Institutional conditions for the development of energy communities in Chile and Brazil

Condições institucionais para o desenvolvimento das comunidades energéticas no Chile e no Brasil

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ABSTRACT

Energy is an essential factor that must not be overlooked in discussions concerning mitigating and confronting effects associated with human-induced climate change. This work delves into the Chilean and Brazilian energy transitions, scrutinizing just and sustainable aspects, primarily in the local context. The study highlights and compares the experiences of both nations' on-grid energy communities. The methodological pathway comprises three phases: examining regulatory frameworks, assessing on-grid energy communities' infrastructure in both countries and delving into emerging energy cooperatives. Our findings suggest that on-grid energy communities have the potential to foster a more widespread sustainable energy transition, especially when established as cooperative entities. However, there are no easy solutions to date, as justice and democracy are not guaranteed if stakeholders are not adequately engaged. Although there are fewer cooperative cases in Chile, all show a cross-cutting involvement of different members of society, while some Brazilian cases do not.

Keywords: Energy transition. Just transition. Energy communities. Chile. Brazil.

RESUMO

A energia é um fator essencial que não deve ser ignorado nas discussões sobre a mitigação e o enfrentamento dos efeitos associados às mudanças climáticas induzidas pelo homem. Este trabalho aprofunda o debate sobre as transições energéticas do Chile e do Brasil, examinando os aspectos justos e sustentáveis, principalmente em âmbito local. O estudo destaca e compara as experiências das comunidades energéticas on-grid de ambas as nações. O percurso metodológico compreende três fases: examinar as estruturas regulatórias, avaliar a infraestrutura das comunidades energéticas on-grid e investigar as cooperativas energéticas emergentes em ambos os países. Nossos resultados sugerem que as comunidades energéticas on-grid têm o potencial de promover uma transição energética sustentável mais ampla, especialmente quando estabelecidas como entidades cooperativas. Embora haja menos casos de cooperativas energéticas operando no Chile, todos eles mostram um envolvimento transversal de diferentes membros da sociedade, enquanto alguns casos brasileiros não o fazem. A justiça e a democracia não são garantidas se as partes interessadas não estiverem adequadamente envolvidas. Ainda que as experiências no Chile e no Brasil apontem direções exitosas, não há soluções únicas até o momento.

Palavras-chave: Transição energética. Transição justa. Comunidades energéticas. Chile. Brasil.

1 INTRODUCTION

Energy plays an essential role in facing and mitigating anthropic climate change through the sustainable energy transition. The International Renewable Energy Agency—Irena (2023)—points out that achieving the goal of limiting global warming to 1.5 °C in alignment with the Paris Agreement necessitates a reduction of approximately 37 gigatonnes (Gt) of carbon dioxide (CO_2) emissions from 2022 levels, along with achieving net-zero emissions in the energy sector by 2050. On the energy production side, low-carbon sources ought to replace fossil fuels. On the demand side, systems should increase efficiency, and electricity must raise its share of end-use energy[1]—the *electrification of the economy* (IPCC, 2022). Currently, all efforts seem insufficient to stop climate and socioecological crises (IEA, 2023; IPCC, 2023). 2023 could represent a pivotal moment in the progression of climate change, with potentially irreversible consequences for the Earth's natural boundaries. Notably, July 2023 set a new record for the warmest month in recent history (Copernicus, 2023; Rohde, 2023).

Sustainable energy transitions are much more than merely technological changes. They imply a complete transformation of how societies consume and produce energy, which takes on different patterns depending on cultural, economic and social factors (Irena, 2023; Sun *et al.*, 2023). The social and human nature of energy has become primordial, and concepts such as 'democracy' and 'justice' have become critical, as have calls for 'just transitions' (Abram; Winthereik; Yarrow, 2020; García Parra *et al.*, 2023; Lampis; Bermann, 2022; Leo Coleman, 2021). Transition-focused scholars highlight how it is crucial to consider social protection, dialogue, well-being, and equity while respecting vulnerable groups and their dignity in decision-making while also maintaining ecological awareness (Heffron *et al.*, 2023; Poque González *et al.*, 2023a).

