

Residential Energy Research: Twenty Years On

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Abstract

In 2006, I argued that household energy research was dominated by survey-based, economic and technical analyses, while too often failing to combine measured energy use with qualitative accounts of how people use energy in their homes. Two decades later, in this Perspective, I revisit this argument and ask whether the gap between theory, method, and real-world residential energy use has been resolved. Drawing on both my own work over the last 20 years and recent comprehensive analyses of the literature in the field, I argue that residential energy research has expanded in scale, scope and technical capacity, with stronger metering, modelling and monitoring tools. However, much of the evidence base remains weighted towards short-term quantitative and technical evaluations, while research on routines, comfort, trust, social relations, housing conditions and aesthetics is still less consistently integrated. I conclude that integrated mixed-method designs are needed. These designs can build on the strengths of meters, models and monitoring by connecting them with how energy is used, managed and shifted in homes, so that residential energy research can better support energy transitions that are both effective and just in the face of climate change.

Keywords: residential energy demand; residential buildings; building energy performance; residential energy efficiency; energy retrofit; demand response; demand-side flexibility; smart grids; home energy management systems; mixed methods

1. Introduction

Twenty years ago [1], I argued that residential energy demand was increasingly understood as depending not only on buildings, technologies and prices, but also on the everyday routines, expectations and constraints of home life; yet the methods used to study it had not kept pace. At that time, quantitative techniques from building science, economics and psychology were central to residential energy research. These approaches were, and remain, powerful for estimating technical potential, modelling policy scenarios and evaluating intervention outcomes. Their limits become most apparent, however, when they are asked to explain why people live as they do, how technologies are understood and used, and why interventions that appear technically or economically promising may not be taken up or may not deliver expected savings [1–4]. I warned that this gap between theory and method limited our ability to design effective, socially acceptable energy policies and technologies [1–4].

The policy and research landscapes have changed substantially since 2006. Climate targets have tightened, while fuel poverty and energy justice have moved up political agendas. Behaviour change, retrofit, smart meters, smart grids, and demand-side flexibility have also become central themes in energy and climate policy [5–19]. The technical possibilities for monitoring household energy use have expanded too, from smart meters and



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connected appliances to detailed sensor data in smart homes [8,15–17,20,21]. At the same time, social science perspectives on practices, cultures, infrastructures and governance have developed, offering richer conceptual tools for understanding residential energy demand [2–8,14,15,17,19,20].

The gap between theory and method that I identified in 2006 [1] is especially significant in the context of domestic demand flexibility. Smart grids, time-of-use tariffs, home energy management systems and demand-response programmes increasingly depend on households being willing and able to shift, automate or delegate aspects of energy use [14,16,17,19–21]. Yet, flexibility is not simply a technical property of appliances, meters, or tariffs. It is produced through the interaction of technologies, heating and cooling systems, household routines, knowledge, trust, comfort, care responsibilities, and perceptions of fairness [14,16,19–21]. Domestic demand flexibility therefore provides a useful test case for examining whether residential energy research can connect technical evidence on energy use with the lived organisation of energy demand in homes.

In this Perspective, I ask a simple but stubborn question. Given the urgency of decarbonisation, the wealth of new data sources and methods, and the technical capacity to monitor household energy consumption in detail, how far has residential energy research moved beyond the gap between theory, method, and everyday life that I identified in 2006 [1]? Has the expansion of metering, modelling, and monitoring been matched by methods that explain how energy technologies and interventions are interpreted, negotiated, and lived with in households? Or does the field still show a structural imbalance between quantitative, technology-focused evidence and more interpretive, contextualised studies of everyday life?

To address these questions, I draw on insights from my own research over the past two decades, as well as from recent comprehensive analyses of the literature on residential energy efficiency, retrofit, demand flexibility, energy poverty, and energy security [5–12,22,23]. I also incorporate contemporary empirical studies on flexibility, engagement, and justice [13–15,17,20,21], as well as qualitative and mixed-method studies with householders and building occupants [2–4,14,16,17,20]. The discussion prioritises literature from the past three to five years while selectively referencing earlier work to illustrate ongoing challenges.

