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Addressing energy poverty through technological and governance innovation

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Abstract

Background: Energy poverty has gained much traction over the last decades, holding both high multidisciplinary conceptual value, but also profound implications from a social policy perspective, being closely linked to the quality of life and well-being. The goal of our study is to evaluate recent measures aimed at tackling energy poverty in Europe by analysing the extent to which they are innovative on technological and governance dimensions. We do so by building an analytical tool which combines evaluation criteria along these two dimensions and by employing it for the analysis of twenty measures aimed at tackling energy poverty that have been designed and employed in ten European countries. These measures were selected with the support of an expert panel.

Results: We identify three categories of innovative measures aimed at alleviating energy poverty: (1) measures with high technological scores, (2) measures with high governance scores, and (3) measures with high scores on both axes. The measures in the third category incorporate a variety of actors in sustainable partnerships and implement monitoring tools throughout the process, complementary to incorporating new technologies into the domestic sphere and promoting consumer awareness and consumption pattern transformation.

Conclusions: Our findings allow for a better perspective on the shape innovation takes in the context of energy poverty policies. Based on our research, we argue that combining technological innovation and governance innovation has a better chance of generating more articulate and scalable, and potentially successful measures with respect to their purpose of tackling energy poverty, since the drivers of energy poverty rarely pertain to only technology or only governance.

Keywords: Energy poverty, Governance innovation, Technological innovation, Energy policy, Vulnerable consumers, Grassroots innovation

Background

Since its emergence in theory and policy in the early nineties, energy poverty has drawn increasing awareness from both academics and policymakers and is now located at the core of many energy and climate policies with an impact on people's quality of life. Moreover, the

private sector and civil society are becoming increasingly aware of the need to tackle both the drivers and the symptoms of energy poverty. However, the concept of energy poverty remains fuzzy as do appropriate solutions for alleviating its practical implications. At a theoretical level, energy poverty is understood as the inability of households to access adequate energy services up to a socially and materially necessitated level in their home [1]. At the political level, a definition of energy poverty applicable across countries has not been agreed upon and there is often significant variation in how energy poverty

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is understood and approached even within countries. For instance, at the level of the European Union, despite a constant push for a common framework, it is still up to the Member States to decide how they approach energy poverty and how they define and quantify it [2–5]. Moreover, the drivers and symptoms of energy poverty are fluid and highly sensitive to contexts of crisis. In recent years, overlapping crises generated by the pandemic, rising energy prices, and the war in Ukraine have expanded the scope of energy poverty to a degree that is still difficult to measure. Before these crises, depending on the indicator used for measurement, the EU's Energy Poverty Observatory had already estimated that between 34 and 82 million households in the EU face energy poverty.

Even before these overlapping crises, a wide array of initiatives—most often with a primarily local dimension, sometimes with a national character, some closely reflective of European frameworks of action—aimed at tackling energy poverty. Some, being driven and implemented by public authorities, are located on the spectrum of public policies, while others are private or NGO initiatives, which sometimes benefit from the support and involvement of public authorities. Regardless of who has the initiative, all practical interventions aimed at tackling energy poverty intrinsically hold two dimensions: a *governance* dimension stemming from the stakeholder networks involved in tackling energy poverty and in relation to the consumers, and a *technological* dimension attached to the equipment to produce, store, and consume energy. *Innovation* is another keyword increasingly attached to such interventions. Partly, this is due to rapidly changing technologies, but often it holds a normative meaning, since “old ways” of producing or providing energy are considered responsible for the occurrence of energy poverty.

Hence, the goal of our study is to evaluate recent measures aimed at tackling energy poverty in Europe by analysing the extent to which they are innovative on those two different dimensions: technological and governance. As we explain in the methods section below, we selected measures which are considered as *being* innovative by a panel of experts. Therefore, we do not aim to establish if measures are innovative (enough) or not, but rather to determine, where the focus of innovation is mainly placed. To do so, we first bridge the literature on the two dimensions outlined above. Then, to evaluate the dominant pattern of innovative solutions addressing energy poverty, we develop an analytical tool combining the two dimensions of innovation and apply it to our sample of measures. Based on the results of the tool's application, we provide a complementary in-depth discussion on the content of the measures to get a more complete image of the shape that innovation takes within each measure. In

the discussion and conclusions, we explain how the findings of our analysis can be used in designing better future measures aimed at tackling energy poverty.

Literature review

In this section, we review the different meanings of innovation, focusing mainly on how the governance and the technological dimensions are attached to it. We then relate this body of literature to some of the theoretical and practical approaches to energy poverty, and, finally, we review existing academic contributions regarding innovation in relation to energy poverty.

A brief overview of the different meanings of “innovation”

Innovation remains a fuzzy term, but it is seemingly everywhere in policy analysis. Often, it is seen as a new way of addressing pressing public policy challenges, and governments are increasingly turning to new policies which acquire the label “innovative”. Scholarly debates of innovation usually refer back to its use in economics, where Schumpeter defined it as “the ability to create economic value from new ideas” [6], but sometimes are associated with implementing “procedures which seek to combine a realistic appreciation of budgetary constraints with responsiveness to varied individual and community needs” [7]. Technological inventions always played into this as a tool that meets a demand in society, like the invention of the cell phone. Following this tradition, contemporary economic literature still assumes that innovation stimulates long-term growth and, therefore, improves the economy and society [8–10], as well as the perception of welfare [11]. Today, innovation as a term is also used to indicate newness in technological, ecological, political or social development, some kind of novelty in society achieved by the use of new ideas and technologies but also a normative goal in itself: “innovative” is regarded as a necessary condition for effectiveness, or to improve living conditions in different ways (both qualitative and quantitatively) [12, 13]. Especially in writings in the wider framework of social and ecological development, innovation is seen as a mutually influenced process [14].

While innovation has long been a term used for new technological and economic development, the concept of social innovation has been developed to intentionally describe the emergence of novel practices in society or “the creative reconfiguration of social relations” [15]. The multiple uses of the term ‘social’ comprise behavioural change, new forms of collaboration, new roles of grassroots and civil society organizations, or changes in institutions. However, governance innovation, as a part of social innovation, while a concept still in need of

clarification [16], points to changes occurring as a result of intentional, directed actions and interactions.

Despite differences in approaches to social innovation, it is usually emphasized that something truly new develops and that the involvement and empowerment of different actors and communities contribute to reconfiguring social relations [17]. Importantly, Sabato et al. [18] stress that governance innovations are highly contextual, meaning that (a) a novel practice in one context might have been already developed and used in a different context, and (b) replication is always an iteration and adjustment to the specificities of a given context. While the first developments on the concept of social innovation were not connected to technical knowledge or to research and development (R&D), more recent contributions have expanded their scope, including the development of technologies with social purposes as well as the cooperation of different categories of actors [19–21]. Closer to the field of energy, governance innovation in different forms has been widely studied in the context of sustainability [22–24] which brings in ‘grassroots innovation’, a perspective highly useful for our research, since it covers the actions of actors such as NGOs or even of informal groups, often involved in promoting energy poverty alleviation. Grassroots innovation is defined as “initiatives undertaken by committed activists within civil society arenas (...) that differ from the more mainstream, market-based innovations” [23].

