparent that this involves judgment, and it sets out its reasoning so that readers can assess the interpretation it advances, in keeping with the standards appropriate to a conceptual contribution. This aspect of the approach reflects the review's purpose of integration rather than enumeration (Anene & Clement, 2024).

The scope deliberately spans several literatures, including engineering, economics, development studies, and energy justice, on the premise that the determinants of durability in climate justice and energy poverty cut across all of them and cannot be apprehended from within any one (Michael & Ogunsola, 2023a). Bringing such varied bodies of work into a single synthesis is demanding, but the review treats this breadth as necessary rather than incidental, arguing that the integration of these perspectives is precisely what the field most needs and what gives the review its value (Michael & Ogunsola, 2022b). The review adopts this aspect of its approach in service of the integrated account it seeks to construct. This element of the approach shapes which findings the review treats as relevant to durability.

The review approach attends explicitly to the conditions under which findings were obtained, distinguishing results from controlled or simulated settings from those grounded in field experience, since this distinction bears on the external validity of conclusions (Michael & Ogunsola, 2024a). By foregrounding the realism of the conditions behind each strand of work, the review assesses not only what the literature claims but how far those claims are likely to hold in the resource-constrained settings that are its concern, reflecting its broader argument that a finding's value cannot be judged apart from its context in climate justice and energy poverty. In view of this, the review organizes its synthesis around themes and arguments rather than individual studies (Michael & Ogunsola, 2023b; Michael & Ogunsola, 2023c).

A further aspect of the review approach concerns its treatment of disciplinary boundaries, which it crosses deliberately on the premise that the determinants of durability in climate justice and energy poverty do not respect the divisions between engineering, economics, and social science (Michael & Ogunsola, 2024c). The review reads across these boundaries throughout, treating their separation as a feature of the field's organization to be overcome rather than a natural division of the subject (Michael & Ogunsola, 2024b). This cross-disciplinary scope is demanding, requiring engagement with literatures that employ different vocabularies and methods, but the review treats it as essential to the integrated account it seeks to construct. This aspect of the approach reflects the review's conviction that a synthesis should serve the improvement of practice.

The review approach also involves explicit attention to the assumptions underlying the works it surveys, since the review's central argument concerns the consequences of assumptions that idealize the conditions of deployment (Michael & Ogunsola, 2025b). By foregrounding these assumptions, the review is able to assess not only what the literature claims but the conditions under which its claims hold, which bears directly on their relevance to the resource-dependent settings of concern (Michael & Ogunsola, 2025a). This attention to assumptions is a deliberate feature of the approach, reflecting the review's broader argument that the value of a finding cannot be assessed apart from the conditions it presupposes. This aspect of the approach reflects the review's purpose of integration over enumeration.

A further aspect of the review approach concerns its orientation toward the construction of an argument rather than the compilation of a survey, since the review advances a thesis about the interdependence of technical and social factors in climate justice and energy poverty and organizes its treatment of the literature in support of that thesis (Michael & Ogunsola, 2019b). This argumentative orientation distinguishes the review from a neutral catalogue, and the review is transparent about it, setting out its thesis and the reasoning behind it so that readers can assess the interpretation it offers. The approach reflects the review's purpose, which is to reframe a field rather than merely to describe it (Michael & Ogunsola, 2025c; Michael & Ogunsola, 2019a; Adelanwa *et al*., 2024a).

The review approach attends, finally, to the relationship between the literature and the practical concerns of the settings in which climate justice and energy poverty operates, reading scholarship with attention to its bearing on the durability and inclusiveness of real interventions (Muhtadi *et al*., 2021). This practical orientation shapes which themes the review treats as central and which gaps it regards as most consequential, anchoring the synthesis in the outcomes that matter for the populations served. The approach reflects the review's conviction that a synthesis of the literature should ultimately serve the improvement of practice, and it orients the review toward the conditions that bear on real-world outcomes (Michael & Ogunsola, 2025d; Middlemiss, 2022).

A related aspect of the review approach concerns its attention to lifecycle considerations, since the review reads the literature with attention to whether it accounts for the costs and conditions of operation over the full life of a system rather than only at installation (Nnaji *et al*., 2020). This attention reflects the review's emphasis on durability, and it shapes its assessment of which findings are relevant to the sustained performance the review treats as central. The approach thus distinguishes studies that consider the working life of interventions from those confined to their deployment, on the reasoning that durability is determined over time rather than at the moment of commissioning in climate justice and energy poverty (Mutambatsere, 2022; Nnaji *et al*., 2019; Basnet *et al*., 2023a).

The review approach also attends to the distributional dimensions of the literature, reading studies with attention to whether they address how benefits and burdens fall within as well as between communities, including along lines of gender (Ntuli *et al*., 2024). This attention reflects the review's treatment of distribution as encompassing intra-community differences, and it shapes its assessment of whether the literature addresses the disparities that determine genuine inclusion (Ntuli *et al*., 2022). The approach thus foregrounds distributional considerations that aggregate analyses obscure, in keeping with the review's broader concern with the inclusiveness of interventions in climate justice and energy poverty. The review adopts this in service of the integrated account it seeks to construct. (Liadi, 2024c).

A further aspect of the review approach concerns its attention to environmental conditions, since the review reads the literature with attention to whether it accounts for the demanding and changing conditions under which systems in the regions of concern must operate (Obogo *et al*., 2020b). This attention reflects the review's argument that durability cannot be assessed apart from the conditions of deployment, and it shapes its assessment of the reliability of findings about whether interventions endure. The approach thus distinguishes studies attentive to environmental resilience from those that assume favorable conditions, in keeping with the review's emphasis on durability under realistic conditions in climate justice and energy poverty (Ntuli *et al*., 2021; Obogo *et al*., 2020a).

A concluding note on the review approach is that it has been guided throughout by the conviction that the value of a synthesis lies in the connections it draws across a fragmented literature, rather than in the comprehensiveness of its coverage of any single strand (Obogo *et al*., 2024a). The review has accordingly prioritized the integration of perspectives over the exhaustive treatment of any one, on the premise that the central need of climate justice and energy poverty is the bringing together of knowledge that has developed in isolation. This note clarifies the basis on which the review has selected and organized the literature, and it situates the synthesis that follows as an exercise in integration rather than enumeration (Obogo *et al*., 2020c; Obogo *et al*., 2021a; Basnet *et al*., 2024).

A further aspect of the review approach concerns the principles by which it has selected and weighed the literature, since a synthesis of this kind must decide which work to foreground and how to assess competing findings (Obogo *et al*., 2021b). The review has prioritized work that bears on the durability and inclusiveness of interventions in resource-dependent settings, and it has weighed findings according to the realism of the conditions under which they were obtained, on the reasoning that relevance to the settings of concern is the appropriate criterion. The review is transparent about these principles so that its synthesis can be assessed, and they reflect its broader purpose of constructing

an account useful to practice in climate justice and energy poverty (Obogo *et al*., 2024b; Obogo *et al*., 2023).

The review approach also involves a deliberate orientation toward the construction of an argument rather than the neutral compilation of a survey, since the review advances a thesis about the interdependence of technical and social factors and organizes its treatment of the literature in support of that thesis (Obogo *et al*., 2019a). This argumentative orientation is appropriate to the review's purpose of reframing a fragmented field, and the review sets out its thesis and reasoning explicitly so that readers can evaluate them. For climate justice and energy poverty, the approach reflects the conviction that the field's central need is not another catalogue of what has been done but a coherent account of what it amounts to and where it must go (Obogo *et al*., 2022; Obogo *et al*., 2024c).

3. Thematic Synthesis: Technical Dimensions

The technical dimensions of intersectional exclusion from energy programs concern the physical and technological characteristics that determine who can access program benefits. Rooftop solar programs provide the clearest example: the benefit mechanism requires a suitable rooftop, which is a function of housing tenure, housing type, and physical structure that systematically excludes renters, apartment dwellers, and households in housing with poor solar exposure. These exclusions correlate with income, race, and immigration status in ways that produce regressive distributions even without any deliberate discriminatory intent. The technical access barrier is not merely a design detail but a structural filter that sorts beneficiaries by social category.

Building energy efficiency programs exhibit similar technical access barriers rooted in housing stock characteristics. Energy efficiency retrofits require structural improvements that are most cost-effective in owner-occupied, single-family homes in adequate structural condition. Renters face a split incentive problem in which they bear energy costs but landlords control structural investment decisions. Households in multifamily buildings face collective action problems in coordinating building-wide improvements. Households in severely dilapidated housing face structural deficiencies that must be addressed before energy efficiency improvements are feasible. Each of these barriers is distributed across the population in ways that correlate with income, race, and housing tenure, producing systematic exclusion of the most energy-vulnerable households.

Electric vehicle programs, whether purchase subsidies or charging infrastructure investments, exhibit strong regressive patterns documented across multiple country contexts. Purchase subsidies are most valuable to households with sufficient income to purchase a vehicle, sufficient credit access to finance a purchase, and a housing situation that allows home charging. Low-income, minority, and renter households meet these conditions at lower rates than the general population, and charging infrastructure investment has been concentrated in higher-income and majority-white communities in contexts where it has been studied. The technical requirements of electric vehicle adoption, vehicle ownership, credit access, and home charging, function as a social filter that channels public subsidy toward higher-income and more privileged households (Dada *et al*., 2021; Isiekwu *et al*., 2021).

Grid infrastructure investment decisions, including the sequencing of grid extension, reliability improvement, and smart grid technology deployment, have distributional consequences that technical planning processes often do not make explicit. Reliability improvements tend to flow first to commercial districts and higher-income residential areas where the economic costs of outages are highest in conventional cost-benefit calculations. Smart grid technology investments, which provide the infrastructure for demand response and time-of-use pricing, are deployed first in areas with sufficient grid modernization to support them, which again correlates with prior investment patterns favoring higher-income areas. The cumulative effect of these technical sequencing decisions is to concentrate energy system innovation in already-advantaged areas while perpetuating service quality gaps in disadvantaged ones.

Synthesizing the technical literature on climate justice and energy poverty reveals a field that has made substantial progress in capability while remaining comparatively silent on the conditions under which that capability is realized in deployment (Obogo *et al*., 2025b). Across the studies reviewed, performance is most often reported under assumptions of reliable infrastructure, adequate maintenance, and stable operation, and the reported frontiers are correspondingly optimistic relative to field experience in resource-constrained settings. This pattern is not a criticism of individual studies, which are typically rigorous within their own terms, but an observation about the literature as a whole, namely that its dominant framing tends to abstract away precisely the conditions that determine whether technical promise translates into durable service (Obogo *et al*., 2019b; Obogo *et al*., 2025a).

A second theme in the technical synthesis is the recurring tension between optimization for peak performance and design for robustness under adverse conditions, a tension that the literature acknowledges but rarely resolves in favor of the latter (Odejobi *et al*., 2025). Studies oriented toward maximal efficiency tend to assume the supporting conditions that resource-dependent regions cannot guarantee, while the smaller body of work oriented toward robustness accepts lower nominal performance in exchange for resilience. Reading these strands together suggests that the appropriate balance is context-dependent and that the field would benefit from framing the choice explicitly as a design decision with social as well as technical consequences, rather than treating peak performance as the default objective (Obogo *et al*., 2019c; Obogo *et al*., 2021c; Adelanwa *et al*., 2024b).

A third theme is the growing technical sophistication of monitoring, control, and analytics, which has made it increasingly feasible to observe and manage systems in detail, yet which also raises the capability and connectivity required to operate them (Okonkwo *et al*., 2024a). The technical literature documents impressive gains in what such tools can do, but it less often examines whether the conditions for using them, including skilled staff, reliable connectivity, and sustained budgets, are present in the settings that would benefit most. This synthesis therefore reads the advances alongside their preconditions, arguing that within climate justice and energy poverty the value of a technical capability cannot be assessed apart from the conditions required to sustain it (OECD, n.d.; Ogunwole *et al*., 2021; Adelanwa *et al*., 2024b; Basnet *et al*., 2023a).

A complementary theme in the technical synthesis concerns

the assumptions about supporting infrastructure that pervade the literature, including reliable communication, stable power quality, and continuous availability of skilled maintenance, none of which can be taken for granted in the settings that are the concern of this review (Okonkwo *et al*., 2024d). Where studies make these assumptions explicit, their conclusions can be appropriately qualified, but where the assumptions remain implicit, the reported performance may mislead. The synthesis therefore reads the technical literature with particular attention to its assumptions, treating the realism of those assumptions as a key determinant of how far a finding is likely to hold in the resource-constrained contexts in which climate justice and energy poverty must actually operate (Okonkwo *et al*., 2024b; Okonkwo *et al*., 2024c).

A further consideration in the technical synthesis is the degree to which reported advances have been validated under conditions resembling those of resource-dependent regions, as opposed to controlled or well-resourced settings (Okonkwo *et al*., 2020). The synthesis finds that validation under realistic conditions is comparatively scarce, which limits confidence that reported performance will be realized in the field. This observation reinforces the review's broader argument that the value of a technical capability cannot be assessed apart from the conditions required to realize it, and it identifies the scarcity of field validation in representative settings as a significant limitation of the current technical literature (Okonkwo *et al*., 2024e; Okonkwo *et al*., 2024f).

Reading the technical literature as a whole, the synthesis observes a tendency to treat the supporting conditions for performance as external to the engineering problem, with the result that those conditions are neither analyzed nor designed for within the technical work itself (Okonkwo *et al*., 2023a). This tendency, the synthesis argues, is precisely what leaves the technical literature unable to explain the gap between laboratory promise and field outcome, since the explanation lies in conditions the literature sets aside. The synthesis therefore calls for a technical literature that internalizes the conditions of deployment rather than abstracting them away, which is the direction the conceptual integration it advocates would encourage (Okonkwo *et al*., 2021a; Okonkwo *et al*., 2025).

The technical synthesis emphasizes that capability and dependability are distinct achievements, and that the literature has advanced the former more than the latter in the settings the review addresses (Okonkwo *et al*., 2018a). Dependable performance under adverse, variable, and under-supported conditions remains harder to secure than peak performance under favorable ones, and the synthesis treats this asymmetry as a key feature of the technical literature (Okonkwo *et al*., 2023b). Within this context, it argues that the field's progress should be assessed by dependability in realistic conditions rather than by capability demonstrated under ideal ones. This theme reinforces the synthesis's broader argument about the dependence of performance on the conditions of deployment.

The technical synthesis observes that the literature's treatment of operating conditions is frequently idealized, with the consequence that reported performance reflects what is achievable under assumptions that resource-dependent settings cannot satisfy (Okonkwo *et al*., 2021b). By foregrounding the realism of these assumptions, the synthesis is able to assess how far technical findings are likely to hold in the field, and it consistently finds that the gap between assumed and actual conditions is large enough to qualify many reported results (Okonkwo *et al*., 2018b). This observation anchors the review's broader argument about the dependence of performance on context. The synthesis treats this as evidence that technical capability cannot be assessed apart from its operating context (Oghenemaiga *et al*., 2024).

The technical synthesis notes that advances in capability have often raised the resources required to deploy and operate systems, creating a tension between sophistication and accessibility (Okoye *et al*., 2023). The literature documents impressive gains in what systems can do alongside relatively little attention to whether the conditions for using them are present where they are needed (Okonkwo *et al*., 2019). For problems of this kind, the synthesis treats this tension as central, arguing that a technical advance whose preconditions cannot be met in the target setting offers little to the populations the field is meant to serve. This observation connects the technical literature to the social conditions examined in the following section.

A theme that the technical synthesis brings to the fore is the trade-off between performance and robustness, since designs optimized for maximal output under favorable conditions often prove fragile under the adverse and variable conditions of resource-dependent settings (Onyiriuka *et al*., 2023). The literature documents both ends of this spectrum, but it less often frames the choice between them explicitly as a design decision with social consequences. The synthesis argues that within climate justice and energy poverty this choice should be made deliberately rather than by default, since the appropriate balance depends on conditions that vary across settings and that bear directly on whether a system endures in service (Okwu *et al*., 2021; Olanrewaju *et al*., 2023; Basnet *et al*., 2023a).

The technical synthesis also draws attention to the increasing role of software, data, and connectivity in the systems that constitute climate justice and energy poverty, a development that expands capability while introducing new dependencies (Orikpete *et al*., 2023). The literature documents impressive gains in what data-driven and connected systems can achieve, alongside relatively little examination of whether the conditions for using them, including reliable connectivity and the capacity to manage them, are present in the target settings (Orikpete & Ewim, 2024). The synthesis treats this as a significant theme, since it bears on whether advances in digital capability translate into durable benefit where infrastructure and capacity are limited. Acknowledging this, in the technical literature motivates the integrated approach the review ultimately advocates (Adelanwa *et al*., 2023; Oghenemaiga *et al*., 2024; Adelanwa *et al*., 2023b; Liadi, 2023a; Basnet *et al*., 2023).

A further theme concerns the maturity and reliability of the core technologies underlying climate justice and energy poverty, which the synthesis finds to be well established in many respects while noting that their performance in the field depends heavily on conditions the literature often assumes (Patrick *et al*., 2021). The technologies themselves are, for the most part, capable; what is less settled is how they behave under the maintenance, environmental, and operational conditions of resource-dependent settings. The synthesis treats this gap between demonstrated capability and field behavior as central, since it locates the explanation of many disappointing outcomes not in the technology but in

the conditions surrounding its use (Oyeleye *et al*., 2022; Patrick *et al*., 2020).

The technical synthesis observes that the literature has devoted considerable effort to optimization and comparatively less to the questions of integration and system-level behavior that determine outcomes in practice (Smith, 2017). Studies frequently optimize individual components or functions while giving less attention to how these interact within a complete system operating under realistic conditions (Rajaperumal & Columbus, 2025). In such settings, the synthesis argues that this emphasis has produced detailed knowledge of parts alongside a thinner understanding of wholes, and that system-level behavior under the conditions of deployment warrants greater attention than the optimization-focused literature has given it. This theme illustrates the gap between demonstrated capability and durable field performance in resource-dependent settings (Lilian *et al*., 2020; Adelanwa *et al*., 2024; Adelanwa *et al*., 2024b).

A final theme in the technical synthesis concerns the assumptions about the human and institutional environment that are embedded, often implicitly, in technical designs, including assumptions about who will operate, maintain, and manage a system (U.S. Department of Energy, 2024). The literature tends to treat these as given rather than as conditions to be examined, with the result that designs may presuppose an environment that the target setting does not provide (Solar Electric Light Fund, 2025). The synthesis argues that within climate justice and energy poverty these embedded assumptions deserve explicit scrutiny, since the mismatch between assumed and actual environments is among the more common and consequential sources of failure the literature documents. This theme reinforces the synthesis's argument about the dependence of performance on its context.

A connected theme in the technical synthesis concerns the relationship between technical design and lifecycle cost, since the literature documents that design choices bear heavily on the costs of operation, maintenance, and replacement that determine affordability over time (Wedraogo & Sanni, 2024). Studies that consider only installation cost, the synthesis argues, misjudge the economic sustainability of the systems they evaluate. Applied to this domain, the synthesis treats lifecycle cost as a technical as well as an economic consideration, since the design of a system shapes the burden of sustaining it, and it identifies the neglect of lifecycle considerations as a limitation of much of the technical literature (Uduafemhe *et al*., 2023; Uduafemhe *et al*., 2024; Liadi, 2023c; Lilian *et al*., 2024).