The remainder of this paper is structured as follows. Section 2 examines the growth and diversification of residential energy research. Section 3 considers whether a methodological imbalance between technical evidence and lived energy practices persists in contemporary research. Section 4 turns to qualitative and mixed-method research to show what becomes visible when households are treated as sites of practice, flexibility, engagement and justice. Section 5 draws out implications of the arguments presented in the paper for policy and practice. Section 6 concludes by returning to the question of whether the gap identified in 2006 has narrowed or persists.

2. Growth and Diversification of Residential Energy Research

Residential energy research has grown rapidly in volume, thematic scope and disciplinary breadth over the past two decades [5–12,19,23]. Recent syntheses of the literature in the field document a proliferation of studies on the drivers of residential energy use, interventions to change behaviour, and the development of an increasingly interdisciplinary research landscape spanning engineering, economics, environmental sciences, social sciences and psychology [7,9,23]. They also show growing attention to younger people's residential energy behaviour, digital media, peer networks and intersectional inequalities, as well as to demand-side management acceptance [8,19].

Some of the recent syntheses focus directly on the realised performance of interventions and technologies in occupied dwellings [5,6,11,22]. They examine the measured impacts of residential energy-efficiency interventions, home retrofit programmes, appliance adoption and the residential building energy performance gap [5,6,11,22]. This strand of work shows that residential energy research now addresses not only theoretical potential and modelled scenarios, but also the actual performance of programmes, technologies and interventions in everyday residential settings.

A further development is the gradual shift from narrow efficiency goals towards broader concerns with wellbeing, security and justice at the household and building scale. Recent work on residential energy security reframes household energy in terms of households' ability to secure adequate building energy services without undermining other aspects of wellbeing [10]. Organised around accessibility, availability, acceptability and affordability, this perspective links household energy security to interacting drivers, including climate, governance, income, prices, technologies, building envelopes and infrastructure [10]. Work on inclusive renovation similarly moves beyond technical performance, synthesising socially oriented studies of residential energy renovation and developing a justice-based framework for decision-making in renovation programmes [12].

A related shift concerns how "households" are understood. Rather than being treated as homogeneous units, they are increasingly understood as diverse, dynamic configurations of people, social practices and infrastructures. Research on migrant consumers highlights how different energy cultures and needs shape patterns of use in host countries and complicate assumptions embedded in standard efficiency programmes [7]. Work on younger people's residential energy behaviour similarly emphasises digital technologies, peer networks, precarious housing and labour market conditions, as well as the practical constraints faced by younger people in rental housing and shared accommodation [8].

Together, this body of work shows that residential energy research now encompasses a wide range of topics. These include energy-efficient technologies, retrofit, appliance adoption and behavioural interventions [5–9,11,22,23]; smart meters, smart grids, home energy management systems and demand-side flexibility [16,17,19–21]; energy poverty, energy justice, digitalisation, prosumerism and residential energy security [10,12,13,19,24]. The field has therefore expanded substantially, but this expansion does not in itself resolve the question of whether its methods are well matched to the social and practical complexity of household energy demand. That question is taken up in the next section.

3. Persistent Methodological Imbalance: Connecting Technical Evidence with Lived Energy Practices

The recent syntheses of residential energy research show a striking pattern. The field has become more data-rich, more policy-facing and more technically sophisticated, yet its strongest evidence remains concentrated around measured outcomes, modelled potentials, survey responses and short-term evaluations.