Energy poverty policies and measures: past and future

Energy poverty measures in Europe (and especially within the European Union) are numerous and diverse, varying across states, depending on the specific drivers and symptoms of energy poverty and taking often divergent priorities and approaches [5, 25, 26]. Energy poverty is often defined based on the traditional nexus of “income, price, and housing” [27, 28], although an increasing body of literature criticizes this approach and considers multi-dimensional facets of energy poverty going beyond the traditional approach. Current energy poverty policies involve mainly two categories of programs. On one hand, curative programs take the form of financial support to help households pay their bills, thus addressing one aspect of energy poverty (i.e., low incomes, high prices). On the other hand, preventive programs usually aim at improving the energy performance of dwellings to help low-income populations reduce their consumption, and hopefully, their energy bill in the long term, thus addressing another aspect of energy poverty (i.e., energy (in)efficiency). From a broader perspective, traditional energy poverty measures focused on financial aid and short-term strategies can be considered as typical products of a traditional paradigm of public administration

[29, 30]. Policies relying on tariff reductions, benefits and subsidies as a short-term remedy lead to the need to constantly pump public funds into unsustainable solutions without solving the energy poverty problem, but rather statistically masking its consequences [31]. Hence, a need for alternative, innovative, frameworks developed from the direction of policy and governance studies, introducing concepts such as co-production [32] and co-creation [29, 33] of services, policies, and measures. This approach has increasingly been adopted in practice as well, with a desire to enlarge the spectrum of involved stakeholders, but also to focus on the empowerment of citizens as active actors in the design, implementation, and evaluation of measures. Thus, this “governance” dimension has grown to hold an intrinsic role, alongside technology, in the development and expansion of innovative pathways to tackle energy poverty.

Innovation in energy poverty policies: the technological and governance perspective

There is a broad and growing body of literature on energy poverty, increasingly capturing its multidimensional nature and the need to constantly approach both its conceptualization and its practical implications with interdisciplinary lenses. When policies or interventions to alleviate energy poverty are analysed, innovation is evaluated using two basic criteria: (1) policies which contain a new idea/problem area, solution, device or method to tackle energy poverty; (2) policy solutions which promise to push the status quo in a positive direction (i.e., consisting of more effective policies than previous approaches). Thus, the energy poverty literature already hints at both technological and governance dimensions, despite not clearly labelling them as such or distinguishing between them, which is what we aim to do through this paper.

Measures aimed at increasing energy efficiency and at housing renovation are seen as the main long-term policy tool to reduce energy poverty and, specifically, energy consumption, as well as to increase overall thermal comfort [34]. Energy efficiency measures are a good illustration of how innovation can be evaluated depending on the context. For some contexts, energy efficiency became mainstream a while ago and the innovative character stems from newer technologies (such as more modern and more efficient building materials) or from the mechanisms through which a large-scale renovation project in a collective building fosters cooperation and trust among owners and between them and institutional stakeholders (or is hindered by the absence of cooperation and trust) [35]. For other contexts, such as in rural post-communist European contexts, measures aimed at increasing energy efficiency are still rather an exception and could be considered as innovative.

A more recent development in the energy poverty literature is a shift of focus from dealing exclusively with heating toward dealing with cooling difficulties as well [36, 37]. Other emphases show how the use of smart technologies helps to decrease the energy demand of energy-poor households [38] or how to incorporate new technologies to track energy poverty conditions at a neighbourhood scale [33, 39].

However, the normative nature of innovation is under scrutiny and caution is advised when pursuing innovative policies. There is increasing awareness that renovation measures are usually very cost-intensive [40, 41]. Households in rental arrangements depend on the decisions of landlords and housing companies, and it is disputed whether energy savings accrue to low-income households in the long run as a result of market mechanisms [42]. Schleich [43] argues that the incorporation of new technologies in energy-poor households might be difficult, because vulnerable populations exhibit lower adoption propensity for all technologies. Similarly, Lowitzsch [44] discusses the difficulties of making renewable energy production in “renewable” energy communities accessible for low-income households. Although technical innovations are taking place, there is no evidence they have a positive impact on energy-poor households [45], except for some applications in specific cases of social housing [46]. Santamouris [45] emphasizes that technologically innovative policies also need to be weighed for their potential to decrease the dependence on assistance programs of energy-poor households. Furthermore, non-energy benefits need to be considered to evaluate the effectiveness of energy efficiency policies, to design and assess these policies, and to incentivize certain measures [33, 47]

These contributions suggest the need for “grassroots innovation”, a more encompassing approach which focuses on the empowerment of energy poor individuals specifically to build acceptance and skills with respect to new technologies. Other contributions point even more decisively toward governance dimensions. According to research stemming from the recent SONNET project, social innovation in the energy sector is understood as “a combination of ideas, objects and/or actions that changes social relations and involve new ways of doing, thinking and/or organising energy.” Governance or Organisational innovation is considered one of the main operational dimensions on social innovation, which includes organisational structures within initiatives to tackle energy poverty and within the energy system. Two recent studies [48, 49], in their research on deep renovation operations in social housing, highlight that the more successful projects involve citizens at an early stage, so that they can “co-construct” the project and express their needs; this,

in turn, may improve the trust relationship among the stakeholders [50]. In addition, Martiskainen et al. [51] highlight network building and empowerment mechanisms fostered by Energy Cafés as useful tools in tackling energy poverty.

Summing up, innovation is increasingly regarded as a necessary attribute of energy poverty policies, as a prerequisite to overcome the systemic failures that foster the occurrence of energy poverty. Technological innovation is hinted at more naturally, especially in relation to household interventions dealing with equipment or building materials and less so with respect to technological improvements in the energy system. In contrast, governance innovation, though not always explicitly labelled as such, is a newer development in the literature. However, most literature points to the need of either or both dimensions in order for measures to be successful. Our purpose is to establish which of the two dimensions is more prevalent in real life interventions. We now turn to explaining how we do so.

Methods

From an analytical perspective, our approach is specific to comparative case study methodology, as we aim to understand the content of the measures selected as units of analysis to evaluate the prevalence of both the technological and the governance dimensions of innovation. Case-oriented research is well-rooted in energy poverty literature [34, 52–54], yet a systematic evaluation of measures themselves is rather new in the field.

We label the units of analysis in this study as measures, understood as any implemented initiatives from public authorities, social and civil organizations, as well as private companies, which have the common goal of addressing energy poverty. We chose the broader concept of measures instead of policies, since the latter are usually associated with some sort of action by the “state”. By measures we understand a set of coherent and specific actions with a clearly stated goal—which, in our case, is the alleviation of drivers and symptoms associated with energy poverty.

Case selection: the expert panel

To capture the diversity of measures aimed at tackling energy poverty, we set up a panel of experts. The framework for the selection of experts was the COST research network ENGAGER,¹ composed of scholars and practitioners specialized in energy poverty from 38 countries. This research was launched in September 2018. As a

¹ European Energy Poverty: Agenda Co-Creation and Knowledge Innovation (ENGAGER 2017–2021). More information: <http://www.engager-energy.net/>.

first step an online form was sent out through internal ENGAGER communication channels² with a request for experts to name measures they regard as innovative, based on their personal assessment, along with a specific indication to include measures that “take new directions in technological or governance approaches”. Twenty-four experts from sixteen different countries replied, with more than fifty suggestions. After analysing all the proposals, we excluded suggestions impossible to analyse, such as “broad” recommendations or measures not actually deployed, as well as literal and virtual duplication.³ This process left us with a final sample of twenty measures, summarized in Table 1.

