

Energy Poverty in Middle-development countries: an interdisciplinary science-policy dialogue from Chile

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Introduction

Since the beginning of the '90s, energy poverty has acquired an increasingly vital role both in the design and evaluation of energy policies, and in the international debates on sustainable development and equity. Scholars have noted that no significant trade-off exists between overcoming energy poverty and fighting against climate and environmental change; conversely, important synergies can be achieved by pursuing both goals at the same time.

Most of the research, however, has tended to polarize either on poor underdeveloped countries, where the problem is usually identified with the lack of sufficient access to adequate, reliable and safe energy services; or on developed countries, where the concept, often relabeled as 'fuel poverty', focuses on issues of affordability and distributional equity.

Significantly less studies have taken into account the case of mid-range countries, such as Chile, where a highly developed network of electrical generation and distribution coexists with bubbles of absolute energetic isolation; with an even broader occurrence of recurrent blackouts and unreliable supply, lacking adequate resilience to the ever more frequent extreme weather events; and with the generalized primacy of gas, -oil- or wood-based solutions particularly for heating, mainly due to one of the most expensive electricity prices in all the region. At the same time, the country's energy matrix has been encountering growing criticism because of its dual dependence on mega-dams, with strong environmental and social impacts on the local level, and high vulnerability to mega-drought conditions expected under future climate change scenarios; and on imported fossil fuels, which have already led to multiple energy crises during the last decade.

In this context, addressing energy poverty and inequality can't be separated from the objectives of securing a reliable energy supply and preventing local and global environmental impacts, and must at the same time consider all the complex and often debated interdependencies with broader development and equity objectives, and with the local social, environmental, and geophysical contexts.

Considering the urgency and complexity of these issues, a diverse team composed by researchers from the University of Chile and other national and international institutions has undertaken an interdisciplinary dialogue directed at building a collaborative definition of Energy Poverty in Chile, identifying its main

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dimensions, available knowledge and research needs in the country, fostering the emergence of a collaborative research network, and engaging key policy-makers from the energy sector. This paper discusses such experience and the outcomes, challenges and lessons learned.

Background

Since the publication of the book *Fuel Poverty*, based on Brenda Boardman's PhD Thesis in 1991, energy poverty (EP from now on) has acquired a growing importance. In UK it has been the base for the UK Fuel Poverty Strategy in 2001, and it has spread to many countries *later*, mainly Europe and New Zealand (Liddell, 2012). In this context, a growing research is being developed, addressing different ways of defining and measuring EP *x* as well as evaluating *x* consequences. The latter has been particularly important because of the relationship between EP and deterioration in quality of life, damage to physical and psychological health, lack of productive opportunities and educational weaknesses (Bridge, Adhikari & Fontenla, 2016; González-Eguino, 2015; WHO, 2006).

However, the interactions between EP and other public policy objectives are hardly unproblematic. First, energy policy shows important links to sustainable development, as one facet of the 'carbon problem' (Estenssoro, 2010): in Chile, the energy sector is responsible of most of greenhouse gas emissions and has the highest mitigation potential (MAPS Chile, 2014). However, as Chakravarty y Tavoni (2013) show, no significant trade-off would exist between fighting EP and climate change; on the contrary, addressing both problems at the same time could lead to significant synergies (Ürge-Vorsatz & Tirado Herrero, 2012). Secondly, energy policies show important connections with other sectoral objectives, such as water and food (Bauer, 2010; Meza, Vicuna, Gironás, Poblete, Suárez & Oertel, 2015), and are deeply associated with environmental or social variables, requiring an integrated consideration of local socio-ecological resilience and avoiding an unproblematic support to the adoption of more modern fuels (Reyes, Nelson, Navarro & Retes, 2015). Sometimes, this transition may end up increasing -rather than reducing- the vulnerability of the community (Herington & Malakar, 2016). Numerous studies have also shown how the success or failure of local energy transitions depends not only on technical factors but also on local specific characteristics, expectations and needs (Lillo, Ferrer-Martí, Boni, & Fernández-Baldor, 2015; Rolffs, Ockwell & Byrne, 2015; Terrapon-Pfaff, Dienst, König & Ortiz, 2014) as well as on *psychological*, sectorial and institutional factors (Puzzolo, Pope, Stanistreet, Rehfuess & Bruce, 2016).