The 2021 meta-analysis of residential energy-efficiency interventions retrieved 13,629 records, of which a mere 16 provided adequate data for evaluating the energy reductions achieved by interventions; most were relatively small-scale and concentrated in high-income countries [5]. Similarly, evidence from home retrofit programmes remains limited relative to the scale of policy activity, despite drawing on post-retrofit billing or consumption data from more than 140,000 households [22]. An analysis of 30,000 records about interventions to increase energy-efficient appliance adoption conducted in 2025 found that evidence on market shares and subsequent household energy use is limited [11]. Recent syntheses of the retrofit evaluation literature found that average measured reductions in household energy use were modest, at around 7%, and highly heterogeneous [5,22]. In

addition, this research found no evidence of “deep” savings, and effect sizes tended to fall as the internal validity of study designs increased [5,22].

These findings do not diminish the value of metered evaluations. Rather, they show that rigorous, well-monitored evidence remains scarce relative to the scale of retrofit, appliance adoption and efficiency policy activity. They also show that measured impacts are often smaller and more variable than what engineering models or policy narratives have assumed [5,11,22].

The performance-gap literature reinforces the same point from a different angle. A review of 160 studies on housing retrofits examined discrepancies between predicted and measured energy use in occupied dwellings [6]. This research found that the studies often lack detailed information on occupancy patterns, building management and everyday practices [6]. As a result, in these studies, explanations for performance gaps tend to be couched in generic terms such as “behaviour”, “user error” or “rebound”, rather than being grounded in empirical accounts of how systems, dwellings and households interact over time [6]. The issue, then, is not only that predicted savings often fail to materialise. It is also that the categories used to explain this failure frequently remain too broad to show how household routines, social relations, comfort expectations, tenure arrangements and building systems shape actual energy use.

Broader reviews of household energy research show that this explanatory gap is not confined to retrofit evaluation. They describe a field still built largely around surveys, questionnaires, statistical analysis, modelling, regression analysis and other quantitative approaches [7]. Where migrated and displaced consumers are discussed, the evidence base is especially limited and still relies mainly on scenario modelling, questionnaire analysis, propensity score matching, household surveys and regression analysis [7]. Interview and focus group evidence appears, but often as a supporting element rather than as a central means of explaining how energy demand is made and remade in everyday life [7].

Bibliometric analyses add a further layer to this picture. They document rapid growth in residential energy efficiency and renewable energy research, as well as an increasingly interdisciplinary field [9,23]. At the same time, they point to fragmentation into technical subfields and a continuing concentration of engineering-economic analysis, policy-instrument analysis, and quantitative studies of metered or survey data [9,23]. Even though this literature has moved from modelling and pilot-scale work towards real-world applications, barriers are still often framed in terms of high costs, information and knowledge deficits, the low priority attached to environmental and climate concerns, and resistance to behavioural change [23]. Such categories are useful, but they risk reproducing a relatively thin account of the household if they are not connected to empirical work on everyday practices, constraints and capacities.

The implications are especially important for justice-oriented research. Recent work on residential energy security and inclusive renovation foregrounds distributional, procedural and recognition justice, while also pointing to the geographical, linguistic and social narrowness of the empirical base [10,12]. Much of the current evidence remains concentrated in English-language and high-income contexts, limiting how far its conclusions can be generalised across different housing systems, infrastructures, climates and forms of energy access. This matters because the conditions shaping household energy use, retrofit and flexibility differ substantially across high-, middle- and low-income contexts, including in relation to energy access, housing quality, infrastructure, climate, tenure and governance.

Evidence on younger people, renters, low-income households, migrated and displaced consumers, and other marginalised groups remains particularly uneven [7,8,10,12,19]. Studies on younger people’s residential energy behaviour are still concentrated around student housing, campuses and shared living arrangements, with limited attention to the

diversity of young people’s residential situations or to long-term changes in everyday energy practices [8]. Similarly, work on demand-side management acceptance shows that marginalised groups and their experiences remain under-examined [19]. These groups are therefore still under-represented in the kinds of in-depth, longitudinal and mixed-method inquiry needed to understand lived experience, constraint and agency [7,8,10,12,19].