We now explain the analytical tool we developed to evaluate the twenty selected innovative measures aimed at tackling energy poverty.

Evaluation criteria for energy poverty measures

The building process of the set of criteria was inspired by the framework of interaction between technological innovation and user practices in low carbon innovations, proposed by Geels et al. [55]. We further tailored this approach to the specifics of energy poverty and made some methodological adjustments. The measures have been assessed according to the degree of change, from incremental to radical. We designed a set of criteria built upon the basis of two main axes: governance and technology innovation (see Table 2). Each axis has dimensions and sub-dimensions, which we have derived based on the literature. The analysis process results in scoring each sub-dimension of each measure on each axis.

Furthermore, we adapted Geels et al.’s scale using a “natural 0”, so we assigned scores for each sub-dimension from 0 to 7, where 0 means the absence of innovation within the evaluated sub-dimension, values of 1 (and closer to 1) indicate an incremental innovative character, while values of 7 (and closer to 7) indicate a

radical innovative approach. We prefer the natural 0 to Geels et al.’s scale allowing for negative values to avoid the interpretation that measures which receive negative scores (in their total score on each axis or along sub-dimensions) completely overlook innovation or might be even regarded as “backward”, since we already established that all the measures included in the analysis are innovative according to our experts and our subsequent evaluation. Thus, each case will receive scores from 1 to 7 on each sub-dimension. Finally, on each axis, the sum of sub-dimension scores divided by the number of sub-dimensions will determine the dimension score and, consequently, the location of the measure on each axis. The final goal of this process is to build a matrix with the two composed scores for technological and governance innovativeness.

Information sources, case analysis procedure, and peer-review process

We analysed each of the twenty selected measures from the ex-ante perspective, considering the design of the measures. Therefore, we evaluate the concept and the design of the measures, rather than their impact. To acquire the information needed for scoring the sub-dimensions, we used policy texts, regulations, official websites, and academic studies. In certain cases, due to the lack of information accessible in English or online regarding the initiative design, we conducted interviews with policymakers, policy experts and national researchers. To increase the validity of the findings, after a first analysis, the preliminary results for each measure were sent to the experts who proposed it within the expert panel. These experts were asked for a review of the preliminary results, based on which we adjusted the final results of the analysis (see Fig. 1).

Results

A graphical overview of the results (Fig. 2) allows us to detect three types of innovative measures: (1) measures with high technological scores, (2) measures with high governance dimension scores, and (3) measures with high scores on both axes. Next, we explain the specifics of each category by detailing some of the measures based on the score it has been assigned in the analysis, while Table 3 provides an overview of all measures in the clusters.

Concerning *measures with radical technological/incremental governance innovation*, three measures stand out. The first one is Robin Hood Energy, a local, public, and not-for-profit energy company, which functioned from 2015 to 2020. Its creation was aimed to primarily tackle energy poverty by allowing people to have access to cheaper, more helpful alternatives to the mainstream

² The first round of proposals from the ENGAGER expert community was collected through a Google Form. The form was not anonymous; therefore the participants had to provide their names, country and contact details. Each participant could contribute to up to three innovative initiatives proposals. For each proposal they had to provide the name of the initiative and a brief description of the elements they identified as innovative.

³ There are several examples of proposals made by the expert panel which have not been included in the final sample of measures. For instance, we did not include proposals which are in fact recommendations or ideas not yet developed in practice, like a proposal for setting up solar based community generation of energy in Turkey or sets of general policy initiatives such as “anti-gentrification policies”. In the detection of duplication, we eliminated several policies which were very similar to others. For instance, the Energy Advice Points in Barcelona, the StromSparCheck in Germany, or the Energy Advice Points by the consumer protection agency Rheinland-Pfalz or NRW in Germany are very similar measures. Out of these, we finally selected the Energy Advice Points in Barcelona for the analysis as it included all the relevant elements.

Table 1 Sample of selected measures (name, country, short description)

Measure (name, country, source)	Description
Mieterstrom-Modell, Germany https://www.bmwk.de/	Promotes decentralized electricity supply. The tenant electricity model is based on the interaction between landlords, tenants and electricity providers: the landlord produces electricity from renewable sources locally on the house and sells it directly to his tenants through the electricity supplier. The local sale has advantages for both sides: the landlord's investments become more profitable, while the electricity costs for the tenants fall
Clean Air Act, Poland https://www.cleanairfund.org/	Double goal: improvement of energy efficiency and reduction of air pollution. Ten-year long programme in family households. Through modernization of buildings, this program aims to reduce emissions of pollutants (mainly carbon dioxide) and reduce final energy consumption. It is also oriented toward the use of renewable energy sources. The innovative aspect of this program is that it is the only one aimed at improving the condition of single-family buildings. In addition, its purpose is to shape attitudes related to energy efficiency of households
Coach Copro, France https://paris.coachcopro.com/	CoachCopro is an independent and free digital platform to coordinate and assess about energy renovation with the following objectives: to reduce co-ownership charges and energy bills, to improve thermal comfort winter as summer, to assure the valuation of its real estate value and to reduce the CO2 emissions from the buildings. The main goal of the project is the renovation of the Parisian residential park for different reasons: reduction of Greenhouse Gas (GHG) emissions and reduction of energy consumption; anticipation of the exhaustion of resources and increased energy prices; mastery of energy charges; and the fight against fuel poverty. The renovation programme includes different steps: (1) energy situation diagnosis, (2) choosing the works to be performed (mandated to individualize the heating costs, insulation renovations), (3) establish a funding plan, (4) organising tasks and (5) performing tasks. The digital platform is oriented to co-owners, members of the trade union council, the co-owner 'energy referent', trustees and their managers, OPAH operators and building professionals
Servei d'assessorament energetic, Barcelona, Spain (Points for Energy Advice—PAEs) https://www.ecoserveis.net/coneix-els-punts-dassessorament-energetic-pae/	This measure consists of Physical Energy Advice Points located around the city. The available services offered are: (1) energy saving and energy efficiency assessment and advice, including energy audits if necessary, (2) energy contracts counselling and (3) orientation and advice on benefits procedures
Energy Café, UK https://energyethics.st-andrews.ac.uk/the-energy-cafe/	Civil society action to deliver energy poverty alleviation at local level. These energy cafes are run by community groups, they rely on local knowledge and knowing the local context. Due to reliance on volunteers and stop-start funding streams, many community groups organising energy cafes have to be innovative and creative in their fund raising. Funding for energy cafes has come from a range of sources, including local authorities, utilities, European funds and government programmes, such as the Big Energy Saving Network
Papillon—a rental model for energy saving appliances for people in EP, France https://www.circularx.eu/en/cases/61/bosch-papillon-project-appliance-leasing	Co-creation between social organisation (Samenlevingsopbouw) and multinational (Bosch)—circular economy—product as a service—lowering energy consumption and bills, lowering CO2-emissions—rental contract over 10 years (service, repairs and guarantee included). This model has been developed by aid of Ashoka Europe and Schneider Electric Foundation
MAGE (Mesurer et Accompagner pour Garantir les Economies), France https://www.precarite-energie.org/	Addresses households that wish to benefit from a measurement tool designed by Eco CO2: a tablet connected to the electricity meter that indicates in real time the power consumption and individual coaching conducted by the association SoliHa Paris Hauts de Seine Val d'Oise. Energy coaching by local agents trained in MAGE (Module Mage: general + collective meeting + individual accompaniment + technology)