In Latin America and the Caribbean, access to quality energy sources is one of the fundamental dimensions of the Millennium Development Goals (CEPAL, 2009). This notwithstanding the fact that most countries do not possess neither explicit strategies nor sufficient information on the issue. Therefore, developing public policy focused on the problem with the necessary scope and coherence is a major challenge for the region. At present, the main measures adopted by Latin American countries aim at favoring access to energy (electricity and/or fuel) to poor or extremely poor groups, either through direct transfer of resources (bonuses, tariff subsidies) or by differential tariffs which may take into account expense capacity (García-Ochoa, 2014).

In Chile⁸, since the 1980s privatization, the energy sector is regulated by the market *which is* divided in the segments of generation, transmission and distribution. Companies are controlled entirely by private capital while the State only exercises regulatory and control functions as well as indicative planning of investments in generation and transmission (Maldonado & Herrera, 2007). Within this model, despite some mechanisms to

⁸ The Chilean territory is supplied by four independent interconnected electrical systems. The Great North Interconnected System (SING) covers the territory between the cities of Arica and Antofagasta; the Central Interconnected System (SIC) extends between the towns of Taltal and Chiloé; the Aysen and Magellan Systems supply the respective regions (INE, 2008).

sustain demand (bonds, tariff subsidies), the access to electricity and to other fuels is primarily determined by market processes rather than by regulation. Although most households have access to electricity (CASEN, 2015), an important knowledge gap still remains regarding the safety and reliability of such access, the quality of energy and its sources, and equity: three of the key dimensions of EP (González-Eguino, 2015).

Lately, the concept of EP in Chile has received more -although incipient- attention and even though the discussion on public policy was fragmentary and limited to the low-income population, without a clear definition of medium- and long-term objectives and strategies (Barrueto, 2014), it started showing up in newspapers a few years ago. This situation seems to be changing with the introduction of the concept of EP as one of the objectives of the new Energy Agenda promoted by the Ministry of Energy, "Energía 2050". According to its roadmap, EP "is addressed for the first time in Chile in a comprehensive way, with a vision of universal and equitable access to energy services to meet the needs of the population. Overcoming energy poverty does not mean only improving coverage but fundamentally ensuring prices which would allow vulnerable families to meet their basic energy needs, guaranteeing continuity of supply and minimum standards of thermal and lighting comfort in homes as well. " (Ministerio de Energía, 2014: 11). This declaration makes it all the more urgent to improve our understanding of this phenomenon and the development of indicators and methods that can guide, implement and evaluate effective and efficient measures for EP in Chile.

The Energy Poverty Network

The Energy Poverty Network (hereinafter RdPE) aims to address the complexity of this phenomenon through a transdisciplinary process of knowledge construction, jointly articulating different perspectives to build contextualized and socially robust knowledge regarding manifestations of EP in the country. Adopting a transdisciplinary model involves a double challenge: on the one hand, overcoming the rigid boundaries between disciplines in favor of a holistic understanding of the problem; on the other hand, to assume the necessary unpredictability, value-loadedness, and plurality of legitimate perspectives of knowledge creation, opening the doors to an expanded participation of social actors and their respective criteria of truth and evaluation (Cornell, et ál., 2013; Nowotny, Scott & Gibbons, 2003; Spangenberg, 2011; Walter, Helgenberger, Wiek & Scholz, 2007).

The project began in 2016, stemming from an interdisciplinary discussion within the University of Chile on the country's energy challenges for the coming years. Before the concept was mentioned in Energía 2050, there was no discussion about its scope, dimensions and how to address it so a group of professors from different faculties of the University of Chile founded the RdPE consolidating it during 2017. More than 60 professors from at least 15 specialized areas and 9 universities throughout the country are involved in the project together with independent researchers, graduate students, state officers and representatives of civil society. Each of them brings his/her own expertise focusing on different problem dimensions with the common interest of making it visible in the country and contributing to solutions.