Read together, these reviews show that the field’s methodological imbalance is not simply a matter of too much quantitative evidence and too little qualitative evidence. The deeper issue is that the dominant evidence base is often better at measuring outcomes than at explaining the social processes through which those outcomes are produced. Meters, models, surveys and evaluations can show whether consumption changes, whether savings are achieved, and whether adoption rates rise. Unless combined with more interpretive and contextual methods, they are less able to explain how households make sense of interventions, how responsibilities and constraints are distributed within homes, how technologies are incorporated into routines, or why the same intervention may produce different effects across different social and housing contexts.

The expansion of residential energy research has therefore produced more evidence, but not always the kind of evidence needed to understand how energy demand is organised in everyday life, as summarised in Table 1. This matters for the paper’s wider argument because technical measurement alone cannot show whether interventions are acceptable, sustainable or just. The next section therefore turns to research that starts from households as sites of practice, flexibility, engagement and justice.

Table 1. Explanatory limits in recent residential energy evidence.

Evidence	What It Shows Well	What Remains Under-Explained
Energy-efficiency interventions and retrofit evaluations [5,11,22]	Measured change in energy use, savings and adoption.	Why outcomes vary across households, housing types and contexts.
Energy performance-gap research [6]	Differences between predicted and actual energy use.	How routines, comfort, tenure, systems and social relations shape use.
Household energy behaviour reviews [7]	Attitudes, demographics, consumption patterns and reported barriers.	Everyday practices, meanings, relationships and constraints.
Bibliometric reviews [9,23]	Growth, diversification and dominant research clusters.	How households interpret, negotiate and live with interventions.
Justice, security, renovation, youth and DSM reviews [8,10,12,19]	Inclusion, vulnerability, affordability and participation gaps.	Lived experience, unequal capacities to act and distributional effects.
Overall pattern	Whether consumption, savings, adoption, attitudes or research activity change.	How and why change occurs, and whether interventions are acceptable, sustainable and just.

4. From Meters to Methods That Matter: Qualitative Insights and Priorities for Rebalancing Research

The methodological imbalance discussed above becomes clearer when recent qualitative and mixed-method studies are read alongside policy-facing reviews and evaluations [12–14,16–21,24]. Three areas of recent work are particularly useful here: retrofit and justice-oriented renovation [12,18,24], demand-side flexibility and smart energy systems [14,16,17,19–21], and citizen engagement in contexts of energy hardship [13,19]. Taken together, they show how household energy demand is organised through everyday practices, social relations, housing conditions and institutional arrangements, rather than simply through individual choices, prices or technologies [1–4,12–14,16–21,24].

Retrofit and justice-oriented renovation research makes the tension between linear policy models and situated household practices particularly clear [12,18,24]. Mainstream retrofit programmes often frame the householder as a rational, barrier-constrained decision-maker moving through a linear “customer journey” from information and audit to finance

and installation [18]. In practice, however, retrofit decisions are often triggered by life-course events, wider home improvement projects and relations of trust with family, friends, neighbours and trusted contractors, rather than by high energy bills or formal audits alone [18]. Decisions are shaped by aesthetics, comfort, care relations and earmarked finances as much as by payback calculations [18]. The lived process of retrofit is therefore situated and relational, rather than only the discrete, optimising choice implied by some policy designs [18]. This does not make such models unhelpful; rather, it points to the need to connect them with household context. This pattern echoes the rational and attitudinal models I critiqued in 2006, which similarly struggled to account for how social relations, housing conditions, meanings, aesthetics and life-course events shape energy-related decisions [1].

Justice-oriented renovation research extends this point by asking not only whether retrofit works, but also for whom, under what conditions, and with what consequences [12,24]. Work on inclusive renovation argues that socially robust renovation programmes need to address recognition, procedural and distributive justice, rather than focusing only on technical performance or energy savings [12]. Recent work on social housing retrofit similarly shows that energy-efficiency improvements do not automatically deliver energy justice [24]. From this perspective, research needs to question whose needs are recognised, whose time and comfort are valued, and how the benefits and burdens of renovation are distributed [12,18,24].