The technical synthesis also examines how designs accommodate the environmental conditions of resource-dependent regions, finding that the literature varies widely in the attention it gives to climatic stress, dust, humidity, and temperature extremes (World Bank, 2024). Designs developed for temperate, well-supported settings frequently underperform under these conditions, and the synthesis treats environmental resilience as a technical dimension that the literature addresses unevenly (Wen *et al*., 2024). On this account, this theme reinforces the synthesis's broader argument that technical performance cannot be assessed apart from the conditions of deployment, of which the environmental conditions are among the most demanding and least uniformly considered. The synthesis treats this as evidence that capability cannot be judged apart from deployment conditions.

A further theme concerns the extent to which technical designs are matched to the capacity available to operate and maintain them, since the synthesis finds that the literature often presupposes a level of technical capability that resource-dependent settings cannot provide (Abolarin *et al*., 2024). Designs requiring expertise or resources beyond what is locally available tend to degrade regardless of their quality, and the synthesis treats the matching of design to capacity as a technical consideration the literature frequently neglects. For climate justice and energy poverty, this theme connects the technical and social dimensions directly, since the sustainability of a technical design depends on the human and institutional capacity to sustain it (World Resources Institute, n.d.; Wustenhagen *et al*., 2007).

A concluding observation from the technical synthesis is that the literature, taken as a whole, describes a set of capabilities whose realization in the field depends on conditions it largely leaves unexamined, so that the gap between what the technologies can do and what they reliably achieve in resource-dependent settings remains incompletely understood (Ahmad *et al*., 2020). The synthesis treats the closing of this gap as a priority for climate justice and energy poverty, since it is in that gap that the difference between technical promise and durable service is determined, and it argues that doing so requires the integration of technical analysis with attention to the conditions of deployment that the technical literature has tended to set aside (Adeyemi, 2024; Agbabiaka *et al*., 2019; Liadi, 2022).

A further dimension of the technical synthesis concerns how the literature treats the relationship between laboratory or simulation results and field performance, since the two frequently diverge in ways that the literature acknowledges but does not always resolve (Akindeji *et al*., 2024). Results obtained under controlled conditions establish what is achievable in principle, while field experience reveals what is achievable under the constraints of resource-dependent settings, and the gap between them is precisely where the conditions governing durability operate. The synthesis treats this gap as a central feature of the technical literature on climate justice and energy poverty, arguing that the realism of the conditions under which a result was obtained should weigh heavily in assessing its relevance to deployment (Ahmed *et al*., 2020; Akindeji & Ewim, 2023).

The technical synthesis also considers how the literature handles the cumulative and interacting effects that arise when technologies are combined into complete systems, finding that component-level analysis predominates over system-level understanding (Ambali *et al*., 2021). Studies frequently characterize the behavior of individual technologies in isolation while giving less attention to the interactions that emerge when they operate together under field conditions. The synthesis argues that this emphasis leaves the field with detailed knowledge of parts alongside a thinner understanding of wholes, and that the behavior of complete systems under realistic conditions warrants greater attention than the prevailing component focus has afforded it (Aliliele *et al*., 2023; Aliliele *et al*., 2025).

4. Thematic Synthesis: Socio-Technical Dimensions

The socio-technical dimensions of intersectional exclusion concern the institutional and social processes through which

program benefits are delivered, claimed, and used. Information barriers are among the most pervasive: universal programs that require households to apply, navigate bureaucratic eligibility processes, and make informed choices among complex options systematically disadvantage households with lower administrative literacy, limited English proficiency, less access to professional advice, and greater time poverty due to multiple employment and caregiving demands. These information barriers are rarely visible in program design discussions but appear consistently in evaluations as explanations for low uptake among intended beneficiaries.

Trust and civic exclusion shape program uptake in ways that intersect with race, immigration status, and prior experiences of institutional discrimination. Households with histories of negative interactions with government programs, or that lack trust in institutions due to immigration status, documentation concerns, or cultural distance from bureaucratic norms, are less likely to engage with universal programs even when formally eligible. These trust barriers cannot be addressed by simplifying application processes alone; they require sustained community engagement, culturally competent outreach through trusted intermediaries, and demonstrable program commitment to serving excluded communities. The socio-technical design of program delivery is as important as the technical design of the benefit mechanism (Oghenemaiga *et al*., 2024).

Gender dynamics within households and communities shape who accesses program benefits and who benefits from energy service improvements within the household. Programs that channel benefits through male household heads, the default in many administrative systems, may not reach women and children whose energy needs differ from those of male adults. Energy access improvements that reduce the burden of biomass collection or cooking time have disproportionate benefits for women and girls who bear primary responsibility for these tasks; programs that ignore this differential impact fail to capture substantial social value and may inadvertently reinforce gendered labor divisions by making existing arrangements slightly more tolerable without transforming the underlying structure.

Disability and health-related dimensions of energy vulnerability receive limited attention in both universal program design and intersectional energy research. Households with members who are dependent on electrically powered medical equipment, who have chronic respiratory conditions worsened by poor home energy quality, or whose mobility limitations reduce their capacity to access program services face energy poverty that is qualitatively different from income-driven vulnerability alone. The interaction of disability with poverty, inadequate housing, and institutional exclusion creates a form of energy vulnerability that is severe, multiply determined, and systematically missed by programs designed around the modal energy-poor household.

Synthesizing the socio-technical literature on climate justice and energy poverty brings into focus a body of evidence that performance in the field is shaped decisively by social and institutional conditions that technical evaluation typically omits (Arumosoye & Obriki, 2020). Across the studies reviewed, the conditions most consistently associated with durable outcomes, including participation, local capacity, governance legitimacy, and procedural fairness, recur with a regularity that suggests they reflect general features of how socio-technical systems behave rather than the idiosyncrasies of particular cases. This review treats that regularity as significant, reading it as evidence for the proposition that social conditions function as determinants of technical outcomes and not merely as context surrounding them (Arumosoye & Obriki, 2018; Arumosoye & Obriki, 2019; Liadi, 2024d).

A central strand of this synthesis concerns intersectional, quantitatively grounded targeting as the agenda for just transition, which appears across the literature as a recurring but inadequately formalized influence on outcomes (Arumosoye & Obriki, 2023). Studies repeatedly identify it as consequential, yet they less often render it in terms that would allow it to enter design and evaluation systematically, with the result that its influence is acknowledged in interpretation but excluded from analysis. This review draws these scattered observations together, arguing that the consistency with which the factor appears across otherwise diverse studies is itself reason to treat it as a first-order variable, and that the field's failure to measure it is a methodological gap rather than evidence of its unimportance (Arumosoye & Obriki, 2021; Arumosoye & Obriki, 2022). These themes and their relationships are mapped in Fig 2.

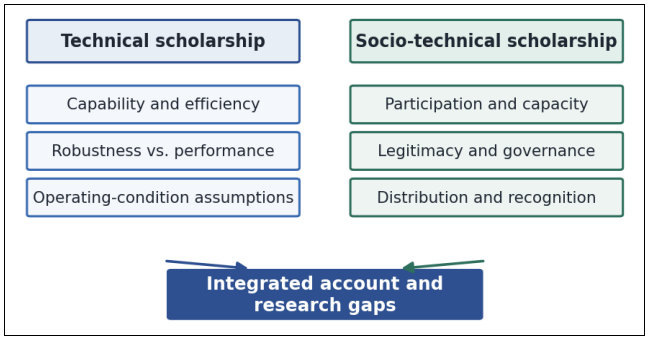

Fig 2: Thematic synthesis of the technical and socio-technical literature toward an integrated account

Another theme in the socio-technical synthesis concerns distribution, since the literature increasingly documents that interventions improving aggregate conditions can nonetheless leave the most marginalized groups no better off, or worse off in relative terms (Babawurun *et al*., 2023). This finding, which recurs across settings and technologies, reframes the question of success from whether an intervention works to for whom it works, and it carries particular weight for regions transitioning away from fossil fuel dependence, where the perceived fairness of the transition will shape its legitimacy. Synthesizing this evidence, the review argues that distributional outcomes must be treated as integral to the evaluation of climate justice and energy poverty rather than as a secondary concern (Arumosoye & Obriki, 2024; Arumosoye *et al*., 2025; Liadi, 2023a).

A final theme in the socio-technical synthesis concerns the question of capacity, which recurs across the literature as a binding condition on durability and which connects the social and technical dimensions directly (Collath, 2021). Studies repeatedly find that systems exceeding the local capacity available to operate, maintain, and govern them tend to degrade regardless of their technical quality, which reframes capacity not as a soft accompaniment to deployment but as a hard precondition for it. The synthesis draws these findings together to argue that within climate

justice and energy poverty the matching of system complexity to local capacity is as consequential as the technical specifications themselves, and that the neglect of this matching helps explain the gap between technical promise and field outcome (Bednar *et al*., 2017; Bhattacharyya *et al*., 2021; Anene & Clement, 2024).

A further strand of the socio-technical synthesis concerns the relationship between distribution and legitimacy, since the literature increasingly connects the perceived fairness of an intervention to the cooperation and acceptance on which its durability depends (Dagodzo & Patrick, 2020). Studies suggest that interventions seen to distribute benefits unfairly struggle to secure the legitimacy that sustained operation requires, even where they perform well technically. The synthesis draws these findings together to argue that distribution and legitimacy are not separate concerns but linked determinants of durability, and that attention to one without the other is unlikely to produce interventions that endure in the settings the review addresses (Dagodzo, 2018a; Dagodzo, 2018b). (Liadi, 2024b).

The socio-technical synthesis also finds growing recognition in the literature that the social dimension of energy provision is itself a matter for design rather than something to be secured after the technical work is complete (Dagodzo & Patrick, 2022). This represents a shift from earlier framings in which social acceptance was treated as an external constraint, toward an understanding in which participation, governance, and distribution are designed deliberately. Within this context, the synthesis treats this shift as significant, since it aligns the social-science literature with the socio-technical perspective the review adopts and points toward the integration of technical and social design that the review ultimately advocates (Dagodzo & Patrick, 2021a; Dagodzo & Patrick, 2021b; Liadi, 2024d).

The socio-technical synthesis emphasizes the consistency with which social conditions appear as determinants of durability across diverse studies, treating that consistency as evidence of underlying regularities rather than coincidence (Dagodzo & Patrick, 2023b). The recurrence of conditions such as participation, capacity, legitimacy, and fairness across settings and technologies suggests that they reflect general features of how socio-technical systems behave, and the synthesis draws them together into a coherent account of the conditions that govern whether interventions in climate justice and energy poverty endure (Dagodzo & Patrick, 2023a). This theme reinforces the synthesis's argument that social conditions function as determinants of durability rather than context. The synthesis treats this as part of the interrelated system of conditions that together govern outcomes.

The socio-technical synthesis foregrounds intersectional, quantitatively grounded targeting as the agenda for just transition as a recurring but under-formalized influence, arguing that its frequent appearance across the literature is reason to treat it as a first-order variable rather than as context (Dagodzo *et al*., 2022). The synthesis observes that the factor is acknowledged in interpretation far more often than it is analyzed, and it treats this gap between recognition and analysis as a methodological shortcoming to be remedied rather than as evidence of unimportance, which is consistent with the review's broader call for the measurement of social conditions (Dagodzo & Patrick, 2025). This observation connects the social literature to the technical considerations examined earlier. Acknowledging this, in the socio-technical literature motivates the integrated evaluation the review advocates (Liadi, 2023b).

The socio-technical synthesis connects the dimensions of distribution, legitimacy, and capacity, arguing that they operate together rather than independently in determining durability (El-Rashidy *et al*., 2025). Interventions that distribute benefits unfairly tend to lack legitimacy, those that exceed local capacity tend to decay, and those that lack legitimacy tend to forfeit the cooperation that sustained operation requires (Dioha *et al*., 2021). By drawing these connections, the synthesis builds an integrated account of the social determinants of durability in climate justice and energy poverty rather than a list of separate factors. This theme illustrates why an account of durability confined to technical factors is incomplete. This theme reinforces the synthesis's treatment of social conditions as determinants rather than context (Anene & Clement, 2024).

A theme the socio-technical synthesis brings forward is the role of ownership in conditioning durability, since the literature repeatedly associates community ownership and control with interventions that endure (Ewim *et al*., 2023a). Ownership appears to shape the incentives, stewardship, and legitimacy on which sustained operation depends, and its absence is associated with the neglect that undermines technically sound systems (Ewim & Dosunmu, 2025). The synthesis draws these findings together to argue that within climate justice and energy poverty the structure of ownership is not an administrative detail but a determinant of outcomes, one that the social literature has consistently identified even where it has not formalized it. The synthesis reads this as one element of an interrelated system of conditions governing durability.

The socio-technical synthesis also foregrounds the relationship between affordability and sustained use, since the literature documents that systems which are nominally available but not genuinely affordable for the populations they serve tend to be underused or abandoned (Ewim *et al*., 2021). Affordability emerges not as a single threshold but as a distribution, with interventions reaching average households sometimes failing to reach the poorest (Ewim *et al*., 2023b). For problems of this kind, the synthesis treats affordability as a social condition bearing directly on durability, and it argues that aggregate measures of cost obscure the distributional realities that determine whether an intervention is actually used and sustained. This observation connects the social scholarship to the technical considerations examined earlier.

A further theme concerns the importance of intermediary institutions, including cooperatives, local organizations, and community bodies, which the literature associates with the governance and capacity that condition durability (Eyetsemitan *et al*., 2020). These institutions appear to mediate between technologies and the populations they serve, providing the structures through which systems are governed and sustained (Ewim *et al*., 2024). The synthesis argues that within climate justice and energy poverty the presence and strength of such intermediary institutions is a recurring determinant of outcomes, and that interventions which neglect or bypass them tend to lack the institutional foundation on which durable operation depends. Acknowledging this, motivates the systematic measurement of social conditions the review calls for.

The socio-technical synthesis draws attention to the dynamic and reciprocal relationship between trust and performance,

since the literature suggests that trust supports the cooperation that improves performance, while demonstrated performance in turn reinforces trust (Eyetsemitan *et al*., 2023a). This reciprocal relationship implies that early experience can set a system on a trajectory of either reinforcement or erosion, depending on whether initial performance and governance build or undermine confidence (Eyetsemitan *et al*., 2021). In such settings, the synthesis treats this dynamic as important, since it explains why interventions with similar technical characteristics can diverge over time along paths shaped by their social conditions. The synthesis treats this theme as evidence that durability has irreducibly social determinants (Liadi, 2023c; Liadi, 2024b).

A final theme in the socio-technical synthesis concerns recognition, namely the extent to which interventions acknowledge and accommodate the circumstances, knowledge, and priorities of the communities they serve (Eyetsemitan *et al*., 2025). The literature, particularly the justice-oriented strand, associates recognition with the legitimacy and acceptance that condition durability, and its absence with the rejection of interventions perceived as imposed (Eyetsemitan *et al*., 2023b). The synthesis argues that within climate justice and energy poverty recognition is a social condition bearing on outcomes alongside distribution and procedure, and that attending to it is part of designing interventions that communities accept and sustain rather than resist. This theme illustrates why an account confined to technical factors remains incomplete.

An additional theme in the socio-technical synthesis concerns the gendered distribution of the benefits and burdens of energy interventions, since the literature documents that access and its absence affect women and men differently within the same community (Eyetsemitan *et al*., 2024b). This theme establishes that distribution operates within communities and not only between them, and the synthesis treats gender as a dimension of the distributional conditions governing durability and equity. Applied to this domain, the synthesis draws this literature together to argue that an account of inclusive outcomes must attend to intra-community disparities, which aggregate measures obscure and which bear on whether interventions are genuinely inclusive (Eyetsemitan *et al*., 2022; Eyetsemitan *et al*., 2024a).

The socio-technical synthesis also examines the relationship between affordability and durability over time, since the literature documents that interventions affordable at installation can become unaffordable to sustain, undermining the use on which durability depends (Hamdan *et al*., 2023). Affordability emerges as a condition extending over the life of a system rather than a threshold met once, and the synthesis treats it as a social and economic determinant of durable operation. On this account, this theme reinforces the synthesis's argument that the conditions governing durability are dynamic, and that an account confined to the moment of deployment will misjudge whether interventions endure (Fawole *et al*., 2023; Guerrero *et al*., 2013).

A further theme concerns the role of local knowledge and priorities in conditioning the success of interventions, since the literature documents that systems designed without regard to the knowledge and circumstances of the communities they serve frequently encounter resistance or neglect (IEEFA, 2024). This theme establishes recognition of local knowledge as a social condition bearing on durability, and the synthesis treats it as part of the participation and legitimacy that the evidence links to sustained operation. For climate justice and energy poverty, the synthesis argues that attending to local knowledge is not a courtesy but a condition of the acceptance and stewardship on which durable interventions depend (Hichri *et al*., 2024; Idoko *et al*., 2023).

A concluding observation from the socio-technical synthesis is that the social conditions it has surveyed, including participation, capacity, legitimacy, distribution, and recognition, are best understood not as a list of separate factors but as an interrelated system whose combined state governs durability in climate justice and energy poverty (International Energy Agency, n.d.). The synthesis argues that the literature, while documenting each condition, has been slower to examine how they interact and reinforce one another, and it treats the understanding of these interactions as a priority, since it is the configuration of social conditions as a whole, rather than any single factor, that determines whether interventions endure in the settings of concern (Ikemba *et al*., 2024; International Energy Agency, 2023; Liadi, 2024a).

Another aspect of the socio-technical synthesis concerns the temporal character of the conditions it examines, since the literature increasingly recognizes that participation, capacity, trust, and legitimacy evolve over the life of a system rather than being fixed at its deployment (Kou *et al*., 2024). Studies that assess these conditions at a single moment, typically near commissioning, risk misjudging the trajectory along which an intervention will succeed or fail, since early conditions can be reinforced or eroded by subsequent operation and governance. The synthesis draws these observations together to argue that within climate justice and energy poverty the durability of an intervention is shaped by how its social conditions develop over time, a dynamic that static assessment cannot capture (Jalal *et al*., 2024; Jessel *et al*., 2019; Adelanwa *et al*., 2023a).

The socio-technical synthesis also brings together the literature's treatment of the relationship between local context and the transferability of findings, since interventions that succeed in one setting frequently disappoint in another despite technical similarity (Liu *et al*., 2014). This pattern, recurring across the literature, points to the influence of context-specific social and institutional conditions that conventional analysis leaves unmeasured. The synthesis treats the explanation of this pattern as central, arguing that within climate justice and energy poverty the divergence of outcomes across similar interventions is evidence for the causal significance of social conditions, and that understanding it requires attention to the context-specific factors that determine how a given intervention will fare (Liao *et al*., 2023; Lilian *et al*., 2024).

5. Critical and Comparative Assessment

Comparative assessment of universal programs across country contexts reveals that regressive distribution is robust to variation in program design details but sensitive to the presence of targeted complementary interventions. Countries that pair universal baseline programs with well-designed targeted complements, including means-tested energy assistance, targeted weatherization programs, and community outreach infrastructure for excluded populations, achieve substantially more equitable distributional outcomes

than countries relying on universal programs alone. The evidence base for this comparison is strongest in OECD contexts and weaker in low-income country contexts, where evaluation infrastructure is less developed.

The intersectional framework adds analytical value over standard distributional analysis by revealing interaction effects that single-axis analysis misses. Low-income white households and low-income minority households in the same income bracket exhibit different program uptake rates, different energy poverty severity, and different responses to identical interventions in contexts where this comparison has been examined. The income similarity masks important differences rooted in housing tenure, neighborhood location, institutional trust, and access to social networks that provide information and assistance with program navigation. Intersectional analysis that incorporates these additional dimensions produces more accurate targeting predictions and more effective program designs.