Table 1 (continued)

Measure (name, country, source)	Description
L'Atelier solidaire, France https://www.edf.fr/	L'Atelier solidaire consists of a solidarity workshop conducted with the inhabitants. It has been created through a partnership between Toulouse Métropole, the City of Toulouse, Habitat Toulouse, EDF, the Caisse d'Allocations Familiales of Haute-Garonne via the Centre Social Empalot, Leroy-Merlin, and the Builder Companions. This workshop aims to reduce residents' energy and water costs, combat energy poverty, and create neighborhood-level social ties as part of the city's policy. Co-construction with local stakeholders (multi-partnership), empowerment and involvement of citizens, collective diagnosis of the needs to define the district of intervention and the needs of the vulnerable consumers to work on the comfort, safety of the electrical installations and the devices. Address both the energy poverty and poor housing
Cold home toolkits, UK https://www.citizensadvice.org.uk/	Benefits include better standards of living, improved and more energy efficient houses, fewer avoidable winter deaths and reduces costs for the health, well-being and care services. Based on good practice from across England, the toolkits offer useful insight on the most effective ways of working, along with helpful case studies, and useful resources
Tutor per l'Energia Domestica (TED), Italy https://www.ecologiaeconsulenza.it/sportelloenergia/tutor-energia-domestica/	This measure is included in the broader project ASSIST (now closed). The specific measure consists in promoting the creation of a network of innovative professional figures to support vulnerable consumers with respect to their domestic energy consumption (the Household Energy Advisors)
Energiesubsidiewijzer, Netherlands https://www.isde.nl/energiesubsidiewijzer.html	Project promoted by the Dutch public administration with the civil organisation Milieu Centraal. It consists of a digital platform to explore possible grants, loans and other support measures to perform actions and works to improve energy efficiency and other energy subsidies. It is a digital, open and free platform
Dampoort KnapT OPI, Belgium https://degroteverbouwing.eu/	The programme offers intensive social and construction technical guidance to "emergency buyers" (people that are in a poor financial situation after buying a house). The origins of the programme were in an innovative and democratic community model to retrofit significantly, and at affordable prices, vulnerable people's properties. The programme addresses houses located in Dampoort district, improving their quality, safety and energy efficiency. The programme involves actors from the business sector, social sector, communities and local authorities. The programme coordinator is the Public Center for Social Welfare in Gent (OCMW Gent)
Bielefelder Klimabonus, Germany https://www.klimaschutz.de/	The Bielefeld Klimabonus was introduced to generate energy savings and reduce social hardship by ensuring tenants were not priced out of their homes following an energy retrofit—which in Germany leads to an increase in rent. The Klimabonus operates using a pay-as-you-save model, whereby the money spent on the energy retrofit is gradually recouped through payment of a higher rental amount once the work is completed. It is designed around the principle that the lower the level of energy consumption for a property, the higher the rent which can be charged. This energy consumption must be documented and validated with an energy performance certificate. The result should be that the resident is no worse off, as the increased rental level is offset by the decrease in energy bills
VERBUND-Stromhilfefonds, Austria https://www.verbund.com/	Double goal: help people in financial distress and climate goals. VERBUND electricity assistance fund of Caritas helps energy poor people with the following measures: (1) Energy saving and energy efficiency assessment for affected households. (2) Device replacement. (3) Emergency subsidies to pay bills before disconnection (which only applies if there is a previous energy assessment and efficiency measures)
Energy Company Obligation (ECO), UK https://www.ofgem.gov.uk/environmental-and-social-schemes/energy-company-obligation-eco/energy-company-obligation-eco-support-improving-your-home	Double goal: to help reduce carbon emissions and to tackle energy poverty. The energy efficiency scheme includes the following obligations: (1) Carbon Emissions Reduction Obligation (CERO)—Under CERO, obligated suppliers must promote 'primary measures', including roof and wall insulation and connections to district heating systems. Some CERO must also be delivered in rural areas. (2) Home Heating Cost Reduction Obligation (HHCRO)—Under HHCRO, obligated suppliers must promote measures which improve the ability of low income and vulnerable households to heat their homes. This includes actions that result in heating savings, such as the replacement or repair of a boiler. Each obligated supplier has an overall target based on its share of the domestic energy market in Britain

Table 1 (continued)

Measure (name, country, source)	Description
Home Energy Efficiency Programmes for Scotland (HEEPS), UK https://www.eas.org.uk/home-energy-efficiency-programmes-for-scotland-and-heeps	Double goal: increase energy efficiency and tackle energy poverty. It is a cluster of programmes including: (1) Area-Based Schemes (starting in most deprived areas, according to data of multiple deprivation, child poverty, House conditions and heat mapping, with the aim of covering all homes in Scotland in 10 years)—Local Authorities/Free to the householder/All type of tenures. (2) Warmer Homes Scotland (7-year programme) including measures as wall insulation, loft insulation, draught-proofing, central heating and renewables—Home energy Scotland/Low-income homeowners or tenants of private sector landlords. (3) Home energy Scotland Loan Scheme: loans up to 32,500pounds and interest-free to install energy efficiency measures, such as wall insulation, double glazing, boilers, warm air units and other forms of renewable technologies—Home Energy Scotland/owner occupiers and registered private sector landlords. (4) equity loans to homeowners on low incomes, and small landlords, to help them make essential repairs to leaking roofs and building structures to make their homes warmer—Home Energy Scotland/Applied to local authorities areas (Glasgow City, Argyll and Bute, Perth and Kinross, Inverclyde, Renfrewshire, Stirling, Dundee and the Western Isles)
Robin Hood Energy, UK (closed since 2020) https://www.ofgem.gov.uk/publications/robin-hood-energy-limited-final-order-0	Robin Hood Energy was the first not-for-profit energy company owned by a local authority. It was set up to tackle energy poverty and to help give people a cheaper, more helpful alternative to the “Big Six”. Launched and owned by Nottingham City Council, a not-for-profit company
Community-based project for Biomass Briquette Production, Hungary https://www.ecoserveis.net/wp-content/uploads/2019/02/Atlas-of-energy-poverty-initiatives-in-Europe.pdf (page 16)	This project consisted of implementing a project of production of eco heating source—biomass briquettes from feedstock, donated by a local cooperative, to tackle both access to energy and energy poverty
CAF-Acció, Spain https://www.ecoserveis.net/en/donation/caf-accio/	The project was implemented between October 2015 to October 2016 in seven self-funded communities in Catalonia, which were selected after taking into account geographic diversity, different kinds of users, and various operating group models. However, the methodological guidance and social interventions developed by the project represent a starting point, not a goal. The initial part of the project targeted migrants from Africa and South America who had been living in Catalonia for at least 3–4 years, and who were members of established communities with strong relationships and trust levels (usually around 10–15 people). The projects targeted migrants who do not have money to spend on energy efficiency improvements in their homes and who were likely to stay in their dwelling for at least 3 years
Energy Local Club, UK https://energylocal.org.uk/	This is a pilot project for sixty vulnerable households that aims to promote the creation of similar initiatives across the UK. The goal is addressing energy poverty by increasing the local consumption of locally generated renewable energy (mostly solar power). The program is based on a pre-existing program that was restricted to households on credit meters (smart meters). The program consists in developing the technology and processes to include the most vulnerable consumers with prepayment meters in these schemes