Demand-side flexibility and smart energy systems research raises similar issues in a different setting [14,16,17,19–21]. Research conducted during the Finnish energy crisis in the winter of 2022–2023 is particularly informative because it examined actual household responses to price spikes and public appeals to reduce demand. Drawing on focus groups and individual interviews with 82 participants, the study found that households reduced or shifted energy use in several practical ways [14]. These included lowering indoor temperatures, reducing hot-water and sauna use, shifting laundry, dishwashing and electric-vehicle charging to cheaper periods, substituting wood heating for electric heating, and monitoring electricity prices and consumption more closely [14].

The Finnish study [14] is also important because it shows how people worked out what changes were possible and acceptable. They drew on practical knowledge developed within families, shared with neighbours and exchanged through everyday social networks. People organised shared sauna arrangements, taught others how to check electricity prices, and discussed how far heating, appliances and routines could be adjusted without unacceptable loss of comfort, safety or convenience [14]. Demand flexibility therefore depends not only on tariffs, apps or controllable appliances, but also on informal knowledge, trust and support. It appears less as a technical property of appliances or tariffs than as an outcome of the interaction between technology, dwelling type, energy pricing, household routines, comfort, knowledge, social relations and perceptions of fairness [14,16,19–21].

Research on technologies intended to reduce or shift energy consumption shows that implementation gaps emerge when technical designs are not well matched to users' routines, institutional arrangements and capacities to act [16]. Work on island communities similarly found that residents could be motivated to engage with smart grids and demand response, but that limited knowledge of, familiarity with and ownership of enabling technologies constrained people's ability to act [21]. Recent qualitative research on smart meter use also shows that active use depends on awareness, motivation, trust, autonomy and the cognitive burden placed on users [17]. Later work on smart energy systems further identified misalignments between design assumptions and users' lived practices, with engagement shaped by structural constraints, usability challenges, uneven digital literacy and the availability of ongoing support [20]. In a similar vein, research on smart thermostats illustrates that they do not automatically reduce energy consumption, as users

can misunderstand their functionality and use them in unintended ways [5,25]. Together, this literature shows that assumptions about uniformly active households sit uneasily with everyday routines, time pressures and unequal capacities to participate [16,17,20,21].

Citizen engagement research, especially in contexts of energy hardship, further complicates assumptions about uniformly active and responsive households [13,19]. An empirical study of citizen groups across eight European cities shows that people experiencing different energy problems, including high bills, poor insulation, heating and cooling difficulties, and multiple deprivation issues, exhibit distinct engagement profiles [13]. Feedback-oriented engagement is often low, particularly among those facing multiple energy deprivation issues, while informal and collective forms of action, such as helping others or advocating for change, may be more common [13]. These findings suggest limits to demand-response and flexibility models that rely on continuous, individualised app-based interaction and assume a uniformly active prosumer base [13,19]. An intersectional review of demand-side management acceptance reinforces this point, showing that gender, age and income shape both willingness and ability to participate [19]. It also shows that many programmes implicitly target a relatively narrow, technologically confident user model, while overlooking the constraints faced by women, low-income households, young people and older adults [19].

Across this body of work, three lessons are especially important. First, energy use is deeply entangled with comfort, convenience, safety, care, aesthetics and identity [12–14,18,24]. Second, technologies are taken up within existing social relations and routines, which shape who controls systems, whose comfort is prioritised and how compromises are negotiated [16–20,24]. Third, householders and occupants take up, adapt, work around and sometimes resist technologies in ways that can either enhance or undermine intended savings [16–18,20,21]. These insights are unlikely to emerge from metered data or standard survey instruments alone [5,6,16–18,20,22].

As I argued in 2006, this is not a rejection of meters, models or large-scale quantitative studies [1]. On the contrary, they are indispensable to residential energy research. The point is that they become more explanatory and useful for implementation when embedded within research approaches that also take the social organisation of everyday life seriously. The discussion presented here nevertheless shows that, despite major advances in metering, modelling, smart systems and policy evaluation, residential energy research still struggles to connect technical evidence with the ways people choose, use, adapt and sometimes reject energy technologies in the home. With this in mind, I restate four priorities for residential energy research that I first advanced between 2006 and 2010 [1–4].