The network was granted the institutional support of the University of Chile through the Transdisciplinary Networks Unit of the Vice-Rectorate for Research and Development playing an important role in allowing the articulation of different Faculties and providing support to have other institutions involved. The RdPE is also supported by three FONDAP research centers: the Center for Climate and Resilience Research (CR)², the Solar Energy Research Center (SERC) and the Center for Excellence in Geothermal Energy of the Andes (CEGA).

The network developed around collaborative workshops, allowing progress in understanding the phenomenon in the Chilean context through discussion of both international literature and local experiences. Fundamental

organizational decisions were also taken involving the short, medium, and long-term objectives of the RdPE to be achieved during the first three years (2017, 2018 and 2019) including:

- Developing a conceptual and methodological framework so as to allow the proposition of techniques and instruments to approach the EP interdisciplinarily
- Allowing open access to PE-related knowledge
- Identifying the key factors that influence PE at territorial and socio-cultural level in Chile
- Consolidating national and international linkage to specialized networks to promote joint research with a transdisciplinary approach
- Positioning the EP as a relevant factor for inequality reduction at the country level

To face these challenges, the RdPE defined transversal principles both for understanding the phenomenon and for defining response strategies. First, the network envisages sustainable development as a framework and energy transition processes as a horizon for tackling EP, meaning they must go hand in hand with the transition towards clean energy and the reduction of fossil fuel use. Second, intervention strategies developed at the household and community level to reduce EP need to consider their respective sociocultural context incorporating local knowledge and participatory decision-making while also stressing environmental education as a tool for social change. Finally, all work within RdPE must adopt a transdisciplinary approach constituting collaboration between different disciplines and permanent dialogue with the public sector and civil society as basic working principles.

This requires a rich dialogue between disciplines and specialized areas recognizing limits and potentialities of each different perspectives in an holistic understanding of the problem. To encourage this collaborative link at the national level, a virtual collaboration platform was set up gathering all the relevant studies and documents contributed by participants. This is complemented by face-to-face workshops where systematic progress is made on essential network definitions and the elaboration of a joint view.

Up to the moment, this work has allowed the emergence of five research lines which will articulate the RdPE professors and researchers, each judged as critical either for the understanding of the phenomenon and the evaluation of strategies to face it or for its articulation with other phenomena:

- Energy, public policy and development models
- Welfare, culture and energy efficiency
- Environmental justices, atmospheric pollution and vulnerable population
- Renewable energies and local management
- Climate change, socio-environmental risks and resilience

At the same time, the RdPE sought to improve articulation with the public sector initiating dialogues with the Energy, Social Development and Housing and Urbanism Ministries. Their respective strategies to address EP were checked up and confronted with the urgency of establishing an inter-sectorial coordinated approach.

Moreover, during the first year, the network achieved two major results detailed in the following sections: it developed a working definition of energy poverty for the Chilean context establishing priority dimensions and reviewing possible methodologies to measure this phenomenon; and it exhaustively explored the secondary sources available to characterize this phenomenon in the country concluding that they are still insufficient since -while they may be useful to characterize some areas of the problem- they are strongly disconnected one from the other and difficult to compare.

Preliminary results (1): towards a complex definition of EP

Since energy poverty has only been recently addressed in Chile, it is key to properly define it in accordance to the different territorial and socio-cultural contexts of the country. Taking up this challenge, the RdPE first considered the different theoretical and methodological approaches debated in the international literature.

There are many definitions of EP. Yet, most authors agree in conceptual terms with a multidimensional conception of EP understood as "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development" (Reddy, citado en González-Eguino, 2015:379). Thus, precisely because of its multidimensionality, this concept is often used in a variety of ways in different countries.