big energy companies. In this case, the high scores in the technological dimension are motivated by the measure’s use of alternative energy sources and its aim of transforming the energy provision model. On the other hand, despite being an alternative to private suppliers, a focused analysis of its actual governance structure shows low potential in terms of policy adequacy, targeting, and empowerment of affected groups. Robin Hood Energy’s efforts have focused on decreasing energy prices (and diminishing the profits of the company) as a way to tackle energy poverty.

The second measure included in this cluster is the Scottish program Home Energy Efficiency Programmes for

Scotland (HEEPS). It is a holistic measure made up of four subprograms (that can change every year, depending on the needs detected) covering a diversity of aspects. Currently, it consists of Area-Based Schemes, Warmer Homes Scotland, Home Energy Scotland Loan Scheme, and an Equity Loan Pilot Scheme. The high scores in technological dimensions are justified by the program’s emphasis on alternative and sustainable energy sources and by the inclusion of innovative technological means to improve energy efficiency. In contrast, this comprehensive measure did not receive high scores in categories connected to the governance axis, such as behavioural change, policy approach (mostly top-down), affected

Table 2 Evaluation dimensions and criteria along the technological and governance dimensions

Axis	Dimension	Subdimensions	Subdimension description	SCALE							
				1	2	3	4	5	6	7	
A. Technological innovativeness	A.1 Technology innovation	A.1.1 Technological means	From a technological product perspective, does the policy involve fighting energy poverty through "usual/classical" technological elements or does it involve the implementation a new technologies?	Technology is not present at all in the policy	Technology is present, but from a classical approach	Technology is present, but from a classical approach	Technology is present, but from a classical approach	Technology is present, but from a classical approach	Technology is present, but from a classical approach	Technology is present, but from a classical approach	The technology differs significantly in their characteristics or intended uses from previous technology
		A.1.2 Technological process	From a technological process perspective, does the policy involve fighting energy poverty through "usual/classical" means or does it involve the implementation a new technological process?	Technology is not present at all in the policy	Technology is present, but from a classical approach	Technology is present, but from a classical approach	Technology is present, but from a classical approach	Technology is present, but from a classical approach	Technology is present, but from a classical approach	Technology is present, but from a classical approach	The measure includes the adoption of technologically new methods
	A.2 Replicability and applicability	A.2.1 Applicability	Is the technology easily applicable in local and specific contexts, without great effort?	The new technology implemented need to be applied in a centralised way and it needs an important effort	The applicability of the new technology is not relevant in the policy	The applicability of the new technology is not relevant in the policy	The applicability of the new technology is not relevant in the policy	The applicability of the new technology is not relevant in the policy	The applicability of the new technology is not relevant in the policy	The applicability of the new technology is not relevant in the policy	The technology is applied in a decentralised way and can be adapted to different contexts
		A.2.2 Replicability	Is the new technology implicated in the measure easily replicable in other contexts and places?	The application of this new technology highly depends on the specific context and its characteristics. It cannot be easily replicated	The replicability of the new technology is not relevant in the policy	The replicability of the new technology is not relevant in the policy	The replicability of the new technology is not relevant in the policy	The replicability of the new technology is not relevant in the policy	The replicability of the new technology is not relevant in the policy	The replicability of the new technology is not relevant in the policy	The new technology can be easily replicated in other contexts
	A.3 Renewable and alternative energy sources	A.3.1 Renewable and alternative energy sources	Does the measure make an effort to step up progress toward using renewable-energy technologies?	The policy is based on classical and non-renewable energy technologies	The measure does not have impact on this issue	The measure does not have impact on this issue	The measure does not have impact on this issue	The measure does not have impact on this issue	The measure does not have impact on this issue	The measure does not have impact on this issue	The measure make an effort to step up progress toward using renewable energy technologies

Table 2 (continued)

Axis	Dimension	Subdimensions	Subdimension description	SCALE							
				1	2	3	4	5	6	7	
B. Governance innovativeness	B.1 Mode of Action	B.1.1 Policy adequation	Is the policy tailored to the needs of the beneficiary?	No, the beneficiaries receive the same kind of help regardless of their specifics	There are some loose categories of beneficiaries based on specifics and the intervention is based on the categories	Yes, the measures implemented vary and are properly adapted to the specific features of each beneficiary					
		B.1.2 Policy approach	Does the policy emphasize action at the grassroots level (action based on networking and cooperation among individuals)	No, the policy has a full top-down approach, with institutions doing all the work and providing to the citizens	There is a continuous dialogue between representatives (action groups, NGOs, community leaders) of the citizens and institutions to shape actions	There is a clear focus on grassroots action. The policy cannot be properly implemented without active involvement from the citizens. Institutions only create the context for action at the grassroots level					
	B.2 Framing	B.1.3 Resources provided	What type of resources are provided by the policy?	The type of resources provided is financial support with short-term objectives	The resources provided are mainly financial, but through innovative forms (such as reducing taxation, revolving funds, etc.)	The type of resources provided are diverse and seek for longer term impacts					
		B.1.4 Funding method	Does the policy incorporate an innovative funding method?	No, the policy relies on a classical method of funding (based on classical public investment without mechanisms of revolving or financial sustainability)	The policy incorporate some innovative and diverse elements in its funding system It does not require big inversion, it's not relevant	Yes, the policy incorporates as a main goal the incorporation of an innovative funding system that permits the sustainability and evolution of the policy					
		B.2.1 Social inclusiveness criterion	Is the policy focused on social inclusiveness? Does it make a purpose from identifying and targeting socially excluded groups	There is no mention of social inclusiveness as an objective of the policy	Social inclusiveness is a bonus, but it is not the main target	Social inclusiveness is the main goal of the policy					
		B.2.2 Targeting	Does the policy target groups which have not been (adequately) addressed by previous policies? (e.g., elderly unemployed, low-income household which do not receive social benefits)	It does not target specific vulnerable groups	It targets specific groups, but not specifically related to energy poverty needs (e.g., Large families)	It targets specific energy vulnerable groups					

Table 2 (continued)