The critique of universalism advanced in this review requires careful qualification to avoid misappropriation by interests hostile to universal programs for other reasons. Universal programs provide important political coalitions, administrative efficiency, and public goods dimensions that targeted programs cannot replicate. The argument is complementarity, not substitution: universal programs should be maintained and expanded while targeted complements address the populations they structurally fail to reach. Framing the critique as replacement of universalism with targeting misses the complementarity logic and risks collapsing the political coalition that supports public energy investment. (Adelanwa *et al*., 2023a).

The administrative capacity required for effective intersectional targeting is itself unevenly distributed, creating a meta-level intersectionality problem: the jurisdictions with greatest need for targeted complements, those serving the most multiply disadvantaged populations, often have the weakest administrative capacity to design and implement them. Federal or national funding sources that provide both financial resources and technical assistance for program design can partially address this capacity gap, but they require sustained commitment and institutional infrastructure that is not universally available. This administrative challenge is not a reason to abandon intersectional targeting but it is a reason to invest in administrative capacity as a prerequisite for effective implementation.

A critical assessment of the literature on climate justice and energy poverty reveals a field that optimizes heavily for technical metrics and lightly for the conditions that govern durability, with the result that its dominant framing tends to overstate what interventions will achieve in deployment (Mbonu *et al*., 2020). The assessment is not that the technical work is mistaken within its own terms, but that the terms themselves are too narrow, abstracting away the social and institutional conditions that field experience shows to be decisive. Reading the literature critically therefore means reading its silences as well as its claims, and noting that the conditions most consistently associated with failure are precisely those that the prevailing methods do not represent (Mbasso, 2025; Mbonu *et al*., 2018).

The assessment also exposes a divergence between studies validated only in simulation or controlled conditions and those grounded in field experience, with the former tending to favor approaches that the latter find fragile in practice (Michael & Ogunsola, 2021b). This divergence is itself informative, since it signals an external-validity gap in which conclusions drawn under idealized assumptions fail to hold where those assumptions break down. The implication is that the weight given to a finding should depend on the realism of the conditions under which it was obtained, and that the field would benefit from greater caution in generalizing from controlled settings to the resource-constrained contexts that are the subject of this review (Mbonu *et al*., 2022; Michael & Ogunsola, 2021a).

Comparatively, the assessment finds that the social-science and justice-oriented literature, while rich in insight about the conditions governing durability, has supplied fewer of the tools needed to bring those conditions into design, leaving its insights at the level of interpretation rather than analysis (Michael & Ogunsola, 2022b). The technical and social literatures thus exhibit complementary deficiencies: the former measures precisely but omits what matters most for durability, while the latter identifies what matters but measures it least. This complementarity is the crux of the review's critical assessment, and it motivates the call, developed in the following section, for a conceptual integration that draws on the strengths of each to remedy the weaknesses of the other within climate justice and energy poverty (Michael & Ogunsola, 2021c; Michael & Ogunsola, 2022a; Liadi, 2024b).

A further element of the critical assessment concerns the treatment of distribution in the literature, which tends to report performance and cost in aggregate terms while giving comparatively little attention to how benefits and burdens fall across groups (Michael & Ogunsola, 2023c). This aggregate framing, the assessment argues, obscures exactly the distributional outcomes that determine whether an intervention is inclusive, and it can present as a success an intervention that improves average conditions while leaving the most marginalized unreached. The critical implication is that evaluation must attend to distribution as a primary outcome rather than a secondary one, and that the field's prevailing metrics are inadequate to the goal of inclusive transition that the review takes as its standard (Michael & Ogunsola, 2023a; Michael & Ogunsola, 2023b).

A related element of the critical assessment concerns the limited attention the literature has given to the conditions under which findings transfer across settings, an omission that is consequential given the diversity of the contexts in which climate justice and energy poverty is deployed (Michael & Ogunsola, 2024c). The assessment argues that without explicit attention to transferability, the field accumulates findings whose applicability beyond their original settings is uncertain, which limits their cumulative value. For the review, this points to the need for approaches that distinguish the general from the context-specific, and it forms part of the case for the conceptual integration the review proposes as a remedy for the fragmentation it documents (Michael & Ogunsola, 2024a; Michael & Ogunsola, 2024b).

Assessing the literature comparatively, the review finds that the technical and social bodies of work exhibit complementary strengths and weaknesses, with the former offering precision on a narrow set of variables and the latter offering breadth on the conditions that govern durability but with less analytical structure (Michael & Ogunsola, 2025c). This complementarity is the crux of the critical assessment, since it implies that neither literature can remedy its own

deficiencies from within, and that progress requires combining their strengths. Within this context, the assessment thus motivates the integrated approach the review advocates, in which the precision of the technical tradition is brought to bear on the conditions the social tradition identifies as decisive (Michael & Ogunsola, 2025a; Michael & Ogunsola, 2025b).

The critical assessment finds that the literature's dominant metrics, oriented toward technical performance and unit cost, are inadequate to the goal of inclusive transition, since they omit the durability, inclusion, and legitimacy that the evidence identifies as decisive (Michael & Ogunsola, 2019b). By optimizing for what is easily measured rather than for what matters most, the field has, the assessment argues, steered design away from the conditions that govern whether interventions endure (Michael & Ogunsola, 2019a). For problems of this kind, this points to the need for broader evaluation criteria as a precondition for design that serves the populations interventions are meant to reach. This element of the assessment forms part of the case for the conceptual integration the review advocates.

The critical assessment identifies an external-validity gap between studies conducted under controlled or simulated conditions and those grounded in field experience, with the former tending to favor approaches the latter find fragile (Middlemiss, 2022). This gap, the assessment argues, means that the weight given to a finding should depend on the realism of the conditions under which it was obtained (Michael & Ogunsola, 2025d). In such settings, it counsels caution in generalizing from idealized settings to the resource-constrained contexts the review addresses, and it forms part of the case for an integrated approach grounded in realistic conditions. The assessment treats this deficiency as an expression of the separation of technical from social analysis (Liadi, 2024c).

The critical assessment observes that the field's fragmentation imposes a real cost, since insights generated in one subfield often fail to reach others where they would be useful, and since the absence of a shared framework prevents the accumulation of integrated knowledge (Nnaji *et al*., 2019). The assessment treats this fragmentation not as a minor inconvenience but as a central obstacle to progress, and it argues that overcoming it requires the kind of conceptual integration the review advocates, in which technical precision is brought to bear on the social conditions that govern durability in climate justice and energy poverty. This observation connects the critical assessment to the conceptual directions the review proposes (Muhtadi *et al*., 2021; Mutambatsere, 2022).

A further element of the critical assessment concerns the tendency of the literature to report success at deployment rather than durability over time, since studies frequently assess interventions when they are new and external support is present rather than over the years in which durability is actually tested (Ntuli *et al*., 2024). This temporal bias, the assessment argues, leads the literature to overstate success and to underrepresent the conditions that govern whether interventions endure. Applied to this domain, the critical implication is that the field's evidence base is weighted toward the moment of commissioning, and that understanding durability requires longitudinal evidence the literature has been slow to provide (Nnaji *et al*., 2020; Ntuli *et al*., 2022).

The critical assessment also examines the extent to which the literature attends to the perspectives and priorities of the communities that interventions are meant to serve, finding that these are often underrepresented relative to technical and economic considerations (Obogo *et al*., 2020b). Where community perspectives are absent, the assessment argues, the literature risks misjudging what counts as success and overlooking the recognition that conditions durability. On this account, this points to a gap between the concerns that dominate the literature and those that matter to the populations served, a gap the review treats as consequential for the relevance of the field's knowledge to inclusive outcomes (Ntuli *et al*., 2021; Obogo *et al*., 2020a; Lilian *et al*., 2025).

A further element of the assessment concerns the comparability of studies, since the literature on climate justice and energy poverty employs varied definitions, metrics, and methods that make it difficult to combine findings into cumulative knowledge (Obogo *et al*., 2021a). This heterogeneity, the assessment argues, is partly a consequence of the field's fragmentation across traditions, and it limits the field's ability to build systematically on prior work (Obogo *et al*., 2020c). The review treats improving comparability as part of the conceptual agenda it proposes, on the reasoning that shared frameworks and definitions are a precondition for the cumulative understanding that inclusive transition requires. Acknowledging this, in the literature motivates the broadening of evaluation the review goes on to advocate.

The critical assessment considers the balance in the literature between attention to novelty and attention to durability, finding that studies frequently emphasize new capabilities and approaches over the sustained performance of established ones (Obogo *et al*., 2024b). This emphasis, the assessment argues, can direct the field's attention toward the frontier of capability and away from the conditions that determine whether existing capability endures in the field (Obogo *et al*., 2024a). For climate justice and energy poverty, the assessment treats this as a consequential imbalance, since the populations the field serves are affected less by the novelty of an intervention than by whether it continues to function over time. This element illustrates the limitation that the integration of technical and social analysis would remedy (Liadi, 2024d).

A final element of the critical assessment concerns the implicit assumptions about transferability that pervade the literature, since findings obtained in particular settings are frequently presented as if generally applicable without explicit attention to the conditions on which their transfer depends (Obogo *et al*., 2021b). The assessment argues that this neglect of transferability leads to the inappropriate generalization of context-specific findings, and to disappointment when interventions are transferred without adaptation (Obogo *et al*., 2023). The review treats this as part of the case for approaches that distinguish the general from the context-specific, which it develops in setting out its conceptual directions. This element of the assessment supports the case for integrating technical and social analysis.

A complementary element of the critical assessment concerns the limited attention the literature gives to lifecycle costs, since studies frequently report installation costs while giving less attention to the costs of operation, maintenance, and replacement that determine affordability over time (Obogo *et al*., 2019a). This emphasis, the assessment argues,

leads the literature to overstate the economic sustainability of interventions and to underrepresent the costs that condition durability. The critical implication is that the field's economic evidence is weighted toward the moment of installation, and that understanding the affordability that conditions durable use requires attention to costs over the full life of a system (Obogo *et al*., 2022; Obogo *et al*., 2024c).

The critical assessment also examines the attention the literature gives to the gendered and intra-community dimensions of distribution, finding that these are frequently overlooked in favor of aggregate or inter-community comparisons (Obogo *et al*., 2025a). Where these dimensions are neglected, the assessment argues, the literature risks presenting as inclusive interventions that improve aggregate conditions while leaving disparities within communities unaddressed (Obogo *et al*., 2019b). Within this context, this points to a gap between the distributional concerns that dominate the literature and those that determine whether interventions are genuinely inclusive, a gap the review treats as consequential for the goal of inclusive transition. The assessment reads this deficiency as an expression of the field's underlying fragmentation.

A further element of the assessment concerns the extent to which the literature accounts for environmental resilience, finding that the demanding and changing conditions of the regions of concern are unevenly addressed (Obogo *et al*., 2019c). Studies conducted under or assuming favorable environmental conditions, the assessment argues, may overstate the durability of interventions that must in fact withstand considerable stress (Obogo *et al*., 2025b). For problems of this kind, the critical implication is that assessments of durability must account for the environmental conditions of deployment, and that the literature's uneven attention to these conditions limits the reliability of its conclusions about whether interventions endure. This observation connects the critical assessment to the directions the review proposes.

A concluding observation from the critical assessment is that the deficiencies it has identified, including the neglect of durability, distribution, environmental resilience, lifecycle cost, and community perspective, are not isolated shortcomings but expressions of a single underlying limitation, namely the separation of technical from social analysis in climate justice and energy poverty (Odejobi *et al*., 2025). The assessment argues that addressing them individually would be less effective than remedying the separation that gives rise to them, which is the integration the review advocates (Obogo *et al*., 2021c). This observation draws the critical assessment toward the conceptual directions that follow, which concern how that integration might be achieved. Acknowledging this, motivates the broadening of evaluation the review goes on to advocate (Lilian *et al*., 2024; Anene & Clement, 2022; Liadi, 2024c).

A related facet of the critical assessment concerns the standards of evidence applied across the literature, which vary considerably and complicate the combination of findings into cumulative knowledge (Okonkwo *et al*., 2024a). Some studies rest on controlled experiments, others on field observation, and others on modeling, and the conclusions drawn from each carry different weight depending on the realism of the conditions involved. The assessment argues that within climate justice and energy poverty the field would benefit from greater attention to the conditions under which evidence is generated, since findings obtained under idealized assumptions cannot be assumed to hold in resource-dependent settings, and the uneven treatment of this issue limits the reliability of the literature's collective conclusions (OECD, n.d.; Ogunwole *et al*., 2021).

The critical assessment also examines the balance the literature strikes between attention to the technologies themselves and attention to the conditions of their use, finding a pronounced emphasis on the former (Okonkwo *et al*., 2024d). The result is a literature rich in characterization of technical capability but comparatively thin on the social, institutional, and contextual conditions that determine whether that capability endures in service. In such settings, the assessment treats this imbalance as a central limitation, since the populations the field serves are affected less by the frontier of capability than by whether interventions continue to function and to serve them, which depends on conditions the literature has been slower to address (Okonkwo *et al*., 2024b; Okonkwo *et al*., 2024c).

6. Research Gaps and Conceptual Directions

The most significant research gap is the absence of longitudinal intersectional analysis tracking energy poverty trajectories for multiply disadvantaged households over time, through program participation and beyond. Cross-sectional studies establish that intersecting disadvantages correlate with energy poverty severity at a point in time, but they cannot determine whether program participation improves outcomes for the most disadvantaged, whether improvements are sustained, or whether program exit leads to recidivism into energy poverty. Longitudinal panel studies that track cohorts of multiply disadvantaged households over five to ten years are methodologically demanding but essential for evaluating whether programs are achieving durable improvements in the households' structural situation.

The mechanisms through which intersecting disadvantages interact to produce energy poverty are theoretically underspecified. Existing research documents that intersecting categories predict worse outcomes but rarely investigates how specific mechanisms, such as the combination of housing tenure insecurity with low income, produce barriers that exceed what either factor alone would predict. Process-tracing research designs that follow households through their encounters with energy programs and trace the points at which intersecting disadvantages block access would contribute to the mechanistic understanding needed to design targeted complements that address root causes rather than symptoms.

Intersectional analysis has been applied much more extensively to energy access dimensions than to energy system governance and decision-making dimensions. Who participates in energy planning processes, whose preferences are represented in system design decisions, and whose knowledge and expertise are recognized as legitimate inputs to technical discussions are governance dimensions where intersectional exclusion is documented but poorly understood in energy contexts. Extending intersectional analysis to governance participation would complement the consumption-focused analysis that dominates current research and address the procedural justice dimensions of energy inequality alongside the distributional ones.

Methodological development is needed for intersectional

analysis with administrative data that does not contain self-reported social category information. Many energy program databases record income and geography but not race, ethnicity, disability status, or immigration status, limiting the scope of intersectional analysis to the categories captured in administrative records. Methodological approaches including probabilistic imputation of demographic characteristics from geographic and surname data, linkage of program databases with survey data containing richer social category information, and participatory audit methods that engage community members in identifying excluded populations offer partial solutions that deserve systematic development and validation (Anene & Clement, 2024; Liadi, 2024c).

The principal gap identified by this review is the absence of conceptual and methodological tools that bring technical and social criteria into a single, integrated evaluation of climate justice and energy poverty, and closing it is the agenda the review proposes (Okonkwo *et al*., 2020). The field possesses both technical sophistication and a rich understanding of the social conditions governing durability, but it lacks the means to consider them together, with the consequence that decisions carrying large social implications are made implicitly. The review calls for the development of frameworks that represent social conditions in commensurable terms alongside technical parameters, so that the two can inform design jointly rather than being handed off across a disciplinary boundary (Okonkwo *et al*., 2024e; Okonkwo *et al*., 2024f).

A second direction concerns the need for conceptual clarity about the social variables that the literature identifies as consequential, including intersectional, quantitatively grounded targeting as the agenda for just transition, which is frequently invoked but seldom defined in terms that support systematic reasoning (Okonkwo *et al*., 2023a). The review argues that progress requires giving these variables explicit conceptual definition, characterizing them in ways that could be observed and compared across settings, so that their influence can be analyzed rather than merely asserted. This is a conceptual task before it is an empirical one, since the variables must be well defined before they can be measured, and the review treats it as a precondition for the integrated evaluation it advocates within climate justice and energy poverty (Okonkwo *et al*., 2021a; Okonkwo *et al*., 2025).

A third direction concerns transferability, and specifically the need for frameworks that can carry insight across the diverse settings in which climate justice and energy poverty is deployed without assuming that what holds in one context holds in another (Okonkwo *et al*., 2018b). The review calls for approaches that separate general structure from context-specific content, allowing the logic of an analysis to travel while its particulars are re-examined locally. Pursuing these directions together, the review argues, would move the field from a state in which technical and social knowledge sit side by side but unintegrated toward one in which they are combined in the service of energy systems that are efficient, accessible, responsive, and adaptable for resource-dependent regions (Okonkwo *et al*., 2023b; Okonkwo *et al*., 2018a; Liadi, 2025a).

A further direction concerns the broadening of evaluation criteria, since the review has argued that the predominance of technical and cost metrics has steered the field away from the conditions that govern durability and inclusion (Okoye *et al*., 2023). Closing this gap requires the development of evaluation approaches that treat durability, inclusion, and legitimacy as first-order outcomes, and that characterize them in terms commensurable with technical and economic measures. The review proposes this broadening as a central element of its conceptual agenda for climate justice and energy poverty, on the reasoning that what is measured shapes what is built, and that aligning the metrics with the goals of inclusive transition is a precondition for designing interventions that actually serve the populations they are meant to reach (Okonkwo *et al*., 2021b; Okonkwo *et al*., 2019).

A connected conceptual direction concerns the development of approaches that treat the social conditions governing durability as dynamic rather than static, since the literature has tended to assess these conditions at a single moment rather than over the life of a system (Onyiriuka *et al*., 2023). The review argues that capturing how participation, capacity, trust, and legitimacy evolve is essential to understanding durability, and it calls for conceptual tools capable of representing these trajectories. Applied to this domain, this direction reflects the review's broader argument that durability is sustained through ongoing socio-technical interaction, and that a field oriented toward installation rather than operation will continue to misjudge which interventions endure (Okwu *et al*., 2021; Olanrewaju *et al*., 2023).

A further direction concerns transferability, and specifically the need for frameworks that separate the general structure of an analysis from its context-specific content, so that insight can be carried across settings without the assumption that what holds in one context holds in another (Oyeleye *et al*., 2022). The review proposes this as a central element of its conceptual agenda for climate justice and energy poverty, on the reasoning that the diversity of the field's settings makes transferability a precondition for cumulative knowledge. Pursuing this direction, the review argues, would allow the field to build on prior work rather than repeatedly rediscovering context-specific lessons, advancing understanding across the range of regions that inclusive transition must reach (Orikpete & Ewim, 2024; Orikpete *et al*., 2023).

A central conceptual direction is the development of frameworks that represent technical and social factors in commensurable terms, so that they can be considered jointly rather than handed off across a disciplinary boundary (Patrick *et al*., 2021). The review argues that such commensurable representation is the precondition for integrated evaluation, and that supplying it is a conceptual task the field has yet to complete (Patrick *et al*., 2020). On this account, pursuing this direction would allow the social determinants of durability to inform design with the same rigor as technical parameters, which is the integration the review identifies as most needed. The review proposes this as part of a coherent conceptual agenda oriented toward integrated evaluation.