First, a common distinction is traced between lack of access to basic energy services and the excessive cost of such access. According to some authors, the second element -also called "fuel poverty"- would be typical of developed countries whereas the first would be limited to poor countries and their structural lack of access to energy (Bouzarovski, Petrova & Sarlamanov, 2012; Bridge, et al., 2016; González-Eguino, 2015). This distinction is often unclear, and in many cases both issues coexist (Ürge-Vorsatz & Tirado Herrero, 2012).

A second aspect is whether the condition should be understood in objective or subjective terms. The first position leads to definitions such as that of the European Council, according to which it affects those "persons, families and groups of persons whose material, cultural and social resources are so limited that they are excluded from the minimum acceptable way of life in the Member State to which they belong" (European Council, 2007, quoted by Moore, 2012:20). A threshold is usually defined in terms of the maximum acceptable proportion of household income that should be destined to energy services. Several methodologies have been proposed to identify this threshold and to calculate the effective expenditure of families using either effective values, household income or regional averages (Moore, 2012). For instance, one of the most widespread definitions is Boardman's 10% (or Ten Percent) Rule" (TPR). It claims that "*a household is in energy poverty when it can not have adequate energy services with 10% of its income*" (1991:34) where 'adequate energy services' is defined quite arbitrarily.

Other alternatives were proposed, such as Hills' (2012) "Low Income-High Cost" indicator or Moore's (2012) *Minimum Income Standard* (MIS). Similarly to TPR, these measures have been criticized for being too reductive and only focusing on economic aspects and thus discarding other dimensions that may be relevant for a comprehensive understanding of the phenomenon.

This led some authors to propose "subjective" indicators which **have** the very households to self-measure their EP; or emphasize the role of culture and social norms and of each country's contextual and economic conditions in the definition of thresholds (Ürge-Vorsatz & Tirado Herrero, 2012:84). Others, such as Healy (2004), tried to combine subjective indicators (referring to the feeling of energy deprivation of people) with more objective ones (referring to housing equipment conditions) or proposed to observe EP along a variety of thresholds at once: technological ones -lack of "modern" energy services-, physical ones -impossibility to satisfy basic needs- or economical ones -maximum acceptable percentage of income expenditure on energy services- (González-Eguino, 2015:380).

Another issue concerns the identification of which 'energy services' should be considered within EP. This varies widely between authors: although some aspects -such as domestic heating- are always deemed relevant, others appear more ambivalent, e.g. modern cooking systems (Guertler, 2012), electric lighting and appliances (Ürge-Vorsatz & Tirado Herrero, 2012) and air conditioning -particularly relevant if you consider the increasing risk of heat waves due to climate change (Healy, 2004).

One of the most important conclusions is that the concept of energy poverty is complex and should be considered country-relative (Scarpellini, et al., 2015:730) since certain variables acquire more or less relevance depending on the territory where it is being observed. Therefore, it is essential to observe this phenomenon in a holistic way so that it is possible to understand that the definition of basic needs, the amount of energy needed to achieve them, the quality of energy, the cost threshold that is considered acceptable for a household and the way to properly assess its income assessment, all these vary significantly according to culture, climate, infrastructure, socio-economic conditions and so on.

For Instance, some of EP's structural components depend on the seasonality, geographic area and the specific individuals, especially those that belong to the most vulnerable groups (such as children, elderly people, people with electro-dependent diseases among others). In fact, poverty hardly manifests itself in a single dimension, so the energy poor are likely to also suffer other forms of "poverty" without there necessarily being a structural correspondence between them.

Thus, it may be also useful to talk about "energy vulnerability", i.e. "the propensity of an individual to become incapable of securing a materially and socially needed level of energy service in the home" (Scarpellini et al., 2015:730) or as quoted in Bouzarovski Petrova & Tirado-Herrero (2014) there's the propensity of a system to fall in a situation of energy poverty, an issue which requires an integral, multidimensional approach, considering at once economic, socio-cultural, territorial and technical conditions.