Axis	Dimension	Subdimensions	Subdimension description	SCALE						
				1	2	3	4	5	6	7
B.3 Affected groups involvement and participation	B.3 Affected groups involvement and participation	B.3.1 Behaviour change	Does the policy aim to 'educate' or to influence/change the behavior of individuals in their households and within the community?	Education is not mentioned in any way as an objective	Education is an objective, but not the main focus					The policy is entirely focused on education
		B.3.2 Accessibility	Is it easily accessible for households?	No, a lot of bureaucracy, consultants or expert intervention is needed	Consultants would ease the application procedure, but the process is accessible to those with a basic understanding of the process					Yes, only a small amount of paperwork needed or it could be easily applied
		B.3.3 Affected groups empowerment	Does the policy promote and impulse the affected groups empowerment?	No, beneficiaries are only recipients "one time" term "blanket" measures	The policy attempts to combine blanket measures with measures aimed at changing behavior and improve quality of housing					Yes, the policy allows the beneficiaries to develop skills and acquire technical capabilities to prevent them from being energy poor in the long run
B.4 Cooperation	B.4.1 Actors partnership	Does the policy aim to develop partnerships across multiple stakeholders/institutions?	No, the entire responsibility falls with only one stakeholder	The policy attempts to identify stakeholders and share responsibilities, but this is not properly done					Yes, there is a comprehensive perspective over the stakeholders and each has a responsibility	
B.5 Monitoring innovation	B.5.1 Monitoring and evaluation tools	Does the policy specify clear follow-up, monitoring and measurement tools to ensure the effectiveness of the policy once implemented?	No, there is no kind of indicator of effectiveness	There are clear effectiveness indicators and monitoring mechanisms, it is clear who does the monitoring, but it is not clear what should be done if the policy is not effective					The outputs of the policy are constantly monitored, measured and reported. It is clear who oversees the monitoring and who is responsible and should intervene to improve the outcomes if necessary. The follow-up is embedded in the policy	

groups empowerment and actors' partnership in policy design, development and evaluation. However, HEEPS is well-regarded in terms of targeting and in the type of resources provided. The third measure is the 'Brixton Energy Local Club', which develops technology to include vulnerable consumers in the existing energy club with prepayment meters. In this latter case, we can see how a measure aiming predominantly at technological innovation manages to target vulnerable consumers by including them in an existing initiative.

Turning now to *measures with incremental technological/radical governance innovation*, we have four measures in this category: L'Atelier Solidaire, Energy Café, the Energy Advisory Offices (PAE⁴), and the CAF-Acció Project. L'Atelier Solidaire promotes local workshops conducted by neighbours and volunteers, with the aim of tackling energy poverty by reducing residents' energy and water costs, improving thermal comfort at home, and creating neighbourhood-level social ties as part of the city's policy. This measure has reached high scores in all sub-dimensions related to affected groups' involvement and participation, and also in social inclusiveness, clearly mentioned as one of its main objectives. It also has a fair rating in actor partnership, because it involves different political actors, from neighbours and affected collectives to the City Council or private actors, thus involving households (including low-income households) in the decision-making process.

Energy Cafés, a measure from the United Kingdom, is a civil society initiative aimed at tackling energy poverty by generating collective spaces, run by community groups. It got higher scores in all criteria related to affected groups' empowerment and participation, and had social inclusiveness as a goal. This measure is highly interesting in terms of empowerment, because it facilitates the autonomy of the affected groups, creating solidarity and resource nets in a local sphere that can be helpful to vulnerable collectives in every area of their lives, beyond what pertains to energy poverty.

Energy Advice Points (PAE), created by the City Council of Barcelona, are located in each of the city's districts of Barcelona and offer information to the general public on energy consumption and saving, as well as advice on self-production or other energy issues. The PAEs also provide specific information to energy-poor people and are the starting point for other measures to combat energy poverty (e.g., energy audits). In contrast to other advice schemes, it is also active from a political perspective, having a role in forming alliances, lobbying, and empowerment. A last measure with a high score on the governance dimension is the CAF-Acció Project. It aims

to tackle energy poverty by promoting the creation of collective self-financing groups through existing neighbourhood communities, providing emergency funds for utility bills, but mainly to self-finance energy efficiency improvements for households. Like the previous three measures, there is a clear focus on empowerment, participation, and social inclusiveness in affected groups.

Concerning technological criteria, the four selected measures have mostly low ratings on technological innovation, with the exception of L'Atelier Solidaire. In some cases, measures emphasizing governance innovation include references to sustainable energies and associated technologies, but not as a main goal.

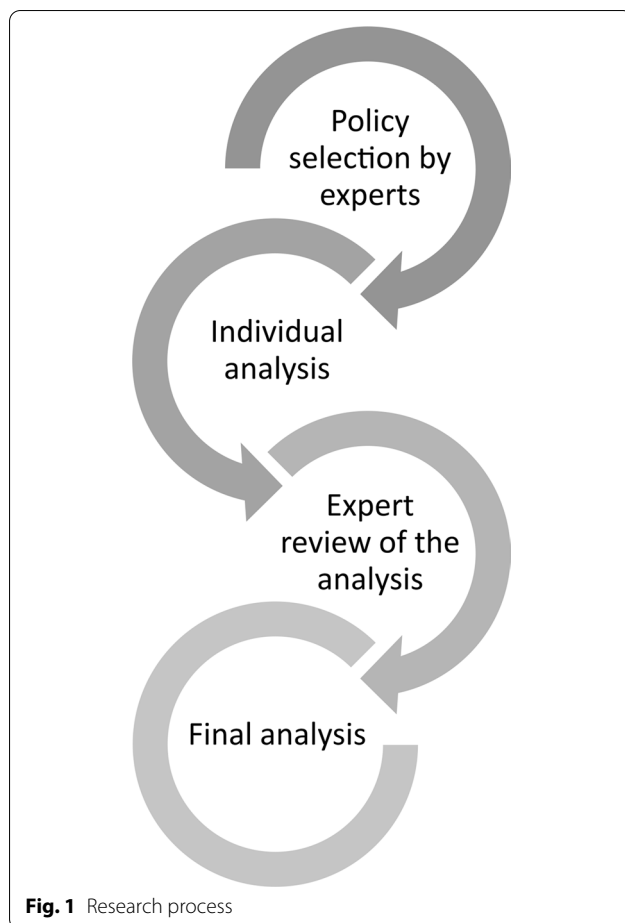
Finally, three measures reached *radical technological/radical governance innovation* scores. Besides good scores in most of the sub-dimensions, the scoring patterns also show that all three measures have no low ratings in any subcategory.

MAGE (Mesurer et Accompagner pour Garantir les Economies) is a household coaching scheme for vulnerable households that incorporates smart technologies as consumption measurement tools. Household beneficiaries have a tablet connected to the electricity meter that indicates their power consumption in real-time.⁵ This activity is complemented by individual coaching conducted by the association SoliHa Paris: Hauts de Seine Val d'Oise. For a year, tenants who wish to will receive three home visits to assist them in controlling their consumption of water and energy, as measured by the tablet, along with tailored advice. In terms of governance innovation, this measure has a clear goal of behaviour change, as well as the incorporation of different actors in a partnership and the long-term use of monitoring tools throughout the process. On the other hand, these are complementary to incorporating new technologies into the domestic sphere and promoting consumer awareness and consumption pattern transformation.

The second measure is CoachCopro, also from France. It is a free digital platform to coordinate and assess energy renovation. The main goal of the project is the renovation of Parisian housing blocks to clearly reduce consumption and related emissions and to alleviate energy poverty. The renovation program includes different steps: (1) energy situation diagnosis, (2) choosing the tasks to be performed (it is mandatory to individualize the heating costs, insulation renovations), (3) establishing a funding plan (4) organizing tasks and (5) performing tasks. The digital platform is oriented to co-owners, members of the trade union council, trustees and their managers, housing operators and building professionals,

⁴ In the original Catalan version: Punts d'Assessorament Energètic.