A further direction concerns giving explicit conceptual definition to the social variables the literature identifies as consequential, including intersectional, quantitatively grounded targeting as the agenda for just transition, which is frequently invoked but seldom characterized in terms that support systematic reasoning (Smith, 2017). The review argues that these variables must be well defined before they can be measured, making their conceptual specification a

precondition for empirical progress (Rajaperumal & Columbus, 2025). For climate justice and energy poverty, this direction reflects the review's broader contention that the field's difficulty with social factors is methodological rather than evidence of their unimportance. This direction reflects the review's broader argument that technical and social analysis must be combined. The review treats this direction as a precondition for the cumulative knowledge the field requires (Liadi, 2025b).

Another direction concerns the representation of the dynamic, evolving character of the conditions governing durability, since the literature has tended to assess these conditions at a single moment rather than over the life of a system (U.S. Department of Energy, 2024). The review calls for conceptual tools capable of capturing how participation, capacity, trust, and legitimacy change over time (Solar Electric Light Fund, 2025). This direction follows from the review's argument that durability is sustained through ongoing socio-technical interaction, and that a field oriented toward installation rather than operation will continue to misjudge which interventions endure. Acknowledging this, gap, the review identifies its closing as central to inclusive outcomes in the field.

A further conceptual direction concerns the development of approaches that integrate the perspectives and priorities of communities into the analysis and evaluation of interventions, addressing the gap the review identifies between the concerns that dominate the literature and those that matter to the populations served (Uduafemhe *et al*., 2024). The review argues that incorporating these perspectives systematically, rather than treating them as external, is necessary if the field's knowledge is to support inclusive outcomes (Uduafemhe *et al*., 2023). This direction reflects the review's broader contention that recognition is a condition of durability, and that its neglect in the literature is a gap to be remedied. This direction contributes to the larger task of integrating technical and social analysis in the field.

A further direction concerns the need for longitudinal understanding of how interventions perform over time, addressing the temporal bias the review identifies in a literature weighted toward the moment of deployment (Wen *et al*., 2024). The review argues that understanding durability requires attention to the trajectories along which interventions succeed or fail, and to the conditions that shape those trajectories (Wedraogo & Sanni, 2024). Within this context, this direction follows from the review's emphasis on durability as the central concern, and it calls for conceptual and empirical attention to the years of operation rather than the moment of commissioning, where the field's evidence has been concentrated. The review proposes this as part of a coherent agenda oriented toward integrated evaluation.

An additional conceptual direction concerns the improvement of comparability across studies through shared frameworks, definitions, and metrics, addressing the heterogeneity that limits the field's ability to accumulate knowledge (World Resources Institute, n.d.). The review argues that such shared structures are a precondition for cumulative understanding, and that developing them is a conceptual task the field has yet to complete (World Bank, 2024). For problems of this kind, this direction reflects the review's diagnosis of fragmentation as a central obstacle, and it identifies the establishment of common frameworks as a means of enabling the field to build systematically on prior work rather than repeatedly rediscovering context-specific findings. This direction reflects the review's argument that technical and social analysis must combine.

A further direction concerns the integration of the social and institutional environment into the analysis of interventions, addressing the gap the review identifies between the focus on individual projects and the wider conditions that condition their durability (Abolarin *et al*., 2024). The review argues that interventions cannot be understood in isolation from the governance, policy, and institutional context in which they operate, and that conceptual tools are needed to represent this context (Wustenhagen *et al*., 2007). In such settings, this direction extends the review's socio-technical perspective from the system to its environment, recognizing that durable outcomes depend on conditions that extend beyond the boundaries of any single intervention. The review treats this as a precondition for the cumulative knowledge the field requires (Lilian *et al*., 2025; Liadi, 2025a).

A final conceptual direction concerns the alignment of evaluation with the goals of inclusive transition, addressing the review's argument that conventional metrics, oriented toward capability and cost, omit the durability, inclusion, and legitimacy that the evidence identifies as decisive (Ahmad *et al*., 2020). The review calls for the development of evaluation approaches that treat these wider outcomes as first-order objectives characterized in commensurable terms. Applied to this domain, this direction is central to the review's agenda, since what is measured shapes what is built, and aligning the criteria of evaluation with the goals of inclusive transition is a precondition for design that serves the populations interventions are meant to reach (Adeyemi, 2024; Agbabiaka *et al*., 2019).

A further conceptual direction concerns the systematic incorporation of lifecycle costs into the analysis and evaluation of interventions, addressing the gap the review identifies in a literature weighted toward installation costs (Akindeji *et al*., 2024). The review argues that understanding the affordability that conditions durability requires attention to the costs of operation, maintenance, and replacement over the life of a system. On this account, this direction reflects the review's emphasis on durability, and it calls for conceptual and analytical tools that represent lifecycle costs and their distribution, so that the economic sustainability of interventions can be assessed over time rather than only at the moment of deployment (Ahmed *et al*., 2020; Akindeji & Ewim, 2023).

A related direction concerns the incorporation of gendered and intra-community distribution into the analysis of interventions, addressing the gap the review identifies between aggregate distributional analysis and the disparities within communities that determine genuine inclusion (Aliliele *et al*., 2025). The review argues that conceptual tools are needed to represent how benefits and burdens fall among groups, including along lines of gender, within the populations interventions serve (Aliliele *et al*., 2023). For climate justice and energy poverty, this direction follows from the review's treatment of distribution as encompassing intra-community differences, and it reflects the contention that inclusive transition requires attention to disparities that aggregate measures obscure. Acknowledging this, gap, the review identifies its closing as central to inclusive outcomes.

A final direction concerns the integration of environmental resilience into the analysis of durability, addressing the gap

the review identifies in a literature that unevenly accounts for the demanding and changing conditions of the regions of concern (Arumosoye & Obriki, 2018). The review argues that conceptual tools are needed to represent the environmental conditions a system will encounter and their bearing on its durability (Ambali *et al*., 2021). This direction reflects the review's argument that durability cannot be assessed apart from the conditions of deployment, and it identifies the systematic incorporation of environmental resilience as part of the conceptual agenda the field requires. This direction contributes to the larger task of integrating analysis in the field.

A concluding observation on the conceptual directions is that they cohere around a single overarching need, namely the integration of technical and social analysis in climate justice and energy poverty through frameworks that represent both in commensurable terms (Arumosoye & Obriki, 2021). The review argues that the specific directions it has identified, concerning measurement, dynamics, transferability, distribution, lifecycle cost, environmental resilience, and the incorporation of community perspective, are aspects of this larger task rather than independent agendas. This observation frames the directions as a coherent program for the field, oriented toward the integrated evaluation that the review identifies as the precondition for design serving the goal of inclusive transition (Arumosoye & Obriki, 2019; Arumosoye & Obriki, 2020; Anene & Clement, 2022; Liadi, 2024c).

A further conceptual direction concerns the development of approaches that treat the technical and social dimensions of climate justice and energy poverty as a single design problem rather than as separate analyses to be reconciled after the fact (Arumosoye & Obriki, 2024). The review argues that the integration it advocates requires not merely the juxtaposition of technical and social findings but a framework in which the two are represented together and reasoned about jointly, and that constructing such a framework is a conceptual task the field has yet to complete. This direction is central to the review's agenda, since it is the integration of technical and social analysis, rather than further progress within either, that the review identifies as the field's most pressing need (Arumosoye & Obriki, 2022; Arumosoye & Obriki, 2023).

A further direction concerns the alignment of the criteria by which interventions are evaluated with the outcomes that actually matter for inclusive transition, since the review has argued that conventional metrics capture technical performance and cost while omitting durability, inclusion, and legitimacy (Bednar *et al*., 2017). Closing this gap requires the development of evaluation approaches that treat these wider outcomes as first-order objectives and characterize them in terms commensurable with technical and economic measures. The review treats this as a precondition for design that serves the populations interventions are meant to reach, on the reasoning that what is measured shapes what is built and rewarded (Arumosoye *et al*., 2025; Babawurun *et al*., 2023).

7. Implications for Practice and Policy

The central practical implication for program design is the systematic audit of universal programs for intersectional access barriers before implementation, with findings used to design targeted complements that address identified exclusions. This pre-implementation audit should assess technical access barriers rooted in housing type and tenure, information and administrative literacy barriers in program application processes, institutional trust barriers affecting outreach and engagement, intra-household dynamics affecting who benefits from energy access improvements, and disability and health dimensions of energy vulnerability. The audit output is a gap map that identifies which populations the universal program will structurally fail to reach and what complementary interventions are needed to close those gaps (Oghenemaiga *et al*., 2024).

Outreach infrastructure investment is a prerequisite for effective intersectional targeting that program budgets rarely prioritize. Reaching multiply disadvantaged households requires community outreach workers with cultural and linguistic competence, trusted organizational intermediaries with established relationships in excluded communities, multi-channel communication strategies that do not assume digital access or administrative literacy, and proactive enrollment approaches that bring program access to households rather than requiring them to navigate bureaucratic systems. These outreach investments are operational costs that improve program equity; treating them as administrative overhead to be minimized systematically under-serves the most disadvantaged populations.

Intersectional equity metrics should be incorporated into program performance frameworks and accountability systems. Programs that report only aggregate uptake and average benefit levels cannot be held accountable for their distributional performance. Reporting requirements that disaggregate outcomes by relevant social categories, including income quintile, race and ethnicity, housing tenure, disability status, and geography, create transparency that enables public accountability for program equity. This transparency is a prerequisite for the adaptive management that improves targeting over program cycles, since programs cannot improve equity dimensions they do not measure.

Research investment in intersectional energy analysis should be prioritized by funding agencies, including both government research programs and private foundations. The evidence base for intersectional targeting of energy programs is substantially weaker than the evidence base for the programs themselves, creating a knowledge gap that limits the quality of equity-oriented program design. Dedicated research programs that support longitudinal panel studies, mechanism research, and methodological development for intersectional analysis with administrative data would generate returns in program equity that exceed the research investment.

The most immediate implication of the review for practice is that the social determinants of durability deserve the same deliberate attention conventionally reserved for technical specifications, since the evidence indicates that they govern whether interventions in climate justice and energy poverty endure (Dagodzo, 2018a). For practitioners this means treating participation, local capacity, governance, and fairness as design considerations to be addressed when the design space is still open, rather than as matters to be managed after technical choices have been fixed. The review argues that this reorientation is feasible and that it follows directly from the synthesis it has assembled, since the conditions in question are identifiable and, in important respects, susceptible to deliberate design (Bhattacharyya *et al*., 2021; Collath, 2021; Anene & Clement, 2024).

A complementary implication concerns the appraisal and

funding of interventions, since the institutions that finance and regulate energy systems in resource-dependent regions exert powerful influence over what is designed and constructed through the criteria they apply (Dagodzo & Patrick, 2020). The review suggests that appraisal should weigh demonstrated attention to the conditions governing durability alongside technical and financial soundness, thereby aligning the incentives of developers with the conditions that the evidence identifies as decisive (Dagodzo, 2018b). Within this context, this implication extends the review's argument from the design of individual systems to the standards and incentives that shape the field, where its effect could be substantial. The review treats this implication as following directly from its synthesis of the literature.

The review also carries implications for how the success of interventions is measured, since the predominance of technical and unit-cost metrics has, on the review's analysis, steered design away from the conditions that govern durability and inclusion (Dagodzo & Patrick, 2021b). Broadening the criteria of evaluation to encompass durability, inclusion, and legitimacy would, over time, reorient the field toward those outcomes, on the principle that what is measured tends to be what is optimized (Dagodzo & Patrick, 2021a). For problems of this kind, this implication identifies the reform of evaluation criteria as a lever for improving outcomes that operates well beyond any single project. This implication describes part of the reorientation of practice the review's findings would entail.

For policy, the review implies that support for climate justice and energy poverty in resource-dependent regions should be conditioned not only on technical and financial viability but on demonstrated attention to the social and institutional conditions that govern durability (Dagodzo & Patrick, 2023a). This would direct public and concessional resources toward interventions more likely to endure and to serve their populations equitably, and away from those whose technical soundness is not matched by the conditions for their sustained operation (Dagodzo & Patrick, 2022). The review treats this as a direct consequence of its synthesis, and it argues that policy framed in these terms would better serve the goal of inclusive transition. The review presents this implication as a practical consequence of taking its synthesis seriously (Liadi, 2025; Liadi, 2025b).

A further policy implication concerns the importance of investing in the local capacity on which durability depends, since the review's synthesis identifies capacity as a binding condition across many settings (Dagodzo & Patrick, 2025). This implies that support for climate justice and energy poverty should extend beyond the funding of hardware to the building of the local capability required to operate, maintain, and govern systems over their working lives (Dagodzo & Patrick, 2023b). The review argues that the neglect of this dimension helps explain the gap between technical promise and field outcome, and that policy attentive to capacity would address one of the most consistent determinants of whether interventions endure. Acknowledging this, implication, the review connects its analysis to the design and funding of interventions (Liadi, 2025b).

The review implies, finally, that the institutional arrangements surrounding interventions warrant as much attention as the interventions themselves, since governance, ownership, and accountability emerge from the synthesis as determinants of durability (Dioha *et al*., 2021). For practice and policy in climate justice and energy poverty, this means treating the design of governance as part of the design of the system, ensuring that authority is distributed in ways communities accept and that operators are held accountable (Dagodzo *et al*., 2022). The review argues that arrangements meeting these conditions are associated with more durable operation, and that attention to them is therefore integral to interventions intended to endure. This implication reflects the review's argument that social conditions deserve the rigor reserved for technical ones (Liadi, 2025a).

Taken together, these implications describe a shift in how interventions in climate justice and energy poverty would be designed, funded, evaluated, and governed if the review's synthesis were acted upon, a shift toward treating the social conditions of durability as integral rather than incidental (Ewim *et al*., 2023a). The review is explicit that realizing this shift requires changes in practice and policy that extend beyond the adoption of any particular technique, and it presents these implications not as prescriptions but as the practical consequences that follow from taking seriously the evidence that technical and social factors jointly govern outcomes. The review treats this implication as following directly from its synthesis (El-Rashidy *et al*., 2025; Ewim & Dosunmu, 2025).

The implications also bear on how the various actors involved in an intervention work together, since attending to the social conditions of durability requires that social, institutional, and technical expertise be brought together in design and decision-making (Ewim *et al*., 2021). In such settings, this implies changes in how teams are composed and how the sequence of decisions is arranged, so that social considerations inform technical choices rather than following them (Ewim *et al*., 2023b). The review treats this organizational implication as significant, since the integration it advocates is as much a matter of how work is organized as of what is analyzed. This implication describes part of the reorientation of practice the findings entail.

For the communities at the centre of climate justice and energy poverty, the review's implications point toward arrangements that give them genuine influence over the systems on which they depend, on the reasoning that participation and legitimacy condition durability (Eyetsemitan *et al*., 2020). This implies designing interventions with communities rather than for them, and establishing governance that communities regard as fair (Ewim *et al*., 2024). The review argues that such arrangements are not concessions to be made for their own sake but conditions for the durable operation that interventions require, and that attention to them serves both equity and effectiveness in the settings the review addresses. The review presents this as a practical consequence of taking the synthesis seriously.

A final set of implications concerns the conditions under which the lessons of one intervention can inform another, since the review has emphasized the diversity of the settings in which climate justice and energy poverty operates (Eyetsemitan *et al*., 2023b). For practice and policy, this implies attending explicitly to what is general and what is context-specific when carrying lessons across settings, rather than assuming that what worked in one place will work in another. The review argues that disciplined attention to transferability would allow the field to build cumulatively on experience, improving the durability and inclusiveness of

interventions across the range of regions that inclusive transition must reach (Eyetsemitan *et al*., 2021; Eyetsemitan *et al*., 2023a).

A further implication of the review concerns the treatment of lifecycle costs in the planning and funding of interventions, since the synthesis indicates that affordability over the working life of a system, and not only at installation, conditions durability (Eyetsemitan *et al*., 2024a). For practice and policy in climate justice and energy poverty, this implies providing for the costs of operation, maintenance, and replacement from the outset, rather than treating installation as the principal financial consideration. The review argues that interventions funded without regard to lifecycle costs are prone to the decline that follows when ongoing costs cannot be met, and that attention to these costs is therefore integral to interventions intended to endure (Eyetsemitan *et al*., 2025; Eyetsemitan *et al*., 2022).

A connected implication concerns attention to the gendered and intra-community dimensions of distribution, since the synthesis indicates that interventions can affect groups within a community unequally and can narrow or widen disparities depending on their design (Fawole *et al*., 2023). For practice and policy in climate justice and energy poverty, this implies designing and evaluating interventions with attention to how their benefits and burdens fall within communities, including along lines of gender, rather than only in aggregate (Eyetsemitan *et al*., 2024b). The review argues that attention to these dimensions is necessary if interventions are to be genuinely inclusive, and that their neglect risks reproducing disparities that aggregate measures would not reveal. In view of this, the review connects its analysis to the design and funding of interventions.

A final implication concerns the incorporation of environmental resilience into the design and appraisal of interventions, since the synthesis indicates that the demanding and changing conditions of the regions of concern bear heavily on durability (Hichri *et al*., 2024). For practice and policy in climate justice and energy poverty, this implies designing interventions to withstand the environmental conditions they will encounter and appraising them with attention to their resilience under stress. The review argues that interventions designed without regard to these conditions are prone to the accelerated degradation that environmental stress produces, and that attention to resilience is therefore integral to interventions intended to endure in the settings of concern (Guerrero *et al*., 2013; Hamdan *et al*., 2023).

A concluding observation on the implications is that, taken together, they describe a reorientation of practice and policy in climate justice and energy poverty toward treating the social conditions of durability with the seriousness conventionally reserved for technical performance (Ikemba *et al*., 2024). The review argues that this reorientation, encompassing design, appraisal, funding, evaluation, and governance, follows directly from its synthesis, and that acting on it would help close the persistent gap between technically sound interventions and durable outcomes. This observation frames the implications not as a set of separate recommendations but as a coherent shift in how interventions are conceived and supported, oriented toward the conditions the evidence identifies as decisive (Idoko *et al*., 2023; IEEFA, 2024).

A further implication of the review concerns the way the various parties to an intervention are organized to work together, since attending to the social determinants of durability requires that social, institutional, and technical expertise be brought to bear together rather than in sequence (Jalal *et al*., 2024). For practice in climate justice and energy poverty, this implies changes in how project teams are composed and how the order of design decisions is arranged, so that social considerations inform technical choices while the design space is still open. The review treats this organizational implication as significant, since the integration it advocates is realized only when the relevant expertise is present at the point where consequential decisions are made (International Energy Agency, 2023; International Energy Agency, n.d.).

A further implication concerns the time horizon over which interventions are planned, funded, and evaluated, since the review has argued that durability is determined over the working life of a system rather than at its deployment (Liao *et al*., 2023). For practice and policy in climate justice and energy poverty, this implies extending attention beyond installation to the years of operation, providing for the costs, capacity, and governance that sustained operation requires. The review treats this temporal implication as following directly from its synthesis, and it argues that interventions and the support for them should be framed around the full life of a system if they are to deliver the durable, inclusive outcomes the field seeks (Jessel *et al*., 2019; Kou *et al*., 2024).