During the last decades, the multidimensional analysis of poverty has received increasing attention and the main international authorities (PNUD, ONU, Banco Mundial, CEPAL) agree in considering poverty as transcending the mere income dimension (Delice, 2014). Recently, the Chilean Ministry of Social Development has adjusted the methodology for measuring poverty with the aim of achieving a multidimensional view of the problem (Berner, 2014). Amartya Sen's (2000) capability approach has been one of the most widely accepted standpoints, proposing to integrate reductive income-based measures with a stronger consideration of the abilities of individuals to satisfy needs and exercise rights in the various areas of human development. According to Sen, for certain sectors of the population not to have access to essential resources means they will not have the possibility to develop the necessary capabilities to participate socially, culturally and economically of the society of which they are part. In this context, energy is an important factor in multidimensional poverty, since energy services enable basic needs to be met such as: cooking, heating, refrigeration, hot water, lighting, access to information and communication technologies (González, 2014). Therefore, energy deficits limit the opportunities of people and their quality of life in relation to the various dimensions of human development. Following ECLAC, "inclusion and therefore access to energy by the postponed is a challenge that democracies must respond to if they wish to be faithful to their postulate of respect for human rights, non-exclusion and transparency in the use of natural resources" (CEPAL,2009:9).

Within this framework, an interesting proposal is García-Ochoa's (2014, 2016) methodology to measure energy poverty in terms of "Satisfaction of absolute energy needs", based on a multidimensional index called "Energy Poverty in the home". This definition makes explicit recognition to spatio-temporal and socio-cultural variability or in Ochoa's words: "a home displays energy poverty when the people who inhabit it do not satisfy their absolute energy needs, which relate to a series of satisfiers and economic goods that are considered essential, in a certain place and time, according to social and cultural conventions" (García-Ochoa 2014: 17).

Based on the RdPE's workshops and the literature discussed above, we propose the following complex definition to observe EP in Chile:

A household suffers EP when it does not have access to sufficient energy to cover basic and secondary needs, considering both those that are 'objectively' acknowledged by society and those that are

‘subjectively’ felt by the very household. Thus, an energy-poor household does not have the capability to decide between a sufficient range of adequate, reliable, sustainable, high-quality and safe energy services which may support both the human and economic development of its members. Both the needs and the possible satisfiers should be considered contextualized on a particular population, located in a specific territory, in a defined temporal context and under specific sociocultural conditions.

Within a more comprehensive definition of energy poverty, we must also include both those problems associated with energy quality, as well as those associated with energy distribution and equity. Therefore, this definition addresses at least three dimensions of poverty: access, quality and equity.

In terms of access, it means overcoming physical thresholds, such as insufficient supply and limitations on access by household geographical conditions; technological thresholds such as the lack of diverse options for obtaining energy and technological devices suitable for the use of these energies; and economic thresholds, such as having sufficient resources to access energy.

In terms of quality, EP may be associated with fuels or poor housing conditions (eg. insulation and ventilation problems) generating either intra-domiciliary or extra-domiciliary pollution, damaging the quality of life, especially in terms of people’s safety and health. On the other hand, the quality of energy supply in the context of socio-natural disasters should be also considered, such as earthquakes, heavy rains, snowfalls or alluviums. The network resilience in the context of these events is directly related to the quality of supply which also defines the conditions of accessing energy under emergency situations.

In terms of equity, it is possible to observe situations of inequality in those households that maintain an excessive energy expenditure in relation to the total budget being limited both access and quality to the economic, social and cultural possibilities of the household (in the choice of energy source, purchase of more efficient devices, access to various energy options and the like) facing situations of unequal opportunities. On the other hand, in this context, we also encounter the problems associated with injustice and environmental inequality embodied in the so-called sacrificial areas where there are multiple problems associated with environmental pollution related to energy sources (Martínez-Alier, 2004, 2008; OLCA 2004, Svampa & Viale, 2014).