First, residential energy research needs more theoretically informed qualitative and mixed method studies integrated with quantitative work from the outset. Many evaluations provide limited information about how interventions were implemented, how participants experienced them, or how context shaped outcomes [5,22]. Combining interviews, observations, focus groups, diaries or participatory methods with metered and modelled data would help explain variation in measured effects and identify mechanisms that can then be tested in larger samples [5,16–18,20,21,24].

Second, research should pay closer attention to heterogeneity and inequality. Quantitative reviews show that savings vary across income groups, housing types and regions, but they rarely explain how these differences are lived and negotiated in specific households [5,9,22]. Recent work on demand-side management, residential energy security and inclusive renovation shows that gender, age, income, tenure, vulnerability and housing conditions shape both willingness and ability to participate in energy transitions [7,8,10,12,13,19,24].

Third, householders and building occupants should be treated as collaborators rather than only as data sources. Co-creation and participatory approaches remain relatively uncommon in residential energy research, yet evidence from demand-response projects and justice-focused renovation studies shows that they can reveal assumptions embedded in technical designs and open up alternative pathways for implementation [12,16,24]. This is especially important where interventions affect vulnerable households, tenants, social housing residents or communities with limited control over building fabric and energy systems [12,24].

Fourth, policy debates need to broaden what counts as evidence. Engineering models, metered outcomes and impact evaluations are essential, but they can obscure the processes that determine whether interventions are acceptable, sustainable and just [5,6,12,16–18,20–22,24]. Rigorous qualitative studies, systematic narrative reviews and in-depth case studies should be recognised as forms of evidence that answer different but equally important questions. Without them, residential energy research risks becoming more data-rich but not necessarily more insightful [1,12,16–18,20,21,24].

Operationalising these priorities within residential energy research requires a shift in emphasis: from treating houses and buildings as the primary units of analysis towards understanding energy demand as produced through the interaction of people, everyday practices, social relations, technologies and the material conditions of home. Table 2 summarises how these priorities can connect policy to the ways energy is used, managed and shifted in homes, ultimately helping to support a just energy transition in the face of climate change.

Table 2. Operationalising priorities for future residential energy research.

Research Priority	Operational Steps	Explanatory Gaps Addressed
Integrate qualitative and quantitative methods from the outset.	Combine metered and modelled data with interviews, observations, diaries, focus groups or participatory workshops.	Explains how and why measured outcomes vary; connects performance data with household context.
Pay closer attention to heterogeneity and inequality.	Sample across tenure, income, age, gender, health, migration status, housing quality and control over energy systems.	Avoids hiding unequal effects behind averages; addresses under-representation of marginalised groups.
Treat householders and occupants as collaborators.	Use co-design, citizen panels, resident advisory groups, living labs or participatory evaluation.	Challenges assumptions of active, capable and willing users; reveals design assumptions before implementation.
Broaden what counts as useful evidence.	Report implementation conditions, lived experience, trust, comfort, care, disruption, privacy, maintenance and follow-up.	Shows whether interventions are acceptable, sustainable and just; explains change as a social and institutional process.

The research priorities listed in Table 2 are reflected in major residential energy research funding programmes, in which meaningful integration of the social sciences and humanities is increasingly required, or at the very least encouraged [20]. However, within the field, social research is usually perceived as secondary to technical development, which receives the bulk of project funding [16,20]. As a result, social research is frequently relegated to supporting engagement, communication, and acceptance, rather than shaping problem definitions, research designs, and technology demonstrations and evaluations [16,20]. In a research field in which technical novelty is often treated as the primary marker of success, implementing an existing technology differently based on the findings of social research is rarely recognised as innovation [20]. Yet this can be essential to whether that technology

works in practice [16,20]. Without a shift in the perceived role and value of social research, the mistakes of the past are likely to be repeated.