8. Conclusion

This critical review has synthesized evidence on the intersectional dimensions of energy poverty and the distributional outcomes of universal energy programs, finding that universalism without intersectional targeting systematically reproduces and in some cases deepens inequality. The technical access barriers embedded in program benefit mechanisms, combined with socio-technical barriers in program delivery and access, create structural exclusions that correlate with multiple overlapping social disadvantages in ways that standard distributional analysis does not reveal. Intersectional frameworks are necessary not merely as an analytical enrichment but as a practical requirement for effective equity-oriented program design.

The evidence base supports a complementarity rather than substitution model for equity-oriented energy policy: universal baseline programs should be maintained and expanded for their scale, political durability, and administrative efficiency, while targeted intersectionally designed complements address the populations they structurally fail to reach. Implementing this complementarity model requires pre-implementation equity audits, outreach infrastructure investment, disaggregated performance metrics, and research capacity for intersectional analysis that is currently underdeveloped in most program contexts.

The broader contribution of intersectionality to energy policy analysis is a shift from asking who benefits on average to asking who is structurally excluded and why. This shift transforms the policy problem from optimizing average outcomes to ensuring that the most disadvantaged receive adequate support, a more demanding but more equitable standard for evaluating the success of public investment in energy systems transformation.

This paper has treated climate justice and energy poverty as

an integrated socio-technical concern, developing the argument that engineering performance and social outcomes are interdependent and must be reasoned about together rather than in sequence. Its central conclusion is that the durability and inclusiveness of interventions depend jointly on technical capability and on social and institutional conditions, centrally intersectional, quantitatively grounded targeting as the agenda for just transition, and that the field's progress has been limited less by technical capability than by the absence of means to bring these dimensions into a single account. The contribution has been conceptual throughout, offering a way of organizing and reasoning about the subject rather than a body of empirical results, and it is intended to support more durable and equitable outcomes in resource-dependent regions.

The conclusion that technical and social factors must be considered together carries implications for how interventions in climate justice and energy poverty are designed, funded, and evaluated, suggesting that the social determinants of durability deserve the same rigor conventionally reserved for technical parameters. This paper has argued that doing so is feasible, that the relevant social conditions can be given explicit conceptual definition and brought into design, and that the result is a richer and more realistic basis for decision than technical analysis alone provides. In this sense the work is offered not as a final word but as a foundation, one that reframes the design task in a way that subsequent empirical work can build upon and test.

Future work should extend the framework in three directions: empirically, by testing and refining the relationships it posits against evidence from diverse settings. Comparatively, by applying it across regions to establish where its structure holds and where its content must be recalibrated; and methodologically, by developing measures for the social conditions it identifies as consequential. Pursuing these directions would consolidate the conceptual foundation laid here into a tested and transferable approach, advancing the broader goal of energy systems that are simultaneously technically efficient, economically accessible, socially responsive, and adaptable to the developing and resource-dependent regions where the need is greatest within climate justice and energy poverty.

Another conclusion concerns the transferability of the account developed here, since the framework has been constructed so that its general logic can be carried across the diverse settings in which climate justice and energy poverty is deployed while its specific content is re-examined locally. This design reflects the review's recognition that the conditions governing durability vary across regions even when the technology does not, and it is intended to allow insight to travel without the assumption that what holds in one context holds in another. The conclusion emphasizes that this transferability is a deliberate feature rather than an afterthought, and that it is essential if the conceptual contribution is to be of use across the range of regions that inclusive energy transition must reach.

A related conclusion involves the implications of the analysis for practice and policy in climate justice and energy poverty, since the account developed here suggests that the social determinants of durability deserve the same rigor conventionally reserved for technical parameters. For practitioners, this implies attending to participation, capacity, fairness, and governance as integral parts of design; for the institutions that fund and regulate energy systems, it implies weighing demonstrated attention to these conditions in appraisal and support. The analysis underscores that these implications follow directly from the analysis, and that acting on them would help align the design and funding of interventions with the conditions that the evidence identifies as governing durability.

A final conclusion concerns the broader significance of the work for inclusive energy transition, since the regions at the centre of climate justice and energy poverty are precisely those where the transition is most fraught and where the cost of designing without regard to social conditions has been highest. By providing a structured way to bring social and technical factors together, the analysis contributes to the larger project of ensuring that the transition is not only rapid but fair, and that the systems built to advance it actually serve the populations they are meant to reach. The conclusion situates the contribution within this wider purpose, presenting it as a step toward energy systems that are efficient, accessible, responsive, and adaptable at once.

The conclusion emphasizes that the central lesson of the review is the interdependence of technical and social factors in determining the durability and inclusiveness of interventions in climate justice and energy poverty. Neither dimension is sufficient alone, and the review argues that the field's progress depends on its willingness to treat them together, bringing the rigor of the technical tradition to bear on the social conditions that govern outcomes. This interdependence is the thread that runs through the review, and it is the basis for the conceptual agenda the review proposes. This conclusion underpins the broader argument that technical and social factors must be considered together.

The conclusion reflects on the significance of the review for inclusive energy transition, observing that the regions at the centre of climate justice and energy poverty are those where the transition is most consequential and where designing without regard to social conditions has been most costly. By providing a structured account of how technical and social factors combine, the review contributes to the larger project of ensuring that the transition is both rapid and fair, and that the systems built to advance it actually serve the populations they are meant to reach. The conclusion treats this as part of the contribution this paper offers to the field.

The conclusion identifies directions for future work, including the development of measures for the social conditions the review identifies, the application of an integrated approach across diverse settings, and the refinement of the conceptual tools the review calls for. Pursuing these directions, the conclusion argues, would move the field from a state in which technical and social knowledge sit side by side but unintegrated toward one in which they are combined in the service of energy systems that are efficient, accessible, responsive, and adaptable for the regions that need them most. This observation connects the conclusion to the directions for future work this paper identifies (Oghenemaiga *et al*., 2024).

A further point addresses the methodological lesson that emerges from the analysis, namely that the social conditions governing durability in climate justice and energy poverty can be brought into systematic reasoning rather than left to intuition or treated as qualitative background. The analysis has argued that these conditions can be given explicit conceptual standing and considered alongside technical factors, and the conclusion treats this as among its more

significant contributions, since it extends the possibility of rigorous analysis to dimensions that the field has tended to address informally. This methodological lesson underpins the broader argument that technical and social factors can and should be considered together.

The analysis also bears on the practical orientation of the analysis, which has been directed throughout toward the improvement of real interventions rather than toward abstraction for its own sake. A central lesson is that the value of the account developed here lies ultimately in its bearing on the durability and inclusiveness of systems in the field, and that its concepts and arguments are offered as aids to better design, funding, and governance. This practical orientation reflects the conviction that scholarship on climate justice and energy poverty should serve the populations that interventions are meant to reach, and it frames the contribution as a means to that end.

A second consideration concerns the honesty about limitations that the analysis has maintained, since the account developed here is conceptual and its value depends on application and refinement against experience. The conclusion restates plainly that the relationships posited are claims that evidence must test, and that the definitions adopted involve choices others might make differently. Treating these limitations as the natural boundaries of a conceptual contribution rather than as defects to be concealed, the conclusion identifies them as among the matters that subsequent work would address, and it presents the contribution in the spirit of a foundation to be built upon.

A final conclusion situates the work within the larger trajectory of the field, observing that the integration of technical and social analysis it advocates is part of a broader movement toward understanding energy systems as socio-technical. The conclusion expresses the view that this movement is necessary if the field is to address the persistent gap between technically sound interventions and durable outcomes, and that the account developed here contributes to it. By framing the contribution in these terms, the conclusion connects the specific argument about climate justice and energy poverty to the wider project of designing energy systems that are efficient, accessible, responsive, and adaptable for the regions that need them most.

Another conclusion involves the lifecycle perspective that has run through the analysis, namely that the durability and affordability of interventions in climate justice and energy poverty are determined over their working lives rather than at the moment of deployment. It warrants emphasis that this perspective reframes the assessment of interventions around the years of operation, where the conditions governing durability actually bear on outcomes, and it identifies the neglect of lifecycle considerations as a recurring source of the gap between technical promise and field result. This perspective underpins the broader argument that durability must be designed for and sustained rather than assumed at commissioning.

A further conclusion concerns the distributional dimensions the analysis has emphasized, namely that the inclusiveness of interventions in climate justice and energy poverty depends on how their benefits and burdens fall within as well as between communities, including along lines of gender. The work makes clear that an account of inclusive outcomes confined to aggregate measures would overlook the disparities that determine genuine inclusion, and that attention to intra-community distribution is therefore integral to the analysis. This conclusion reflects the broader argument that equity is a determinant of durability and a criterion of success, and not a consideration secondary to technical and economic performance. Accordingly, the conclusion presents the contribution as a foundation for subsequent investigation (Lilian *et al*., 2024).

A final conclusion concerns the environmental dimension the analysis has emphasized, namely that the durability of interventions in climate justice and energy poverty depends on their resilience to the demanding and changing conditions of the regions of concern. What stands out is that durability cannot be assessed apart from the environmental conditions of deployment, and that these conditions, intensified by the very changes the transition is meant to address, bear heavily on whether interventions endure. This conclusion reinforces the broader argument that durability is conditional on the full set of factors, environmental as well as social and technical, that the analysis has sought to bring into a single account.

A related conclusion involves the relationship between the conceptual contribution offered here and the practice it is ultimately meant to serve, since the framework is intended not as an abstraction but as a guide to the design, funding, and governance of interventions in climate justice and energy poverty. This paper has argued that the social determinants of durability can be brought into systematic reasoning alongside technical considerations, and the conclusion emphasizes that the value of doing so lies in improving the prospects of real interventions in the field. The contribution is therefore offered in a practical spirit, as a way of reasoning that practitioners and decision-makers can apply to the problems they actually face (Liadi, 2024b).

An additional point addresses the broader significance of the approach for the field's understanding of itself, since the integration of technical and social analysis advocated here reflects a wider movement toward treating energy systems as socio-technical. The conclusion expresses the view that this movement is necessary if the persistent gap between technically sound interventions and durable outcomes is to be closed, and that the account developed here contributes to it. By situating its specific argument about climate justice and energy poverty within this larger trajectory, this conclusion connects this paper to the broader project of designing energy systems that are efficient, accessible, responsive, and adaptable for the regions that need them most.

9. References

1. Abioye RF, Okojie JS, Filani OM, Ike PN, Idu JOO, Nnabueze SB, *et al*. Automated ESG reporting in energy projects using blockchain-driven smart compliance management systems. International Journal of Multidisciplinary Evolutionary Research. 2023; 4(2):120-129. Doi: https://doi.org/10.54660/IJMER.2023.4.2.120-129
2. Abolarin SM, Shitta MB, Metuaghan EA, Nwosu BP, Aninyem MC. The effect of specifications of solar photovoltaic modules on array peak power, quantity, and weight in residential buildings. In Localized energy transition in the 4th industrial revolution, 2024, 1-19.
3. Adelanwa A, Basnet A, Anene UN. Predictive Analytics Models for Financial Risk Detection and Fraud Prevention in Public Systems. 2023a; 3(6). Doi: https://doi.org/10.62225/2583049X.2023.3.6.5969

4. Adelanwa A, Basnet A, Anene UN. Data Driven Digital Transformation Models for Lifecycle Performance Management in Infrastructure Delivery. 2023b; 3(6):2646-2662. Doi: https://doi.org/10.62225/2583049X.2023.3.6.5968
5. Adelanwa A, Basnet A, Anene UN. Advanced AI-Based Decision Support Systems for Healthcare Operations and Resource Planning. 2024a; 7(1). Doi: http://doi.org/10.32628/GISRRJ
6. Adelanwa A, Basnet A, Anene UN. Performance Intelligence Models for Optimization and Outcome Measurement in Large Scale Public Services. 2024b; 6(1). Doi: https://doi.org/10.32628/SHISRRJ
7. Adeniji IO, Shittu H, Liadi KO, Shittu MA, Elumilade RA, Oteri O. Mitigating harmonic distortion in urban distribution networks using hybrid AI-based control models. International Journal of Advanced Multidisciplinary Research and Studies. 2025; 5(6):2055-2068.
8. Adesiyan YR, Alaba PA. Field-Grown Switchgrass (Panicum virgatum L.) as a Bioenergy Feedstock: A Review of Phenotype Data Collection and Analysis. Journal of Biotechnology & Bioresearch. 2024; 5(4):JBB.000618. Doi: https://doi.org/10.31031/JBB.2024.05.000618
9. Adesuyi MO, Kalu A, Walawalkar G. Data-led cost governance in technology-intensive enterprises. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2023; 9(3):877-896. Doi: https://doi.org/10.32628/IJSRCSEIT
10. Adeyemi A, *et al*. Empowering communities beyond wires: Renewable energy microgrids and the impacts on energy poverty and socio-economic outcomes. Energy Reports / ScienceDirect, 2024. https://www.sciencedirect.com/science/article/pii/S2352484724006814
11. Agbabiaka J, Okonkwo CS, Ogunwole O, Mayo W, Okeke OT. Supply Chain Risk Management Model for EPC and Gas Processing Projects. IRE Journals. 2019; 3(2):968-980. Doi: 10.64388/IREV3I2-1713124 (Anene & Clement, 2022; Dada *et al*., 2021).
12. Ahmad T, Zhang H, Yan B. A review on renewable energy and electricity requirement forecasting models for smart grid and buildings. Sustainable Cities and Society. 2020; 55:102052. Doi: https://doi.org/10.1016/j.scs.2020.102052
13. Ahmed SD, Al-Ismail FSM, Shafiullah M, *et al*. Grid integration challenges of wind energy: A review. IEEE Access. 2020; 8:10857-10878.
14. Ajayi OO, Oparah OS, Ezeh FE, Olatunji GI. Policy and systems framework linking agricultural practices with improved nutrition outcomes at population level. International Journal of Applied Research in Social Sciences. 2025; 7(10):783-804. Doi: 10.51594/ijarss.v7i10.2083
15. Ajayi-Kaffi O, Igba E, Azonuche TI, Ijiga OM. Agile-Driven Digital Transformation Frameworks for Optimizing Cloud-Based Healthcare Supply Chain Management Systems. International Journal of Scientific Research and Modern Technology. 2025; 4(5):138-156. Doi: https://doi.org/10.38124/ijsrmt.v4i5.1002
16. Akanbi O, Ganiu OS, Sunday EA. A multi-agent AI framework for swarm intelligence in autonomous mobile robot (AMR) fleet coordination. International Journal of Scientific Research in Humanities and Social Sciences. 2025; 2(1):81-109.
17. Akindeji KT, Ewim DRE. Economic and environmental analysis of a grid-connected hybrid power system for a university campus. Bulletin of the National Research Centre. 2023; 47(1):75.
18. Akindeji KT, Aluko A, Ewim DRE, Egieya JM, Mazibuko T, Moloi K. Combined economic emission dispatch using a novel quantum behaved-BAT algorithm for a hybrid microgrid. Proceedings of the 2024 International Conference on Science, Engineering and Business for Sustainable Development, 2024.
19. Akowuah PA, Gyamfi S. Energy security and the renewable energy transition in Africa: A systematic review. Energy Reports. 2021; 7:7290-7303.
20. Aliliele C, Mbonu IS, Iwuanyanwu U. A Review of API Governance and Risk Prioritization Frameworks in Modern Financial Institutions. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2023; 9(10):395-433. Doi: 10.32628/CSEIT2361072
21. Aliliele C, Mbonu IS, Uzoka E, Iwuanyanwu U. Advances in Data Lakehouse Governance Architectures for Enterprise Data Loss Prevention and Compliance Assurance. Shodhshauryam, International Scientific Refereed Research Journal. 2025; 8(4):193-235. Doi: 10.32628/SHISRRJ258474
22. Ambali KB, Eyetsemitan RA, Oyeleye AO, Fadayomi O. Lean Six Sigma for Small Enterprises: A Systematic Review and Lite-DMAIC Adaptation Framework for Resource-Constrained Organizations. IRE Journals. 2021; 5(5):562-583. Doi: 10.64388/IREV5I5-1716957
23. Aminu-Ibrahim A, Ogbete JC. Governance and accountability models for public private partnerships in healthcare infrastructure development. International Journal of Advanced Multidisciplinary Research and Studies. 2024; 4(6):2943-2960.
24. Aminu-Ibrahim A, Ogbete JC, Iwuanyanwu OC. Sustainable Healthcare Infrastructure Performance Metrics for Long-Term Asset Management and Value Creation. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2025; 11(4):566-601. Doi: 10.32628/CSEIT251116277
25. Aminu-Ibrahim AY, Ogbete JC, Ambali KB. Governance and Accountability Models for Public Private Partnerships in Healthcare Infrastructure Development. International Journal of Advanced Multidisciplinary Research and Studies. 2024; 4(6):2943-2960. Doi: 10.62225/2583049X.2024.4.6.5699
26. Anene UN, Clement T. A Resilient Logistics Framework for Humanitarian Supply Chains: Integrating Predictive Analytics, IoT, and Localized Distribution to Strengthen Emergency Response Systems. 2022; 8(5):398-424. Doi: https://doi.org/10.32628/IJSRCSEIT
27. Anene UN, Clement T. Localized Supply Chain Solutions for Sustainable Community Development. 2024; 11(5). Doi: https://doi.org/10.32628/IJSRST