Access, quality and energy equity are subject to what society defines as: fundamental (eg. food cooking, access to water, refrigeration and minimal lighting), basic (eg. thermal comfort, hot water, lighting, promoting access to health and education) and secondary needs (eg. entertainment and other domestic uses) expressed as an energy demand. It is located in a territorial context, closely linked to a temporal and spatial axis, to the extent that the characteristics of the energy demand, associated energy needs and services, as well as the requirements and solutions that energy must cover. These are constantly defined and re-defined by society. This means that it is a **must** to observe how the energy demand in the country is constructed socio-culturally considering the territorial particularities that this energy demand acquires given the different geophysical and socio-cultural conditions of Chile.

The proposed definitions seek to encompass a holistic and integrated manifestation of energy poverty in the country also allowing the recognition of the capacities and opportunities of local actors with the purpose of using various energy resources existing in the territory to face and even mitigate energy poverty in a sustainable way. Finally, it is emphasized that the interaction between energy poverty and sustainable development allows synergy in relation to the environmental co-impacts that can mean reducing energy poverty both in local terms (reduction of air pollution and its health consequences) and global terms (mitigation and adaptation to climate change).

Identifying or generating indicators to measure this complex reality is not an easy task and, as it will be seen, there are currently no appropriate instruments for measuring energy poverty in the country, at least not according to the previous definition. Moreover, some fundamental methodological problems can be identified.

First, it is important to consider geophysical elements since indicators for measuring this phenomenon in the northern zone must be different from those in the southern part of the country, same as those that will have to be employed in coastal zones will need to be different from those applied to mountain areas; only by doing this, the necessary relevance will be acknowledged to the characteristics of the climatic zones and the elements that make up the territories, reducing or exacerbating the energy vulnerability of the homes in terms of access, quality and energy equity.

On the other hand, as García-Ochoa & Graizbord (2016) noted, an urgent challenge is to know how the energy demand in the country is socially constructed. This manifests in differentiated practices of energy consumption and a corresponding set of satisfiers and economic goods that are socially valued as the most adequate to satisfy this demand, within the framework of a specific socio-cultural significance of energy. Learning in detail about this aspect will allow the construction and design of more robust and territorially located energy poverty indicators without falling in the ‘modern fuel’ fallacy discussed above. The transdisciplinary exercise is fundamental to understand and take charge of the plurality of assessments and cultural uses that different energies present in the territories as well as the importance of developing the field of environmental education to move towards a more efficient use of resources energy sources.

Preliminary results (2): available statistics for the Chilean case

The progress made here is one of the first efforts to characterize the phenomenon of energy poverty in Chile by comprehensively checking up the main sources of secondary data available at national level. These sources collect information that allows us to partially characterize some of the variables that are present in the definitions of the international literature on energy poverty. As these instruments have not been designed to measure energy poverty, this check-up also assesses the potentialities and limitations that each instrument possesses to make an effective measurement of this problem in Chile.

The main features of the sources considered in the study are described below:

Source	Description
National Socioeconomical characterization survey 2015, of the Ministry of Social Development (herinafter CASEN 2015)	Survey designed to be representative at national and regional level, by zone of residence and in communes that concentrate more than 80% of the dwellings of each region. It is applied in 83,887 households in 234 municipalities, in the 15 regions of the country, with a total sample of 266,968 people.
National Energy Survey 2015 and 2016, of the Ministry of Energy (herinafter ENE 2015 and ENE 2016, respectively)	Surveys carried out by market research companies and mandated by the Ministry of Energy. In the case of the 2016 version of the survey, its sample size is 3000 cases, distributed not proportionally according to the size of the national population over 18 years, in the 6 macrozones of the country and in 94 communes. It is representative of the population over 18 years of age in the country.
VII National Family Budget Survey of the National Institute of Statistics (herinafter VII EPF)	Survey conducted by the National Institute of Statistics every 5 years. The study allows to know the structure of urban household expenditure and patterns of consumption in the regional capitals of the country with a reference period of 1 year. Each household is surveyed for 15 days, where their expenses and income are recorded and asked for information on monthly expenses (water, electricity, rent) and expenses over the last 3, 6 and 12 months. Each household represents on average 283 households with similar characteristics, so that the total of households surveyed (10,528) represent 3,009,720 urban households in the country.
Second Environmental Survey 2016	Survey conducted by market research company, mandated by the Ministry of the