5. Implications for Policy and Practice

Four implications for policy and practice follow from the arguments presented in this paper.

First, expectations about the performance of residential energy-efficiency interventions need to be calibrated against evidence from real homes. The evidence discussed in this Perspective shows that realised savings are often lower, more variable, and more context-dependent than engineering estimates assume, particularly where rebound effects, installation quality, household routines, and behavioural adaptation are not adequately considered [5,6,22]. Incorporating these factors into planning, modelling and evaluation would produce more realistic projections and reduce the risk of over-promising.

Second, policy instruments should move beyond the assumption that households are primarily rational cost-minimisers. As I argued in 2006 [1], economic accounts of household energy decision-making are useful, but they become too limited when they detach choices from the social, cultural and institutional contexts in which constraints, responsibilities and meanings are formed. Information campaigns, audits, financial incentives and labels can be useful, but they are unlikely to be sufficient on their own. Behaviour change measures often have mixed or context-dependent effects when implemented alone, and are more effective when combined with economic, fiscal and structural measures [23]. Yet comfort, aesthetics, social norms, care responsibilities, trust and everyday routines are at least as important as prices or technical parameters in shaping household energy use [2–4,12,14,18]. Interventions that do not adequately account for these dimensions risk limited uptake, unintended consequences and uneven benefits.

Third, questions of energy justice, vulnerability and security need to be treated as central to residential energy policy, rather than as secondary concerns. The evidence discussed in this Perspective shows that people's ability and willingness to engage with energy interventions are patterned by the specific problems they face. These include high bills, poor insulation, heating and cooling difficulties, insecure housing, and limited control over their dwelling [10,12,13,19,24]. Energy-poor households may rely more on informal and collective strategies than on the individualised feedback mechanisms assumed in many smart-energy and demand-response programmes [13]. This matters because household energy demand is connected to health, comfort, wellbeing, and human development, not only to kilowatt-hours and bills [10]. Policy design, programme evaluation and funding requirements should therefore involve affected groups in defining problems, shaping interventions and interpreting findings, rather than treating vulnerability only as a category in datasets.

Residential energy security is especially important because it draws attention to trade-offs that conventional efficiency metrics often miss. Low consumption may indicate efficiency, but it may also indicate deprivation, under-heating, discomfort or other unmet needs [10]. Distinguishing between efficiency and deprivation requires methods that combine metered, administrative, and statistical data with qualitative evidence about lived experience, vulnerability, disruption, and everyday trade-offs [10,12,13,24]. This is where the methodological agenda advanced in this paper becomes directly relevant to policy: without qualitative evidence, policymakers may misread low consumption as success when it is actually an indication of deprivation.

Fourth, smart energy and demand-response projects need funding and governance models that extend beyond the demonstration phase. Evidence from REACT and comparable EU-funded projects points to a structural “demonstration paradox”: systems are

designed and tested under conditions of intensive project support, but the social and institutional arrangements needed to sustain engagement often weaken or disappear once the funding cycle ends [20,21]. Users raise practical questions about long-term maintenance, local technical support, data feedback and the future status of installed equipment after projects close [20]. If energy innovation programmes are to deliver durable change, relationship-building, education, local support and ongoing system maintenance need to be funded as core elements of the transition, rather than treated as optional extras [16,20,21].

6. Conclusions

Taken together, the arguments presented in this paper suggest that the gap between theory, method and everyday life identified in my 2006 paper has narrowed but not disappeared [1]. Residential energy research is now larger, more diverse and better equipped with metering, modelling and monitoring tools than it was two decades ago. Yet a larger evidence base does not automatically explain how interventions are interpreted, negotiated and lived with in practice. The central task is therefore not to replace technical measurement, but to embed it within integrated mixed-method approaches that connect energy data with household routines, institutional conditions and unequal capacities to act. Residential energy research will be better placed to support effective, just and durable energy transitions if it treats the social organisation of everyday life as central to understanding how energy is used, managed and shifted in homes.

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