28. Anioke SC, Atima ME. Public health informatics frameworks for protecting vulnerable populations through data-driven policy enforcement. International Journal of Advanced Multidisciplinary Research Studies. 2023; 3(6):2564-2579.
29. Arowogbadamu AA-G, Oziri ST, Bibire OS-L. Data-Driven Customer Value Management Strategies for Optimizing Usage, Retention, and Revenue Growth in Telecoms. Shodhshauryam, International Scientific Refereed Research Journal. 2021; 4(4):294-314. Doi: 10.32628/SHISRRJ214455
30. Arumosoye OM, Obriki OD. Development of an Integrated Heat Stress Risk Conceptual Model for Industrial Operations in Extreme Environments. IRE Journals. 2018; 1(12):141-160. Doi: 10.64388/IREV1I12-1714415
31. Arumosoye OM, Obriki OD. Systematic Review of Near-Miss and Hazard Observation Data Utilization in Industrial Safety Management. IRE Journals. 2019; 3(2):981-999. Doi: 10.64388/IREV3I2-1714417
32. Arumosoye OM, Obriki OD. A Governance-Oriented Conceptual Model for Contractor Safety Performance in Multi-Contract Industrial Projects. International Journal of Multidisciplinary Research and Growth Evaluation. 2020; 1(5):728-740. Doi: 10.54660/.IJMRGE.2020.1.5.728-740
33. Arumosoye OM, Obriki OD. Organizational Learning-Based Conceptual Maturity Model for Continuous Safety Performance Improvement. International Journal of Multidisciplinary Research and Growth Evaluation. 2021; 2(1):970-980. Doi: 10.54660/.IJMRGE.2021.2.1.970-980
34. Arumosoye OM, Obriki OD. Conceptual Risk Pathway Model for Lifting and Rigging Operations in Heavy Industrial Construction. Gyanshauryam, International Scientific Refereed Research Journal. 2022; 5(5):346-369. Doi: 10.32628/GISRRJ2256237
35. Arumosoye OM, Obriki OD. Conceptual Model for Emergency Response Readiness and Capability in Energy and Process Facilities. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2023; 9(3):897-917. Doi: 10.32628/CSEIT25112791
36. Arumosoye OM, Obriki OD. Conceptual Model of Safety Leadership Influence in Large Temporary Project Organizations. International Journal of Advanced Multidisciplinary Research and Studies. 2024; 4(6):3034-3047. Doi: 10.62225/2583049X.2024.4.6.5895
37. Arumosoye OM, Obriki OD, Ozobu CO. Conceptual Framework for Environmental Risk Control and ESG Performance Through Waste Handling and Operational Discipline. Gyanshauryam, International Scientific Refereed Research Journal. 2025; 8(4):177-198. Doi: 10.32628/GISRRJ258367
38. Awanye EN, Ekpedo L, Morah OO, Adeyoyin O, Agbosu EK. Conceptual framework for integrated energy trading risk governance and value optimization decisions. Shodhshauryam, International Scientific Refereed Research Journal. 2024; 7(3):273-290. Doi: https://doi.org/10.32628/SHISRRJ
39. Azeez LO, Badmus O. Predictive analytical framework for identifying vapor intrusion risks across urban redevelopment zones. International Journal of Scientific Research in Humanities and Social Sciences. 2024; 1(1):524-555.
40. Babawurun T, Ewim DRE, Scott TO, Neye-Akogo C. A comprehensive review of wind turbine modeling for addressing energy challenges in Nigeria and South Africa in the 4IR context. The Journal of Engineering and Exact Sciences. 2023; 9(2):15479-15401e.
41. Basnet A, Oghenemaiga E, Anene UN. Real Time Analytics and Monitoring Systems for Livestream Media Performance Using Google Platforms. 2023; 10(1). Doi: https://doi.org/10.32628/IJSRCSEIT
42. Basnet A, Oghenemaiga E, Anene UN. Attribution, Revenue, and Yield Optimization Models Using Google Ad Manager Reporting and Forecasting Tools. 2024; 4(6). Doi: https://doi.org/10.62225/2583049X.2024.4.6.5667
43. Bednar DJ, Reames TG. Recognition of and response to energy poverty in the United States. Nature Energy. 2020; 5(6):432-439.
44. Bednar DJ, Reames TG, Keoleian GA. The intersection of energy and justice: Modeling the spatial, racial/ethnic and socioeconomic patterns of urban residential heating consumption and efficiency in Detroit, Michigan. Energy and Buildings. 2017; 143:25-34. Doi: https://doi.org/10.1016/j.enbuild.2017.03.028
45. Bhattacharyya S, Pathak M, Sharifpur M, Chamoli S, Ewim DRE. Heat transfer and exergy analysis of solar air heater tube with helical corrugation and perforated circular disc inserts. Journal of Thermal Analysis and Calorimetry. 2021; 145(3):1019-1034.
46. Bibire Seyi-Lande O, Arowogbadamu AA, Oziri ST. End-to-End Product Lifecycle Management as a Strategic Framework for Innovation in Telecommunications Services. International Journal of Multidisciplinary Evolutionary Research. 2020; 1(2):54-64. Doi: 10.54660/IJMER.2020.1.2.54-64
47. Bouzarovski S, Petrova S. A global perspective on domestic energy deprivation: Overcoming the energy poverty-fuel poverty binary. Energy Research and Social Science. 2015; 10:31-40.
48. Burke MJ, Stephens JC. Political power and renewable energy futures: A critical review. Energy Research and Social Science. 2018; 35:78-93.
49. Chizoba Michael Okafor, Vivian Chilee Osuji, Omoize Fatimetu Dako. Harmonizing Risk Governance, Technology Infrastructure, and Compliance Frameworks for Future-Ready Banking Systems. International Journal of Scientific Research in Humanities and Social Sciences. 2024; 1(1):316-337. Doi: 10.32628/IJSRSSH
50. Collath N, *et al*. What drives capacity degradation in utility-scale battery energy storage systems? The impact of operating strategy and temperature in different grid applications. Journal of Energy Storage. 2021; 44. Doi: https://doi.org/10.1016/j.est.2021.103217
51. Collins PH. Black Feminist Thought: Knowledge, Consciousness, and the Politics of Empowerment (2nd ed.). Routledge, New York, 2000.
52. Crenshaw K. Demarginalizing the intersection of race and sex: A Black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. University of Chicago Legal Forum. 1989; 1:139-167.
53. Dada T, Isiekwu CP, Oluwo K. Advances in multinational cash flow consolidation and FX risk

control using tiered treasury architecture. IRE Journals. 2021a; 4(11):601-620. Doi: https://doi.org/10.64388/IREV4I11-1714351
54. Dada T, Isiekwu CP, Oluwo K. Designing CRM-based sales forecasting models for multichannel lending institutions. IRE Journals. 2021b; 5(3):451-466. Doi: https://doi.org/10.64388/IREV5I3-1714352
55. Dada T, Isiekwu CP, Oluwo K. Longitudinal study on the effectiveness of entrepreneurial training in emerging economies. International Journal of Advanced Multidisciplinary Research and Studies. 2024; 4(6):2994-3007.
56. Dagodzo D. A Conceptual Framework for UAV Integration into National Power Grid Inspection Programs. IRE Journals. 2018a; 2(5):391-412. Doi: 10.64388/IREV2I5-1716082
57. Dagodzo D. A Review of UAV Applications in Electrical Transmission Line Inspection: Methods, Technologies, and Challenges. IRE Journals. 2018b; 2(6):234-254. Doi: 10.64388/IREV2I6-1716083
58. Dagodzo D, Ahiaeke Patrick MC. UAV-Based Pipeline and Corridor Monitoring: A Review of Current Practices and Emerging Technologies. IRE Journals. 2020; 3(10):574-597. Doi: 10.64388/IREV3I10-1716084
59. Dagodzo D, Ahiaeke Patrick MC. A Review of GIS Applications in Utility Asset Management and Infrastructure Planning. IRE Journals. 2021a; 5(3):468-492. Doi: 10.64388/IREV5I3-1716085
60. Dagodzo D, Ahiaeke Patrick MC. An Integrated Framework for UAV, LiDAR, and GIS in Infrastructure Corridor Management. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2021b; 7(5):497-524. Doi: 10.32628/CSEIT217566
61. Dagodzo D, Ahiaeke Patrick MC. A Review of Right-of-Way Encroachment Detection Methods Using Geospatial Technologies. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2022; 8(1):638-667. Doi: 10.32628/CSEIT2281226
62. Dagodzo D, Ahiaeke Patrick MC. A Framework for Integrating Drone Operations into Enterprise GIS Systems for Utility Companies. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2023a; 9(4):924-957. Doi: 10.32628/CSEIT23564536
63. Dagodzo D, Ahiaeke Patrick MC. A Review of UAV Regulatory Frameworks in Developing Economies: Progress, Gaps, and Recommendations. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2023b; 9(4):958-994. Doi: 10.32628/CSEIT23564537
64. Dagodzo D, Ahiaeke Patrick MC. A Framework for National-Scale UAV Deployment in Power Infrastructure: Lessons from Developing Economies. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2025; 11(4):779-824. Doi: 10.32628/CSEIT251116286
65. Dagodzo D, Ahiaeke Patrick MC, Aliliele C. AI and Deep Learning for Vegetation Classification in Power Corridor Management: A Review. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2022; 8(1):668-698. Doi: 10.32628/CSEIT2281227
66. Dioha MO, Kumar A, Ewim DRE, Emodi NV. Alternative scenarios for low-carbon transport in Nigeria: A long-range energy alternatives planning system model application. In Economic effects of natural disasters, 2021, 511-527.
67. Drehobl A, Ross L. Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities. American Council for an Energy-Efficient Economy, Washington, DC, 2016.
68. Efobi OZ, Akinleye OK, Fasawe O. Framework for Data-Driven Operations Management and Performance Improvement in Educational Institutions, 2021.
69. Ekechi AT. Framework for Evaluating the Thermodynamic Behavior of Gas Turbine Components under Variable Conditions. International Journal of Multidisciplinary Futuristic Development. 2020; 1(5):358-374.
70. Ekechi AT. Conceptual Model for Renewable Energy Integration in Industrial Chemical Engineering Processes. International Journal of Future Engineering Innovations. 2024; 1(6):68-89.
71. Ekechi AT. Framework for Energy Efficiency Enhancement through Process Parameter Optimization in Power Systems. International Journal of Advanced Multidisciplinary Research and Studies. 2024; 4(6):2709-2730.
72. Ekechi AT. Conceptual Framework for Sustainable Chemical Engineering Practices in Emerging Energy Economies. International Journal of Future Engineering Innovations. 2025; 2(6):9-36.
73. Ekechi AT, Fasasi TS. Conceptual Framework for Process Optimization in Gas Turbine Performance and Energy Efficiency. International Journal of Future Engineering Innovations. 2020; 1(2):138-153.
74. El-Rashidy N, Ali ZH, Sultan YA. A Predictive Machine Learning Approach for Early Fault Identification in Solar Photovoltaic Systems. Electric Power Systems Research. 2025; 247:111856. Doi: https://doi.org/10.1016/j.epsr.2025.111856 (Oluwo *et al*., 2024; Adelanwa *et al*., 2024a).
75. Ewim DRE, Dosunmu AG. Bridging gaps: The intersection of women in engineering and gender studies, challenges, advances, and future directions. Discover Global Society. 2025; 3(1):43.
76. Ewim DRE, Olatubosun SA, Abolarin SM. Energy alternatives and efficiency options for sustainable development in Nigeria. In Localized energy transition in the 4th industrial revolution, 2024, 225-245.
77. Eyetsemitan RA, Ambali KB, Oyeleye AO, Fadayomi O. Multi-Stakeholder Governance Alignment in Joint Venture Operations: A Conceptual Framework for Coordinating Business Processes in Highly Regulated Environments. IRE Journals. 2020; 4(4):418-441. Doi: 10.64388/IREV4I4-1716955
78. Eyetsemitan RA, Ambali KB, Oyeleye AO, Fadayomi O. Translating Tax and Regulatory Requirements into SME Compliance Workflows: A Conceptual Framework for Implementing IAS 12, VAT, PAYE, and Withholding Tax. IRE Journals. 2021; 4(11):621-641. Doi: 10.64388/IREV4I11-1716956
79. Eyetsemitan RA, Ambali KB, Oyeleye AO, Fadayomi

O. Change Management in Small Business Digital Transformation: A Systematic Review and Lean Change Adoption Framework. Gyanshauryam, International Scientific Refereed Research Journal. 2023a; 6(6):521-550. Doi: 10.32628/GISRRJ236648
80. Eyetsemitan RA, Ambali KB, Oyeleye AO, Fadayomi O. User Acceptance Testing in Small Business Technology Deployment: A Structured Validation Framework for Lean Operational Environments. International Journal of Multidisciplinary Research and Growth Evaluation. 2023b; 4(6):1512-1531. Doi: 10.54660/IJMRGE.2023.4.6.1512-1531
81. Eyetsemitan RA, Ambali KB, Oyeleye AO, Fadayomi O. An Integrated Lean-Digital Framework for Scaling Small Business Operations: Synthesizing SOP Design, Automation, Compliance, and Change Management. International Journal of Multidisciplinary Research and Growth Evaluation. 2025; 6(6):1341-1360. Doi: 10.54660/IJMRGE.2025.6.6.1341-1360
82. Eyetsemitan RA, Oyeleye AO, Ambali KB, Fadayomi O. Standard Operating Procedures as Strategic Assets in Small Business Operations: A Systematic Review and Implementation Framework. Gyanshauryam, International Scientific Refereed Research Journal. 2022; 5(2):438-465. Doi: 10.32628/GISRRJ225356
83. Eyetsemitan RA, Oyeleye AO, Ambali KB, Fadayomi O. CRM and Workflow Automation in Small Healthcare Practices: A Process Efficiency Framework for Scalable Patient Engagement. International Journal of Multidisciplinary Research and Growth Evaluation. 2024a; 5(6):1931-1949. Doi: 10.54660/IJMRGE.2024.5.6.1931-1949
84. Eyetsemitan RA, Oyeleye AO, Ambali KB, Fadayomi O. Data-Driven Process Optimization in Micro-Enterprises: A Conceptual Framework for Funnel Analysis and Bottleneck Identification. International Journal of Multidisciplinary Research and Growth Evaluation. 2024b; 5(6):1950-1968. Doi: 10.54660/IJMRGE.2024.5.6.1950-1968
85. Farris F, Mele C. Beyond income: Intersectional dimensions of energy poverty in Southern European cities. Energy and Buildings. 2022; 263:112036.
86. Fawole AA, Orikpete OF, Ehiobu NN, Ewim DRE. Climate change implications of electronic waste: Strategies for sustainable management. Bulletin of the National Research Centre. 2023; 47(1):147.
87. Goldemberg J, Johansson TB, Reddy AKN, Williams RH. A global clean cooking fuel initiative. Energy for Sustainable Development. 2004; 8(3):5-12.
88. Guerrero JM, Chandorkar M, Lee T-L, Loh PC. Advanced control architectures for intelligent microgrids, part I: Decentralized and hierarchical control. IEEE Transactions on Industrial Electronics. 2013; 60(4):1254-1262.
89. Hamdan A, Al-Salaymeh A, Al Hamad IM, Ikemba S, Ewim DRE. Predicting future global temperature and greenhouse gas emissions via LSTM model. Sustainable Energy Research. 2023; 10(1):21.
90. Heffron RJ, McCauley D. The concept of energy justice across the disciplines. Energy Policy. 2017; 105:658-667.
91. Hichri A, Hajji M, Mansouri M, Nounou H, Bouzrara K. Supervised Machine Learning-Based SALP Swarm Algorithm for Fault Diagnosis of Photovoltaic Systems. Journal of Engineering and Applied Science. 2024; 71(1):12. Doi: https://doi.org/10.1186/s44147-023-00344-z
92. Idoko IP, Ayodele TR, Abolarin SM, Ewim DRE. Maximizing the cost effectiveness of electric power generation through the integration of distributed generators: Wind, hydro and solar power. Bulletin of the National Research Centre. 2023; 47(1):166.
93. IEEFA and auctusESG. Blended Finance: A viable mechanism for financing energy transition in developing countries, 2024. https://ieefa.org/articles/blended-finance-viable-mechanism-financing-energy-transition-developing-countries
94. Ijiga OM, Anim-Sampong SD, Ilesanmi MO. Land Use Optimization for Utility-Scale Solar and Wind Projects. International Journal of Scientific Research in Science, Engineering and Technology. 2022; 9(6):505-510.
95. Ijiga OM, Okika N, Balogun SA, Agbo OJ, Enyejo LA. Recent Advances in Privacy-Preserving Query Processing Techniques for Encrypted Relational Databases in Cloud Infrastructure. International Journal of Computer Science and Information Technology Research. 2025; 13(3). Doi: https://doi.org/10.5281/zenodo.15834617
96. Ikemba S, Song-Hyun K, Scott TO, Ewim DRE, Abolarin SM, Fawole AA. Analysis of solar energy potentials of five selected south-east cities in Nigeria using deep learning algorithms. Sustainable Energy Research. 2024; 11(1):2.
97. Ilesanmi MO, Bamigwojo OV, Jinadu SO, Oyekan M, Ijiga OM. Mitigating Regulatory and Market Risks in U.S. Renewable Energy Portfolios: A Portfolio Asset Manager's Perspective. International Journal of Scientific Research in Science and Technology. 2023; 10(6):878-906. Doi: https://doi.org/10.32628/IJSRST5231103
98. Ilesanmi MO, Okoh OF, Balogun SA, Ijiga OM. Data-Driven Portfolio Optimization for Utility-Scale Solar, Wind, and Battery Energy Storage Systems (BESS): Integrating Performance Analytics with Investor EBITDA Targets. International Journal of Scientific Research and Modern Technology. 2024; 3(11):141-155.
99. Ilesanmi MO, Raphael FO, Oyekan M, Jinadu SO, Ijiga OM. Hydrogen Integrated Wind Farms: Applying Real-Time Electrolyzer Optimization and Turbine Curtailment Minimization Strategies. South Asia Journal of Multidisciplinary Studies, 2025.
100. International Energy Agency. Accelerating Just Transitions for the Coal Sector: Policies for people-centred and just transitions. IEA, 2023. https://www.iea.org/reports/accelerating-just-transitions-for-the-coal-sector
101. International Energy Agency. Ensuring a Strong Labour Dimension for Just and Inclusive Energy Transitions. IEA. https://www.iea.org/reports/ensuring-a-strong-labour-dimension-for-just-and-inclusive-energy-transitions
102. International Renewable Energy Agency (IRENA). Renewable Power Generation Costs in 2020. IRENA, Abu Dhabi, 2021.
103. Isiekwu CP. A social marketing framework for reducing public resistance to new policy interventions.