of the Ministry of the Environment (herinafter ENMA 2016)	Environment. Its sample size is of 5,664 cases distributed in the 15 regions of the country. It is done by telephone (fixed and cellular) and its weighting factor allows for national representation.
National Monitoring Network of the Ministry for Housing and Urbanism (herinafter ReNaM)	Monitoring system that generates real-time data of variables such as temperature, humidity, noise and air quality inside the country's dwellings, by means of sensors installed both inside and outside the buildings, to evaluate the performance of the same during its operation. It is currently monitoring 209 homes nationwide, in four cities in the country (Antofagasta, Valparaíso, Santiago and Coyhaique).

Table 1 – Sources reviewed (prepared by the authors)

From the analysis of available statistics, it is possible to identify preliminarily some findings in relation to the established dimensions:

- **Access:** While 99.6% of urban respondents declare access to the public power grid, only 92% of rural respondents do. The lack of connection is largely concentrated between the regions of Araucanía (23%), Bio Bio (13%) and the Metropolitan Region (11%) (CASEN 2015). At the same time, according to the Same survey, only 0.6% of the respondents lack heating systems in their homes, contradicting the 8.1% saying they do not use heating in the ENE 2016 survey of the Ministry of Energy. Finally, although 11.6% of the population surveyed state that they do not use or have no hot water system in their homes, this percentage increases significantly in the regions of La Araucanía (29% of the population), Los Ríos (24.2%) and Los Lagos (22.6%) (VII EPF).
- **Quality:** the use of wood as fuel is concentrated between the Bio Bio and Aysén regions, with 30% of the respondents preferring it for its low cost, 18% because of its calorific characteristics. Likewise, of the users of firewood surveyed in ENE 2015, 55% declare that they are not willing to change the type of firewood they currently use for one of better quality. In relation to housing, it is identified that although the diversity of materials for walls, floors and ceilings described in CASEN 2015 present characteristics that influence the management of the temperature in the homes, it is not possible to carry out a characterization of thermal insulation with the data available in the survey, since there is no basic information about the insulation, possible house leaks and the like. However, we could notice that regarding building conservation state, there is a higher percentage of female heads of household who report poor conditions compared to that reported by men.
- **Equity:** Data from the VII EPF show that the highest income quintiles are the ones that spend most on electricity, gas and other fuels. However, this item represents a larger percentage of the expenditure structure for the most income quintiles low. That is, the poorest segments of the population spend less in absolute terms but more in relative terms to their own monthly income. The results of the ENE 2015 survey have some similarities with those of the VII EPF since both instruments show that the average monthly expenditure on heating for Chilean households is around \$40,000 pesos representing a 14.8% % of the current minimum salary of \$270,000 pesos. At the same time, about 34% of the people marked as “poor” in the ENE 2016 declared they suffered because of cold temperatures last winter. The same happens with 27% of the vulnerable respondents and with 21% of the lower middle class (ENE 2016). Likewise, ReNaM monitoring data from a week in July, identified the indoor temperature as on average 8% below the healthy temperature (16°C) and 21% below the temperature of comfort (21°C).

The preliminary analysis to characterize the phenomenon of energy poverty in Chile allows us to conclude the need to generate analysis of the dimensions identified from a transdisciplinary perspective. The proposed guidelines stress the importance of understanding cultural, social and territorial components, as well as others related to technical and economic aspects in order to produce consistent information to diagnose the country's energy vulnerability.

With respect to the information sources, a significant bias in the differentiation of the territory by regions is identified since the internal climatic variability is homogenized in spite of the fact that the city climatic characteristics are quite different from the coast's and from those of a town in the highlands or a city in the valley. Therefore, it appears evident that there is a need to observe data according to climatic zones allowing us to distinguish the conditions of the country energy poverty based on this criterion also.