⁵ The Tablet was designed and provided by one of the partners: the private company Eco CO2.



who are involved at each step of the process. Finally, the Mieterstrom Model (“tenants-electricity model”, Germany) is a family of measures which support a decentralized electricity supply that enables not only better-off households and homeowners, but also low-income tenants, to benefit from the subsidies for generating solar energy. The Mieterstrom Model is based on interaction between landlords, tenants and electricity providers: the landlord produces electricity from alternative and sustainable sources local to the house and sells it to his tenants through the electricity supplier for a reduced price. The local sale has advantages for both sides: the landlord’s investments become more profitable, while electricity costs for tenants decrease. Moreover, regional programs, such as the Thuringian “Solar Invest”, provide better frameworks and financial support.

Discussion

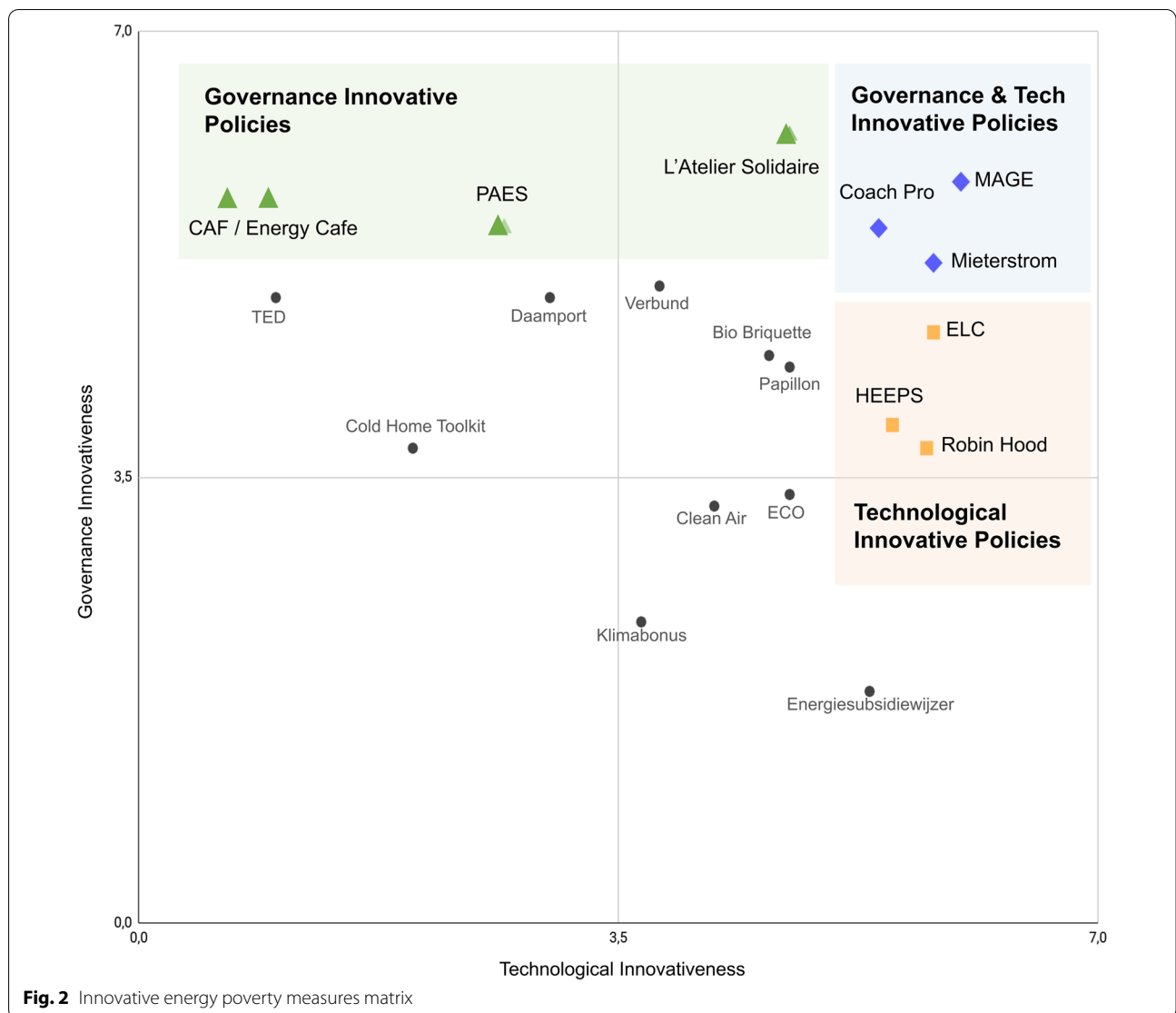
The goal of this research was to analyse the direction taken by recent innovative measures addressing energy poverty in various European contexts along technological and governance dimensions. Both dimensions are

regarded, either separately or together, as features of innovation and also hold normative importance as a must for a truly innovative nature. Within this exploratory study we elaborated a set of evaluation criteria based on elements of technological and governance innovation and applied it to a set of twenty recent measures identified as innovative by energy poverty experts. Our findings allow for a better perspective of how innovation takes shape in the context of energy poverty, and also result from passing energy poverty through the analytical lenses of technological and governance dimensions of innovation.

Our research analyses the innovative nature of these measures in the specific contexts in which they have been enacted, based on the premise, outlined by Alic and Sarewitz [56], that the introduction of technological innovations must be examined within the complexity of political, institutional and cultural contexts. From a policy perspective, an open question remains regarding the transferability of measures across contexts. The emphasis of Sabato et al. [18] regarding governance innovations as novel practices in context, rather than universal novelties, is quite relevant. In addition, our research points out that merging technical and social knowledge in the energy poverty policy field does not always occur. Measures scoring high in governance innovation do not incorporate a technical dimension in most cases explored, just as Edwards-Schachter and Wallace [19] highlight for governance innovation in general. However, the few exceptions in our sample which incorporate technologies into the everyday life of affected groups do so in ways that allows these groups to improve their own self-awareness and to redefine their relationship with energy. This resembles the ‘human in the loop’ approach, in line with Wurtz and Delinchant’s [57] proposal to use technology to empower vulnerable consumers into conscious consumers, as well as with the broader line of research focusing on the importance of “lived experiences” at the foundation of elaborating new policies [58].