International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2025; 11(4):602-624.
104. Isiekwu CP, Oluwo K, Dada T. A conceptual model for CFO-led strategic finance in joint venture and cross-border partnerships. IRE Journals. 2021; 4(7):383-400. Doi: https://doi.org/10.64388/IREV4I7-1714350
105. Isiekwu CP, Oluwo K, Dada T. A post-pandemic strategic collaboration model for banks and capital markets: Addressing resilience, recovery, and growth challenges. International Journal of Advanced Multidisciplinary Research and Studies. 2025; 5(6):2104-2116.
106. Jalal M, Khalil IU, Ul Haq A. Deep Learning Approaches for Visual Faults Diagnosis of Photovoltaic Systems: State-of-the-Art Review. Results in Engineering. 2024; 23:102622. Doi: https://doi.org/10.1016/j.rineng.2024.102622
107. Jessel S, Sawyer S, Hernandez D. Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature. Frontiers in Public Health. 2019; 7:357. Doi: https://doi.org/10.3389/fpubh.2019.00357
108. Jinadu SO, Akinleye KE, Ijiga OM. Deployment of Geological CO_2 Sequestration with Proprietary Injection Techniques for Oil Yield Optimization and Energy Independence. International Journal of Scientific Research in Science, Engineering and Technology. 2024; 11(6).
109. Kou G, Dincer H, Yuksel S, Deveci M. Synergistic integration of digital twins and sustainable industrial internet of things for new generation energy investments. Journal of Advanced Research. 2024; 66:39-46.
110. Lacroix E, Chaton C. Fuel poverty as a determinant of residential energy expenditures: Evidence from France. Energy Policy. 2015; 78:729-736.
111. Liadi KO. Developing a Peacebuilding Effectiveness Framework for Nigeria's Foreign Policy in West Africa. Gyanshauryam, International Scientific Refereed Research Journal (GISRRJ). 2022; 5(1). Doi: 10.32628/GISRRJ203359
112. Liadi KO. An Economic Interdependence Model of Nigeria-China Relations and its Effects on Industrial Growth and Infrastructure. SHISRRJ. 2023a; 6(4). Doi: 10.32628/SHISRRJ236175
113. Liadi KO. Designing an Oil Diplomacy Diversification Model: Assessing the Shift from Petroleum Influence to Broader Economic Engagement. SHISRRJ. 2023b; 6(3). Doi: 10.32628/SHISRRJ236925
114. Liadi KO. A Model for Linking Nigeria's Diplomatic Engagement to Sustainable Development Outcomes in ECOWAS States. GISRRJ. 2023c; 6(3). Doi: 10.32628/GISRRJ236332
115. Liadi KO. A Soft Power Projection Framework: Education, Cultural Diplomacy, and Regional Development in Nigeria's Foreign Policy. GISRRJ. 2024a; 7(2):241-268. Doi: 10.32628/GISRRJ247230
116. Liadi KO. Designing a Cross-Border Security Cooperation Model: Nigeria's Foreign Policy Response to Regional Terrorism. GISRRJ. 2024b; 7(3). Doi: 10.32628/GISRRJ247324
117. Liadi KO. Developing a Humanitarian Diplomacy Model: Nigeria's Foreign Policy and Post-Conflict Recovery in the Sahel. SHISRRJ. 2024c; 7(4). Doi: 10.32628/SHISRRJ247161
118. Liadi KO. Conceptualizing a Governance Reform Impact Model for Nigeria's Peacekeeping Missions in Post-Conflict States. Int. J. Adv. Multidiscip. Res. Stud. 2024d; 4(1):1622-1636. Doi: 10.62573/ijamrs.4.1.2024.ID49
119. Liadi KO. Developing a Continental Peace Integration Framework: Nigeria's Role in African Union Foreign Policy Initiatives. IJMRGE, 2025a.
120. Liadi KO. A Policy Alignment Model for Nigeria's Foreign Policy and Global Climate Diplomacy Goals. IJMRGE, 2025b.
121. Liao W, Ruan J, Xie Y, *et al*. Deep learning time pattern attention mechanism-based short-term load forecasting method. Frontiers in Energy Research. 2023; 11. Doi: https://doi.org/10.3389/fenrg.2023.1227979
122. Lilian IN, Liadi KO, Yeboah TJ. Multilingual ecofeminism and environmental justice: Rethinking gender, language, and ecology in global contexts. Journal of Humanities and Social Policy. 2024; 10(6):195-222.
123. Lilian IN, Liadi KO, Yeboah TJ. Language and Collaboration Across the Humanities and Social Sciences: Addressing Global Challenges Through Multidisciplinary Dialogue. IRE Journals. 2025; 9(1). Doi: 10.64388/IREV9I1-1713696
124. Lilian IN, Liadi KO, Yeboah TJ, Apelehin AA. Understanding Cross-Cultural Communication: Identity, Diversity, and Global Interaction. GISRRJ. 2020; 3(4). Doi: 10.32628/GISRRJ21352
125. Liu W, Gu W, Sheng W, Meng X, Wu Z, Chen W. Decentralized Multi-Agent System-Based Cooperative Frequency Control for Autonomous Microgrids with Communication Constraints. IEEE Transactions on Sustainable Energy. 2014; 5(2):446-456.
126. Lund PD, Lindgren J, Mikkola J, Salpakari J. Review of energy system flexibility measures to enable high levels of variable renewable electricity. Renewable and Sustainable Energy Reviews. 2015; 45:785-807.
127. Mbasso WF, Harrison, *et al*. Digital twins in renewable energy systems: A comprehensive review of concepts, applications, and future directions. Energy Strategy Reviews / ScienceDirect, 2025. https://www.sciencedirect.com/science/article/pii/S2211467X25001774
128. Mbonu IS, Aliliele C, Iwuanyanwu U, Oluoha OM. A Conceptual Framework for Legal and Ethical Risk Modeling in Enterprise Data Protection Governance Systems. Iconic Research and Engineering Journals. 2018; 2(2):207-226. Doi: 10.64388/IREV2I2-1714911
129. Mbonu IS, Iwuanyanwu U, Aliliele C, Uzoka E. Advances in Infrastructure as Code Governance for Secure Terraform Based Enterprise Cloud Deployments. International Journal of Multidisciplinary Research and Growth Evaluation. 2020; 1(5):811-828. Doi: 10.54660/.IJMRGE.2020.1.5.811-828
130. Mbonu IS, Iwuanyanwu U, Aliliele C, Uzoka E. Advances in Cloud Identity and Access Governance Optimization in Large Scale AWS Enterprise Environments. Shodhshauryam, International Scientific Refereed Research Journal. 2022; 5(3):403-438. Doi: 10.32628/SHISRRJ225490

131. Memmott T, Carley S, Graff M, Konisky DM. Sociodemographic disparities in energy insecurity among low-income households before and during the COVID-19 pandemic. Nature Energy. 2021; 6(2):186-193.
132. Michael ON, Ogunsola OE. Analyzing the Alignment of Agricultural Policy Frameworks with National Sustainable Development Priorities. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2021a; 7(1):492-518. Doi: 10.32628/IJSRCSEIT
133. Michael ON, Ogunsola OE. Assessing the Role of Digital Agriculture Tools in Shaping Sustainable and Inclusive Food Systems. Gyanshauryam, International Scientific Refereed Research Journal. 2021b; 4(4):154-181. Doi: 10.32628/GISRRJ
134. Michael ON, Ogunsola OE. Impact of Data-Driven Agricultural Policy Models on Food Production Efficiency and Resource Optimization. Gyanshauryam, International Scientific Refereed Research Journal. 2021c; 4(4):182-208. Doi: 10.32628/GISRRJ
135. Michael ON, Ogunsola OE. Examining the Socioeconomic Barriers to Technological Adoption Among Smallholder Farmers in Remote Rural Areas. Shodhshauryam, International Scientific Refereed Research Journal. 2022a; 5(6):484-519. Doi: 10.32628/SHISRRJ
136. Michael ON, Ogunsola OE. Exploring Gender Inclusion and Equity Across Agricultural Value Chains in Sub-Saharan Africa's Emerging Markets. Gyanshauryam, International Scientific Refereed Research Journal. 2022b; 5(5):258-289. Doi: 10.32628/GISRRJ
137. Michael ON, Ogunsola OE. Applying Quantitative Agricultural Economics Models to Improve Food System Efficiency and Policy Decision-Making. Shodhshauryam, International Scientific Refereed Research Journal. 2023a; 6(1):228-255. Doi: 10.32628/SHISRRJ
138. Michael ON, Ogunsola OE. Evaluating the Effectiveness of Rural Innovation Hubs in Accelerating Agricultural Transformation and Economic Empowerment. Gyanshauryam, International Scientific Refereed Research Journal. 2023b; 6(1):369-399. Doi: 10.32628/GISRRJ
139. Michael ON, Ogunsola OE. Integrating Entrepreneurship Education into Agribusiness Curricula to Strengthen Sustainable Agricultural Competitiveness. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2023c; 10(1):782-808. Doi: 10.32628/IJSRCSEIT
140. Michael ON, Ogunsola OE. Assessing the Potential of Renewable Energy Technologies for Sustainable Irrigation and Smallholder Farm Productivity. International Journal of Scientific Research in Humanities and Social Sciences. 2024a; 1(1):380-411. Doi: 10.32628/IJSRSSH
141. Michael ON, Ogunsola OE. Developing Circular Economy Frameworks for Waste Reduction and Resource Efficiency in Agricultural Systems. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2024b; 10(8):271-300. Doi: 10.32628/IJSRCSEIT
142. Michael ON, Ogunsola OE. Evaluating the Role of International Research Collaboration in Strengthening Global Food Security and Agricultural Innovation. International Journal of Scientific Research in Humanities and Social Sciences. 2024c; 1(1):412-441. Doi: 10.32628/IJSRSSH
143. Michael ON, Ogunsola OE. Advancing Rural Agribusiness Innovation Strategies for Building Climate-Resilient and Economically Inclusive Communities. Journal of Social Science and Human Research Studies. 2025a; 1(5):161-177. Doi: 10.65150/EP-jsshrs/V1E5/2025-02
144. Michael ON, Ogunsola OE. Agribusiness Diversification Strategies for Managing Economic Volatility in Resource - Constrained Agricultural Economies. IRE Journals, 2025b. ISSN: 2456 - 8880. f
145. Michael ON, Ogunsola OE. Evaluating the Impact of Sustainable Agriculture Curriculum Integration on STEM Education and Career Outcomes. Journal of Social Science and Human Research Studies. 2025c; 1(5):178-194. Doi: 10.65150/EP-jsshrs/V1E5/2025-03
146. Michael ON, Ogunsola OE. Determinants of Access to Agribusiness Finance and their Influence on Enterprise Growth in Rural Communities. Iconic Research and Engineering Journals. 2019a; 2(12):533-548.
147. Michael ON, Ogunsola OE. Strengthening Agribusiness Education and Entrepreneurial Competencies for Sustainable Youth Employment in Sub-Saharan Africa. Iconic Research and Engineering Journals. 2019b; 2(9):416-431.
148. Michael ON, Ogunsola OE. Assessing the Role of Artificial Intelligence in Transforming Decision Making Across Modern Agricultural Systems. Engineering and Technology Journal, 2025d. e-ISSN: 2456-3358. Doi: 10.47191/etj/v10i12.06, I.F. - 8.482
149. Michael ON, Ogunsola OE. Analyzing the Alignment of Agricultural Policy Frameworks with National Sustainable Development Priorities. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2021; 7(1):492-518. Doi: 10.32628/IJSRCSEIT
150. Michael ON, Ogunsola OE. Assessing the Potential of Renewable Energy Technologies for Sustainable Irrigation and Smallholder Farm Productivity. International Journal of Scientific Research in Humanities and Social Sciences. 2024; 1(1):380-411. Doi: 10.32628/IJSRSSH
151. Middlemiss L, *et al*. Who is vulnerable to energy poverty in the Global North, and what is their experience? WIREs Energy and Environment. 2022; 11. Doi: https://doi.org/10.1002/wene.455
152. Muhtadi A, Pandit D, Nguyen N, Mitra J. Distributed Energy Resources Based Microgrid: Review of Architecture, Control, and Reliability. IEEE Transactions on Industry Applications. 2021; 57(3). Doi: https://doi.org/10.1109/TIA.2021.3065329
153. Mutambatsere E. Blended finance can catalyse renewable energy investments in low-income countries. Global Infrastructure Hub / IFC, 2022. https://www.gihub.org/articles/blended-finance-can-catalyse-renewable-energy-investments-in-low-income-countries/
154. Nduka S. Digital Framework for Precision Soil Management Using Geospatial and Predictive

Analytics. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2023; 9(6). Doi: https://doi.org/10.32628/CSEIT23906207
155. Nnabueze SB, Ike PN, Olatunde-Thorpe J, Aifuwa SE, Oshoba TO, Ogbuefi E, *et al*. End-to-end visibility frameworks improving transparency, compliance, and traceability across complex global supply chain operations. International Journal of Multidisciplinary Futuristic Development. 2021; 2(2):50-60. Doi: https://doi.org/10.54660/IJMFD.2021.2.2.50-60
156. Nnaji EC, Adgidzi D, Dioha MO, Ewim DRE, Huan Z. Modelling and management of smart microgrid for rural electrification in sub-Saharan Africa: The case of Nigeria. The Electricity Journal. 2019; 32(10):106672.
157. Nnaji EC, Adgidzi D, Dioha MO, Ewim DRE, Huan Z. Corrigendum to Modelling and management of smart microgrid for rural electrification in sub-Saharan Africa: The case of Nigeria. Electricity Journal. 2020; 33(4):106751.
158. Ntuli MN, Dioha MO, Ewim DRE, Eloka-Eboka AC. Review of energy modelling, energy efficiency models improvement and carbon dioxide emissions mitigation options for the cement industry in South Africa. Materials Today: Proceedings. 2022; 65:2260-2268.
159. Ntuli MN, Eloka-Eboka AC, Mwangi FM, Ewim DRE, Dioha MO. Energy sustainability and carbon dioxide emissions mitigation options for South Africa's road transport sector. Bulletin of the National Research Centre. 2024; 48(1):37.
160. Ntuli M, Ewim DRE, Dioha M, Eloka-Eboka AC. Energy efficiency improvement and CO_2 emission mitigation options for the cement industry in South Africa. 5th International Conference on Engineering for a Sustainable World (ICESW), Covenant University, Ota, Nigeria, 2021.
161. Nussbaumer P, Bazilian M, Modi V. Measuring energy poverty: Focusing on what matters. Renewable and Sustainable Energy Reviews. 2012; 16(1):231-243.
162. Obogo SF, Arumosoye OM, Obriki OD. Advances in Internal QHSE Audit Systems for Industrial Engineering Operations. Iconic Research and Engineering Journals. 2020a; 4(4):399-417. Doi: 10.64388/IREV4I4-1715499
163. Obogo SF, Arumosoye OM, Obriki OD. Conceptual Risk Management Model for Heavy Lifting and Crane Installation Engineering Operations. Shodhshauryam, International Scientific Refereed Research Journal. 2020b; 3(4):122-144. Doi: 10.32628/SHISRRJ214441
164. Obogo SF, Arumosoye OM, Obriki OD. Critical Review of Occupational Safety Management Systems in Oil and Gas Maintenance Projects. Shodhshauryam, International Scientific Refereed Research Journal. 2020c; 3(4):145-166. Doi: 10.32628/SHISRRJ214442
165. Obogo SF, Arumosoye OM, Obriki OD. Advances in Proactive Hazard Recognition and Near Miss Reporting Systems. International Journal of Multidisciplinary Research and Growth Evaluation. 2021a; 2(6):835-846. Doi: 10.54660/IJMRGE.2021.2.6.835-846
166. Obogo SF, Arumosoye OM, Obriki OD. Review of Sustainable Environmental Practices in Occupational Safety Management Systems. International Journal of Scientific Research in Civil Engineering. 2024a; 8(3):164-196. Doi: 10.32628/IJSRCE248420
167. Obogo SF, Nwafor MI, Ozobu CO. Conceptual Leadership Model for Safety Culture Development in Construction and Engineering Projects. International Journal of Scientific Research in Civil Engineering. 2023; 7(6):121-153. Doi: 10.32628/IJSRCE237554
168. Obogo SF, Obriki OD, Arumosoye OM. Conceptual Model for Incident Prevention in Industrial Maintenance Engineering Environments. International Journal of Multidisciplinary Research and Growth Evaluation. 2021b; 2(6):847-858. Doi: 10.54660/IJMRGE.2021.2.6.847-858
169. Obogo SF, Obriki OD, Arumosoye OM. Conceptual Safety Governance Model for Large Commercial Facility Operations. Gyanshauryam, International Scientific Refereed Research Journal. 2022; 5(6):383-410. Doi: 10.32628/GISRRJ225639
170. Obogo SF, Ozobu CO, Nwafor MI. Conceptual Environmental Safety Compliance Framework for Construction and Infrastructure Projects. International Journal of Scientific Research in Civil Engineering. 2024c; 8(3):132-163. Doi: 10.32628/IJSRCE248419
171. Obogo SF, Ozobu CO, Uduokhai DO. Advances in Leadership Driven Safety Culture Transformation in Large Construction Workforces. Iconic Research and Engineering Journals. 2019a; 3(5):507-523. Doi: 10.64388/IREV3I5-1715497
172. Obogo SF, Ozobu CO, Uduokhai DO. Development of a Construction Safety Risk Governance Model for Multi Contractor High Rise Projects. Iconic Research and Engineering Journals. 2019b; 2(9):502-522. Doi: 10.64388/IREV2I9-1715495
173. Obogo SF, Ozobu CO, Nwafor MI, Adio SA. Advances in Hazard Identification Systems for Large Scale Construction Operations. International Journal of Scientific Research in Civil Engineering. 2025a; 9(6):37-70. Doi: 10.32628/IJSRCE2154969
174. Obogo SF, Ozobu CO, Sanusi AN, Ajirotutu RO. Conceptual Integrated Safety Management Model for Multi Zone Urban Infrastructure Projects. International Journal of Scientific Research in Civil Engineering. 2025b; 9(5):22-55. Doi: 10.32628/IJSRCE2593012
175. Obogo SF, Uduokhai DO, Ozobu CO. Systematic Review of Hazard Identification and Risk Control Practices in Urban Construction Projects. Iconic Research and Engineering Journals. 2019c; 2(12):666-681. Doi: 10.64388/IREV2I12-1715496
176. Obogo SF, Uduokhai DO, Ozobu CO. Review of Contractor Safety Compliance Systems in Infrastructure Engineering Projects. International Journal of Scientific Research in Civil Engineering. 2021c; 5(4):76-100. Doi: 10.32628/IJSRCE215412
177. Odejobi OD, Okonkwo CS, Ahiaeke Patrick MC, Okeke OT, Mayo W. AI-Augmented Secure Software Engineering: Leveraging Deep Learning for Autonomous Threat Detection and Mitigation. International Journal of Engineering and Modern Technology (IJEMT). 2025; 11(12):101-121. Doi: 10.56201/ijemt.vol.11.no12.2025.pg101.121
178. OECD. Blended Finance for Clean Energy: Revisiting the OECD DAC Blended Finance Principles. OECD Publishing. https://www.oecd.org/en/about/programmes/clean-energy-finance-and-investment-mobilisation/blended-finance-for-clean-energy.html