One other aspect to research more in depth relates to the energetically vulnerable household characterization that is given particular characteristics. To do this, it is necessary to have specific references regarding: household members educational level, employment status (identifying unemployed, retired, or part-time workers), immigration status, household composition (single-parents, with the presence of children, elderly people, chronic or electro-dependent patients in health) and situation regarding dwelling ownership or rental (to the extent that this could limit the home investment in improvements of housing conditions). It is also recognized the need to inquire regarding those groups that declare not using heating, observe in greater detail the socio-cultural and economic characteristics as well as their geographical location. On the other hand, it is also necessary to ask about households that do not have access to hot water, especially in the regions of La Araucanía, Los Ríos, Los Lagos and Aysén. This situation of energy vulnerability could be closely related to other vulnerabilities also found in these territories. This first approach in numbers allows us to diagnose this situation but a more detailed study would be needed regarding the social construction of energy demand for these special cases.

Firewood associated with air pollution is a fundamental issue for the country's energy poverty situation since it is a problem directly associated with public health. This problem has edges that refer to access, quality and equity with respect to energy. It is urgent to know how the energy demand of firewood is built in areas that have an energy matrix dependent on it, especially in the face of evidence that consumers are aware that moist firewood produces atmospheric pollution, but in any case still go on using because of custom. This tells us about other possible uses or functions associated with firewood for these consumers which must be properly identified and needs to be deepened through specific investigations for this situation.

Finally, the need to produce information regarding the house thermal insulation characteristics is identified since many heating problems can be associated with poor housing conditions that do not allow adequate heat management. This is of crucial importance if we think it is linked to public policy on building social and middle-class housing, which coincidentally, those who inhabit are those who declare to be colder in winter. This leads to a critical review of the regulations associated with construction, differentiating properly according to the different climatic zones that the country presents and collecting the energy demand of the homes, so that it allows to improve their energy efficiency.

It is important to highlight the difficulty of investigating a concept based on questionnaires and instruments designed for other purposes and that do not produce dialogue or are not comparable to each other. While it is true that these secondary data sources may be useful for contextualizing and knowing the state of the art of data available for the field of study, it is very difficult to make inferences that allow the characterization of the conditions of energy poverty at the national level. To a large extent, this is due to the diverse nature of the data gathered by different instruments, with no greater possibility of establishing analyzes that show consistent results. The instruments analyzed in this document touch on aspects related to the use of energy in the household, relating it to a set of sociodemographic and socioeconomic variables, but do not directly address the problem, which prevents the establishment of causal relationships between variables, as well as counting on a reliable and valid instrument for the systematic study of the subject.

Final remarks

In assessing the current possibilities of characterizing energy poverty in Chile, it is possible to identify that, first, there is the problem of inconsistencies of results between analyzed instruments, which show substantial differences in the values of similar or equivalent variables. Despite the existence of periodic studies addressing energy and energy consumption issues, there is unfortunately a lack of consistency in sample designs and sizes, questionnaire design, depth of approach to variables, and comparability between measurements. Given the above, the production of data that characterize the phenomenon of energy poverty for Chile, considering its different dimensions (access, quality and equity), climatic zones and socio-cultural diversity of the country is considered fundamental and urgent. A standardized national instrument would be fundamental to visualize this relevant problem, which has several implications for the quality of life of the population and also for the necessary focus on the intervention of different State agencies, although it would not be sufficient by itself: rather, it should be complemented by qualitative research in different sociocultural contexts, coupled with technical analysis focused on the particular problems of climatic zones and their various geographic conditions.

The challenge of developing an approach to tackling energy poverty in Chile involves multi-level efforts: collaborative academic work, development of common perspectives involving decision makers and civil society, as well as engaging communities to develop an approach with cultural and territorial relevance. Addressing energy poverty from a transdisciplinary perspective allows us to develop a complex and multidimensional approach, allowing us to face the problem in depth. However, the effort is going to be great and our task has just begun.

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