Policy implications

Currently, many policies addressing energy poverty are elaborated at national level, without taking into account the variations of the phenomenon at local levels. Moreover, many use an “assistential” approach, with little involvement from those targeted by the policies, often with eligibility criteria stemming from social welfare policy, focusing only on low income as a criterion to identify the energy poor, thus overlooking how many are energy poor as a result of other causes [5, 25, 26]. Our research sheds light on how new governance models, focusing on more participation and dialogue at the community level, in combination with new technologies, can change the



paradigm. From a technological perspective, the measures analysed in our research with high scores for technological innovativeness show how technologies focusing on renewable energy sources or ICT technologies can be made available to those affected by energy poverty and how they can fix two inter-related issues: reduce the energy bill (without necessarily implying a drop in thermal comfort) and help these consumers become proactive actors, thus increasing their level of participation and interaction with the energy system. Previous research [49] shows that the success of introducing new technologies depends highly on the early involvement of the beneficiaries, yet energy poor households have few incentives to adopt the latest technological innovations and rather face burdens in incorporating them [43]. Our sample of analysed measures confirms that a balance between

technological and governance innovation is hard to strike, yet it also points to examples of measures which have been able to do that. Combining the two dimensions of innovation should become the focus of future measures (coming from state and non-state actors) aimed at addressing energy poverty, especially if we consider that the supply side of energy will increasingly integrate decentralized renewable sources relying on new(er) technologies, thereby requiring early and active involvement of citizens.

Conclusions

In sum, we argue that combining technological with governance innovation has a better chance, compared to technology-only or governance-only measures, to generate more articulate, scalable, and ultimately successful

Table 3 Scoring on sub-dimensions and average scores for each measure

	Mieter "Clean Air" Modell	Clean Coach PAES Copro	Energy Cafe	WAGE	Latelier	Cold	Tutor per Energie	Dampoor Energie KnapT OPI	Bielefelder Klimabonus fonds	VERBUND- Energy Company	HEEPS RobinHood Energy	Papillon	Biomass Briquette	CAF- Energy Local Club					
A. Technological innovativeness																			
A.1 Technology innovation	4	6	1	1	7	5	2	1	5	4	5	1	6	6	6	4	3	1	7
A.1.1 Technological means																			
A.2 Replicability and applicability	4	6	1	1	6	4	2	1	5	4	5	1	5	6	5	4	5	1	7
A.2.1 Technological process																			
A.2.1 Applicability	4	5	4	1	5	5	2	1	6	3	4	5	5	5	5	5	5	1	3
A.2.2 Replicability	4	5	3	1	6	5	2	1	5	3	3	5	5	5	5	6	5	1	5
A.3 Renewable and alternative energy sources	6	5	6	1	6	5	2	1	6	1	1	7	3	6	7	5	5	1	7
A.3.1 Alternative energy sources																			
Average	5.8	4.2	5.4	3.0	1.0	4.8	2.0	1.0	5.4	3.0	3.6	3.8	4.8	5.6	5.8	4.8	4.6	1.0	5.8
B. Governance innovativeness																			
B.1 Mode of Action	6	6	7	7	7	7	3	7	2	6	1	7	6	6	1	7	5	6	5
B.1.1 Policy adequation																			
B.1.2 Policy approach	1	7	2	7	5	7	1	5	1	5	1	6	1	2	5	1	3	7	5
B.1.3 Resources provided	6	1	6	6	7	7	2	3	2	6	3	7	6	7	3	6	6	5	4
B.1.4 Funding method	6	1	4	3	4	5	4	3	1	7	6	4	5	4	5	7	1	7	3
B.2.1 Social inclusiveness criterion	4	4	7	7	3	7	4	4	1	5	1	6	1	4	5	6	3	6	5
B.2.2 Targeting	6	3	4	7	6	6	7	6	1	5	1	1	2	6	1	7	7	6	6

Table 3 (continued)

	Mieter strom- Modell	"Clean Coach Air"	PAES Copro	Energy Cafe	MAGE Cafe	Latelier solidaire	Cold home	Toolkits	Tutor per Energie subsidie Domestica (TED)	Dampoort KnapT OPI	Bielefelder Klimabonus fonds	VERBUND- Stromhilfe fonds	Energy Company Obligation	HEEPS Energy	RobinHood Energy	Papillon	Biomass Briquette	CAF- Accio	Energy Local Club
B.3 Affected groups involve-Behaviour change participation	4	5	6	6	7	7	4	7	1	4	1	6	1	1	5	4	6	5	7
B.3.1 groups involve-Behaviour change																			
B.3.2 Accessibility	5	4	5	7	7	6	2	2	6	1	4	6	3	5	7	2	7	3	2
B.3.3 Affected groups empower- ment	4	4	7	4	7	4	4	4	1	7	1	1	1	2	1	1	5	7	4
B.4 Coopera- tion	7	1	4	4	7	7	6	7	3	3	3	5	5	2	4	6	5	4	4
B.4.1 Actors partner- ship																			
B.5 Monitoring innovation evaluation tools	6	7	7	1	7	1	4	6	1	5	4	6	6	4	4	1	1	6	6
Average	5.7	3.6	6.0	6.0	6.2	6.4	6.8	4.1	5.4	5.4	2.6	5.5	3.7	4.3	3.7	4.8	4.9	6.2	5.1

measures relative to their purpose to tackle energy poverty, because the drivers of energy poverty rarely pertain to just technology or just governance. This is an important point to make especially with respect to the policy paradigms through which many states deal with energy poverty, rooted in short-term assistential measures and often tied mainly—or exclusively—to income despite resorting to “innovative” as a buzzword attached to their policy design and outcomes. The measures enacted by national governments in the context of the current energy crisis, but also in the context of rising energy consumption during the Covid lockdowns [59] and even before them [26, 60–62], have largely fallen into this paradigm. Meanwhile, energy poverty is only deepening, and recent developments have shown that such short-term measures do not protect consumers in the long term nor empower them with the knowledge to face shocks and challenges.

However, unlike measures stemming from civil society and grassroots, policies designed and implemented by local or central authorities benefit from significant additional leverage and funding capability. Therefore their potential to enact change is much higher. Many of the measures which scored high on innovation in this paper are pilot projects, addressing rather small samples of households or small communities, yet they have displayed the potential to produce change through combinations or technological and governance means once upscaled.

Moving further, a next step, one building on our research, would require assessing the effects of these measures in terms of their impact and efficiency, meaning if they manage to lift the energy poor households out of energy poverty in the longer term. In addition, their impact should be evaluated from both technological and governance perspectives to see how well each manages to attain its goal. The potential negative side effects of innovation also need to be considered. As Ayob et al. [16] mention, actors developing new solutions assume these solutions “have a positive societal impact”, but whether this happens or to what extent remains to be seen [62], especially with respect to a phenomenon as complex as that of energy poverty.

Another promising line of further research could explore the mutual influence of different types of innovation. As Edwards-Schachter and Wallace [19] argue, social innovation is part of the ‘black box’ of general innovation, therefore, it can occur within the interplay of various innovation processes and contribute to both social and technological changes, as Geels et al. have shown in their multi-perspective analysis of socio-technical regime change. Finally, both further scientific research and policy-making targeting energy poverty need to address the knowledge gap between the experts

in energy (a highly specialized field), on one hand, and experts in social practices, on the other hand, to remove potential barriers to introducing new technologies for the benefit of the energy poor.

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Author contributions

AV acquired the information and material from public websites, conducted the coding and scoring, elaborated the tables and figures for synthesis, conducted the analysis of the results. GJ contributed to the methodological design. AV, KG, RG, GJ contributed to identifying the experts for the expert panel and contributed to the literature review and to the analysis of the results. All authors read and approved the final manuscript.

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Availability of data and materials

The information regarding the measures included in the analysis are acquired from public websites. The coded information used for the analysis are summarized in Table 1 and can be used as such.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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