179. Ofoedu AT, Ozor JE, Sofoluwe O, Jambol DD. A machine learning-based fault forecasting model for subsea process equipment in harsh production environments. International Journal of Scientific Research in Civil Engineering. 2022; 6(6):123-135.
180. Ofoedu AT, Ozor JE, Sofoluwe O, Jambol DD. A Holistic Control System Framework for Managing Complex Multistream Crude Processing in Floating Production Units. International Journal of Scientific Research in Civil Engineering. 2023; 7(3):83-101.
181. Ogbuefi E, Aifuwa SE, Olatunde-Thorpe J, Akokodaripon D. Resilience in Critical Infrastructures: Conceptual Frameworks Addressing Convergence of Communication, Energy, Finance, and Healthcare Systems. convergence (Ngonso *et al*., 2025; Oni, 2025). 2025; 33:54.
182. Oghenemaiga E, Basnet A, Anene UN. Predictive Analytics Applications for Forecasting Traffic Patterns Across Owned and Operated Media Platforms. 2024; 4(6). Doi: https://doi.org/10.62225/2583049X.2024.4.6.5668
183. Ogunsola OE, Michael ON. Analyzing the alignment of agricultural policy frameworks with national sustainable development priorities. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2021; 7(1):518.
184. Ogunwole O, Okonkwo CS, Agbabiaka J, Mayo W, Okeke OT. Supply Chain Resilience Framework for Critical Infrastructure and Gas Processing Plants. Shodhshauryam, International Scientific Refereed Research Journal. 2021; 4(4):444-461. Doi: 10.32628/SHISRRJ214462
185. Okafor CM, Osuji VC, Dako OF. Harmonizing risk governance, technology infrastructure, and compliance frameworks for future-ready banking systems. International Journal of Scientific Research in Humanities and Social Sciences. 2024; 1(1):316-337.
186. Okojie JS, Filani OM, Ike PN, Okojokwu-Idu JO, Nnabueze SB, Ihwughwavwe SI. Integrating AI with ESG metrics in smart infrastructure auditing for high-impact urban development projects. International Journal of Multidisciplinary Futuristic Development. 2023a; 4(1):32-44. Doi: https://doi.org/10.54660/IJMFD.2023.4.1.32-44
187. Okojie J, Ike P, Idu J, Nnabueze SB, Filani O, Ihwughwavwe S. Predictive analytics models for monitoring smart city emissions and infrastructure risk in urban ESG planning. International Journal of Multidisciplinary Futuristic Development. 2023b; 4(1):45-57. Doi: https://doi.org/10.54660/IJMFD.2023.4.1.45-57
188. Okonkwo CS, Agbabiaka J, Mayo W, Okeke OT. Conceptual Framework for Digital Supply Chain Governance in Energy and Infrastructure Sectors. Gyanshauryam, International Scientific Refereed Research Journal. 2024a; 7(4):335-356. Doi: 10.32628/GISRRJ247423
189. Okonkwo CS, Agbabiaka J, Mayo W, Okeke OT. Framework for Secure and Scalable Supply Chain Systems Supporting National Energy Reliability. International Journal of Advanced Multidisciplinary Research and Studies. 2024b; 4(6):2816-2826. Doi: 10.62225/2583049X.2024.4.6.5494
190. Okonkwo CS, Agbabiaka J, Mayo W, Okeke OT. Model for Predictive Procurement Planning to Sustain Operational Uptime. International Journal of Scientific Research in Humanities and Social Sciences. 2024c; 1(2):909-928. Doi: 10.32628/IJSRSSH242772
191. Okonkwo CS, Agbabiaka J, Mayo W, Okeke OT. Review of Advances in Procurement Strategy, ERP Adoption, and Logistics Performance. International Journal of Advanced Multidisciplinary Research and Studies. 2024d; 4(6):2827-2835. Doi: 10.62225/2583049X.2024.4.6.5495
192. Okonkwo CS, Agbabiaka J, Mayo W, Okeke OT. Review of Digital Supply Chain Models for Cost Control and Operational Continuity. International Journal of Advanced Multidisciplinary Research and Studies. 2024e; 4(6):2836-2846. Doi: 10.62225/2583049X.2024.4.6.5496
193. Okonkwo CS, Agbabiaka J, Mayo W, Okeke OT. Supply Chain Automation Framework Using Service Management Platforms. Shodhshauryam, International Scientific Refereed Research Journal. 2024f; 7(2):157-177. Doi: 10.32628/SHISRRJ2472157
194. Okonkwo CS, Agbabiaka J, Mayo W, Okeke OT. Framework for National-Scale Supply Chain Optimization Through Integrated IT and Procurement Systems. Gulf Journal of Advance Business Research. 2025; 3(12):1610-1625.
195. Okonkwo CS, Agbabiaka J, Ogunwole O, Mayo W, Okeke OT. Model for Demurrage Elimination and Port Logistics Efficiency in Emerging Economies. International Journal of Multidisciplinary Research and Growth Evaluation. 2020; 1(5):552-562. Doi: 10.54660/IJMRGE.2020.1.5.552-562
196. Okonkwo CS, Agbabiaka J, Ogunwole O, Mayo W, Okeke OT. Supply Chain Resilience Framework for Critical Infrastructure and Gas Processing Plants. Shodhshauryam, International Scientific Refereed Research Journal. 2021; 4(4):444-461.
197. Okonkwo CS, Agbabiaka J, Ogunwole O, Mayo W, Okeke OT. Conceptual Model for Materials Readiness and Maintenance-Driven Supply Chain Performance. International Journal of Multidisciplinary Research and Growth Evaluation. 2021a; 2(6):584-594. Doi: 10.54660/IJMRGE.2021.2.6.584-594
198. Okonkwo CS, Ahiaeke Patrick MC, Okeke OT, Mayo W. Framework for Integrating IT Systems Engineering with Supply Chain Operations. International Journal of Advanced Multidisciplinary Research and Studies. 2023a; 3(6):2580-2589. Doi: 10.62225/2583049X.2023.3.6.5500
199. Okonkwo CS, Mayo W, Okeke OT. Conceptual Model for Asset Lifecycle Management and Inventory Visibility. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2023b; 10(1):809-824. Doi: 10.32628/CSEIT2391568
200. Okonkwo CS, Ogunwole O, Okeke OT. Framework for Strategic Procurement Optimization in Oil and Gas Operations. IRE Journals. 2018a; 1(7):153-168. Doi: 10.64388/IREV1I7-1713119
201. Okonkwo CS, Ogunwole O, Okeke OT. Model for Inventory Availability and Plant Uptime Improvement in Energy Facilities. IRE Journals. 2018b; 2(4):160-172. Doi: 10.64388/IREV2I4-1713120

202. Okonkwo CS, Ogunwole O, Mayo W, Okeke OT. Framework for Regulatory-Compliant Procurement in High-Risk Energy Environments. International Journal of Multidisciplinary Research and Growth Evaluation. 2021b; 2(6):595-605. Doi: 10.54660/IJMRGE.2021.2.6.595-605
203. Okonkwo CS, Ogunwole O, Okeke OT, Mayo W. Conceptual Framework for Cost Reduction Through Contract Negotiation and Vendor Governance. IRE Journals. 2019; 2(9):468-482. Doi: 10.64388/IREV2I9-1713121
204. Okonkwo CS, Agbabiaka J, Mayo W, Okeke OT. Conceptual Framework for Digital Supply Chain Governance in Energy and Infrastructure Sectors. Gyanshauryam, International Scientific Refereed Research Journal. 2024; 7(4):335-356. Doi: 10.32628/GISRRJ247423
205. Okoye CC, Scott TO, Uchechukwu ES, Okeke NM, Onyebuchi CN, Udokwu STC, *et al*. Integrating business principles in STEM education: Fostering entrepreneurship in students and educators in the US and Nigeria. IJEBD. 2023; 6(4):590-605.
206. Okuh CO, Nwulu EO, Ogu E, Egbumokei PI, Dienagha IN, Digitemie WN. A Strategic Model for Carbon Emission Reduction through Process Optimization in Energy Sector Operations. International Journal of Multidisciplinary Research and Growth Evaluation. 2024; 5(1):1309-1317.
207. Okuh CO, Nwulu EO, Ogu E, Egbumokei PI, Dienagha IN, Digitemie WN. Creating a Workforce Upskilling Model to Address Emerging Technologies in Energy and Oil and Gas Industries. International Journal of Multidisciplinary Research and Growth Evaluation. 2024; 5(1):1327-1339.
208. Okwu MO, Samuel OD, Ewim DRE, Huan Z. Estimation of biogas yields produced from combination of waste by implementing response surface methodology (RSM) and adaptive neuro-fuzzy inference system (ANFIS). International Journal of Energy and Environmental Engineering. 2021; 12(2):353-363.
209. Olabi AG, Abdelkareem MA. Renewable energy and climate change. Renewable and Sustainable Energy Reviews. 2022; 158:112111.
210. Oladoye SO, Bamigwojo OV, James AO, Ijiga OM. AI-Driven Predictive Maintenance Modeling for High-Voltage Distribution Assets. International Journal of Scientific Research in Science, Engineering and Technology. 2021; 11(2):387-411.
211. Oladoye SO, Bamigwojo OV, James AO, Ijiga OM. Grid Integration and Reliability Analysis of Electric Vehicle Charging Infrastructure in Weak Distribution Networks. International Journal of Scientific Research in Science and Technology. 2022; 9(3):881-902.
212. Oladoye SO, Bamigwojo OV, Ogboji AJ, Ijiga OM. Techno-Economic Evaluation of Hybrid Solar Diesel Microgrids for Underserved Communities. Engineering Science and Technology Journal, 2023. Doi: 10.51594/estj.v5i
213. Olanrewaju FB, Oboh IO, Adesina OA, Anyanwu CS, Ewim DRE. Modelling and simulation of hydrogen production plant for minimum carbon dioxide emission. The Journal of Engineering and Exact Sciences. 2023; 9(1):15394-01e.
214. Olatunde-Thorpe J, Aifuwa SE, Oshoba TO, Ogbuefi E, Akokodaripon D. Framework for aligning organizational risk culture with cybersecurity governance objectives. International Journal of Multidisciplinary Futuristic Development. 2021; 2(2):61-71.
215. Oluwo K, Dada T, Isiekwu CP. Transforming insurance underwriting with machine learning: A review and application cases. International Journal of Advanced Multidisciplinary Research and Studies. 2024; 4(6):3008-3019.
216. Onyiriuka EJ, Ewim DRE, Abolarin SM. An optimization technique to identify simulation assumptions for various nanofluids using machine learning. International Heat Transfer Conference Digital Library, 2023.
217. Oparah OS, Ezeh FE, Olatunji GI, Ajayi OO. Framework for integrating climate data and health outcomes to improve mortality risk prediction systems. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2024; 10(2):1128-1150.
218. Oparah OS, Ezeh FE, Olatunji GI, Ajayi OO. Framework for Integrating Climate Data and Health Outcomes to Improve Mortality Risk Prediction Systems. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2024; 10(2):1128-1150. Doi: 10.32628/IJSRCSEIT
219. Orikpete OF, Ewim DRE. Adoption of occupational health and safety as a fundamental human right and its implications for Nigerian workers. International Journal of Occupational Safety and Health. 2023; 13(3):396-408.
220. Orikpete OF, Ewim DRE. Harmonising efficiency and sustainability: A techno-economic analysis of green hydrogen production methods. In Challenges and opportunities in green hydrogen production, 2024, 537-567.
221. Orikpete OF, Gungura NM, Ehimare E, Ewim DRE. A critical review of energy consumption and optimization strategies in the Nigerian aviation sector: Challenges and prospects. Bulletin of the National Research Centre. 2023; 47(1):170.
222. Orikpete OF, Ikemba S, Ewim DRE. Integration of renewable energy technologies in smart building design for enhanced energy efficiency and self-sufficiency. The Journal of Engineering and Exact Sciences. 2023; 9(9):16423-01e.
223. Oyeleye AO, Eyetsemitan RA, Ambali KB, Fadayomi O. Reducing Client Onboarding Cycle Time in Small Professional Services Firms: A Lean Six Sigma Process Redesign Framework. Gyanshauryam, International Scientific Refereed Research Journal. 2022; 5(2):467-498. Doi: 10.32628/GISRRJ225357
224. Oziri ST, Arowogbadamu AA, Bibire Seyi-Lande O. Transforming Big Data into Strategy: Comprehensive Frameworks for Business Optimization in Telecommunications. Gulf Journal of Engineering & Technology. 2025; 1(5):94-111. Doi: 10.47191/gjet/v10501.94
225. Oziri ST, Arowogbadamu AA-G, Seyi-Lande OB. Transforming big data into strategy: Comprehensive frameworks for business optimization in

telecommunications. Gulf Journal of Engineering & Technology. 2025; 1(5):94-111.
226. Ozor JE, Sofoluwe O, Jambol DD. Next-generation micro emulsion breaker technologies for enhanced oil recovery. Environments. 2021; 20(1):21-35.
227. Pai S, Harrison K, Zerriffi H. A systematic review of the key elements of a just transition for fossil fuel workers. One Earth. 2021; 4(11):1398-1411.
228. Patrick MCA, Okonkwo CS, Mayo W, Okeke OT. A GIS Enabled Framework for Modern ERP Procurement Processes. International Journal of Multidisciplinary Research and Growth Evaluation. 2020; 1(5):499-508. Doi: 10.54660/IJMRGE.2020.1.5.499-508
229. Patrick MCA, Okonkwo CS, Mayo W, Okeke OT. Model for Data Driven Vendor Evaluation and Bid Selection Using Geospatial Intelligence. Shodhshauryam, International Scientific Refereed Research Journal. 2021; 4(4):426-443. Doi: 10.32628/SHISRRJ214461
230. Pierson P. Increasing returns, path dependence, and the study of politics. American Political Science Review. 2000; 94(2):251-267.
231. Rajaperumal TA, Christopher Columbus C. Enhanced wind power forecasting using machine learning, deep learning models and ensemble integration. Scientific Reports. 2025; 15. Doi: https://doi.org/10.1038/s41598-025-05250-3
232. Reames TG. Targeting energy justice: Exploring spatial, racial/ethnic and socioeconomic disparities in urban residential heating energy efficiency. Energy Policy. 2016; 97:549-558.
233. Robinson C. Energy poverty and gender in Europe: A systematic review of the evidence. Energy Research and Social Science. 2019; 54:12-26.
234. Rukh S, Seyi-Lande OB, Oziri ST. An integrated framework for AI and predictive analytics in supply chain management. International Journal of Scientific Research in Humanities and Social Sciences. 2024; 1(1):451-491.
235. Shah Rukh, Omorinsola Bibire Seyi-Lande, Stanley Tochukwu Oziri. Framework Design for Machine Learning Adoption in Enterprise Performance Optimization. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2022; 8(3):798-830. Doi: 10.32628/IJSRCSEIT
236. Shah Rukh, Omorinsola Bibire Seyi-Lande, Stanley Tochukwu Oziri. An Integrated Framework for AI and Predictive Analytics in Supply Chain Management. International Journal of Scientific Research in Humanities and Social Sciences. 2024; 1(1):451-491. Doi: 10.32628/IJSRSSH
237. Shittu H, Opara IS, Elumilade RA, Liadi KO, Adeniji IO. Hydrogen as a secondary energy carrier: Modeling its integration in national grids. IRE Journals. 2019; 3(1):628-643.
238. Smith K, *et al*. Life Prediction Model for Grid-Connected Li-Ion Battery Energy Storage System. American Control Conference. National Renewable Energy Laboratory, 2017. NREL/CP-5400-67102. https://docs.nrel.gov/docs/fy17osti/67102.pdf
239. Solar Electric Light Fund. Community Solar Microgrids: A Sustainable Solution for Energy Access, 2025. https://www.self.org/articles/community-solar-microgrids/
240. Sovacool BK. The political economy of energy poverty: A review of key challenges. Energy for Sustainable Development. 2012; 16(3):272-282.
241. Sovacool BK, Dworkin MH. Energy justice: Conceptual insights and practical applications. Applied Energy. 2015; 142:435-444.
242. Stirling A. Transforming power: Social science and the politics of energy choices. Energy Research and Social Science. 2014; 1:83-95.
243. Strengers Y, Maller C. (Eds.). Social Practices, Intervention and Sustainability: Beyond Behaviour Change. Routledge, London, 2015.
244. Suku PG, Ugwoha E, Orikpete OF, Ewim DRE. The socio-economic and environmental impacts of petroleum refinery operations in the Niger Delta region. The Journal of Engineering and Exact Sciences. 2023; 9(11):18333-18333.
245. Sunday EA, Omoegun GO, Essien MA, Oluokun OA. Transitioning from reactive to predictive maintenance in mechanical systems. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2020; 6(6):425-447.
246. U.S. Department of Energy, Office of Electricity. Community Microgrid Assistance Partnership (C-MAP) for underserved and Indigenous communities, 2024. https://www.energy.gov/oe/articles/new-microgrid-program-help-underserved-and-indigenous-communities-0
247. Uduafemhe ME, Ewim DRE, Karfe RY. Adapting to the new normal: Equipping career and technical education graduates with essential digital skills for remote employment. ATBU Journal of Science, Technology and Education. 2023; 11(4):51-62.
248. Uduafemhe ME, Ewim DRE, Karfe RY, Abuh AY. Transforming technical and vocational education and training in Nigeria through AI and new technologies: A strategic framework for enhancing learner engagement and employability. Proceedings of the Hybrid Conference, 2024, p. 524.
249. Uduokhai DO, Garba BMP, Nwafor MI, Sanusi AN. Techno-Economic Evaluation of Renewable-Material Construction for Low-Income Housing Communities. International Journal of Scientific Research in Humanities and Social Sciences. 2024; 1(2):888-908.
250. Uduokhai DO, Nwafor MI, Sanusi AN, Garba BMP. Predictive framework for optimizing maintenance schedules in aging public infrastructure systems. Global Journal of Engineering and Technology Review. 2025; 1(3):142-152.
251. Uduokhai DO, Nwafor MI, Stephen GODI, Adio SA. Simulation-Based Framework for Energy Efficiency Optimization in Educational and Institutional Buildings. Gyanshauryam, International Scientific Refereed Research Journal. 2022; 5(5):305-321.
252. Uduokhai DO, Nwafor MI, Sanusi AN, Garba BMP. Predictive Framework for Optimizing Maintenance Schedules in Aging Public Infrastructure Systems. Global Journal of Engineering and Technology Review. 2025; 1(3):142-152. Doi: 10.65150/EP-gjetr/V1E3/2025-06
253. Uduokhai DO, Nwafor MI, Stephen GODI, Adio SA.

Risk Management Framework for Mitigating Cost Overruns in Public Housing Development Projects. International Journal of Scientific Research in Computer Science, Engineering and Information Technology. 2021; 7(5):325-349. Doi: 10.32628/CSEIT217559
254. Uduokhai DO, Patrick Garba BM, Nwafor MI, Sanusi AN. Techno-Economic Evaluation of Renewable-Material Construction for Low-Income Housing Communities. International Journal of Scientific Research in Humanities and Social Sciences. 2024; 1(2):888-908. Doi: 10.32628/IJSRSSH242771
255. Waddams Price C, Brazier K, Wang W. Objective and subjective measures of fuel poverty. Energy Policy. 2012; 49:33-39.
256. Walker G, Day R. Fuel poverty as injustice: Integrating distribution, recognition and procedure in the struggle for affordable warmth. Energy Policy. 2012; 49:69-75.
257. Wedraogo L, Sanni JO. Machine Learning Models Addressing Uncertainty in Cross-Channel Campaign Performance Forecasting Accuracy. International Journal of Advanced Multidisciplinary Research and Studies. 2024; 4(6):2875-2890. Doi: 10.62225/2583049X.2024.4.6.5648
258. Wen X, Liao J, Niu Q, Shen N, Bao Y. Deep learning-driven hybrid model for short-term load forecasting and smart grid information management. Scientific Reports. 2024; 14. Doi: https://doi.org/10.1038/s41598-024-63262-x
259. World Bank. Towards a just coal transition for workers: What does it take? Studies of Wielkopolska, Silesia, and Lower Silesia, Poland, 2024. https://blogs.worldbank.org/en/jobs/towards-just-coal-transition-workers-what-does-it-take
260. World Bank. Tracking SDG 7: The Energy Progress Report 2021. World Bank Group, Washington DC, 2021.
261. World Resources Institute. Building a Just Clean Energy Transition for US Fossil Fuel Workers. https://www.wri.org/insights/steps-aid-us-fossil-fuel-workers-clean-energy-transition
262. Wustenhagen R, Wolsink M, Burer MJ. Social acceptance of renewable energy innovation: An introduction to the concept. Energy Policy. 2007; 35(5):2683-2691.
263. Yeboah BK, Enow OF. Conceptual framework for reliability-centered maintenance programs in electricity distribution utilities. Iconic Research and Engineering Journals. 2018; 2(3):140-153.
264. Yeboah BK, Ike PN. Programmatic strategy for renewable energy integration: Lessons from large-scale solar projects. International Journal of Multidisciplinary Research and Growth Evaluation. 2020; 1(3):306-315. Doi: https://doi.org/10.54660/.IJMRGE.2020.1.3.306-315
265. Yeboah BK, Ike PN. Conceptual program for workforce training and leadership development in reliability engineering. International Journal of Advanced Multidisciplinary Research and Studies. 2023; 3(1):1641-1650.
266. Yeboah BK, Nnabueze SB. Policy-oriented framework for predictive analytics in maintenance optimization. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, January-February 2021; 7(1):585-602.
267. Yeboah BK, Nnabueze SB. Data-driven policy framework for energy efficiency in higher education institutions. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, December 20, 2024; 10(8):255-270.
268. Yeboah BK, Enow OF, Ike PN, Nnabueze SB. Program design for advanced preventive maintenance in renewable energy systems. Shodhshauryam, International Scientific Refereed Research Journal. 2024; 7(2):138-156. Doi: https://doi.org/10.32628/SHISRRJ2472156
269. Yeboah BK, Enow OF, Ike PN, Nnabueze SB. Conceptual framework for condition-based maintenance as a utility reliability program. Global Journal of Engineering and Technology Research. 2025; 1(2):55-63.
270. Yeboah BK, Enow OF, Ike PN, Nnabueze SB. Policy and compliance program for safety and environmental standards in renewable energy projects. Global Journal of Engineering and Technology Research, October 2025; 1(2). Doi: https://doi.org/10.65150/EP-gjetr/V1E2/2025-04