Latin America and the Caribbean (LAC) is an interesting case since there are diverse, nonconventional perspectives and ideas about energy, the environment, and society (Alarcón, 2023; García Parra *et al.*, 2023). In recent decades, LAC electrical systems have diversified their energy matrices as some countries installed high levels of nonconventional renewable energy (NCRE) sources (Poque González; Silva; Macia, 2022). This study focuses on Chile and Brazil as two major power systems in LAC, with expanding installations of NCREs and emerging regulatory frameworks for distributed generation (DG). Additionally, they have historically relied on water and fossil fuels and are recognised globally as emerging economies. Likewise, both have had conflicts linked to renewables and unresolved social and

environmental challenges, raising new questions about the 'just' and 'sustainable' dimensions of the transition (Lampis *et al.*, 2022; Poque González *et al.*, 2023a).

This paper explores the 'just' and 'sustainable' aspects of energy transitions in Chile and Brazil. The analysis includes a review of the critical literature scrutinizing both energy transition paths, including works by Flores-Fernández (2020) and Lampis *et al.* (2022). As both countries struggle with unfinished tasks related to local energy transitions, this study concentrates on local energy schemes (Hernando-Arrese; Rasch, 2022; Lazaro *et al.*, 2022; Poque González *et al.*, 2023a). As Cunha *et al.* (2021a) emphasised, energy communities (ECs) offer potential as local catalysts for more 'just' and 'sustainable' energy transitions. Typically utilising renewable sources on a small scale, ECs also might empower citizens (Acosta *et al.*, 2018; Cunha *et al.*, 2021a; Lode *et al.*, 2022, 2023; Pérez-Pérez, 2023; Wyse; Hoicka, 2019).

In summary, this paper explores the potential role of ECs in facilitating 'just' and 'sustainable' energy transitions in Chile and Brazil. It investigates the present state of ECs in both countries and the institutional aspects that enable their execution. Furthermore, the study analyses energy cooperatives as a type of EC that advocates for more democratic and participatory social structures (Lode; Coosemans; Ramirez Camargo, 2022; Schneider *et al.*, 2019a).

In addition to this introduction, the paper contains five sections. Section 2 contextualises the 'just' and 'sustainable' energy transition as a worldwide agenda and describes what we know regarding ECs. In Section 3, we describe the methodological path constituting this work. Afterwards, the main content of our arguments on the status of Chilean and Brazilian ECs and energy cooperatives is developed in Section 4. Finally, in Sections 5 and 6, we discuss—in a dialogue with classical and emergent authors and interdisciplinary views—the main findings of our work, intersecting the issues of 'just' and 'sustainable' energy transitions with the Chilean and Brazilian EC cases.

2 CONTEXTUALIZATION

Linked to the contemporary energy transition, 'just' and 'sustainable' concepts have gained acknowledgement in worldwide plans and agendas but are often challenged in the literature. The contradiction between social welfare and environmental challenges is deeply rooted in a broader debate on sustainability within the frame of socioecological crisis—particularly in growth-dependent capitalist economies (Cleveland; Ruth, 1997; Latour, 2017; Leff, 2021; Max-Neef, 2010).

This contradiction triggers discussions on new eco-social policy paradigms, bringing together environmental limits and social rights. The energy sector and socially rooted, ecologically minded initiatives, such as ECs, could play a key role (Carrosio; De Vidovich, 2023; Cunha *et al.*, 2021a). Energy (practices, policies and infrastructures) involves collective life, power distributions and opportunities for participation in managing common goods at different levels (Leo Coleman, 2021). More specifically, a significant emphasis on electricity (production, consumption and transformation) is crucial in investigating contemporary human behaviour and its impact on society (Abram; Winthereik; Yarrow, 2020).

2.1 'JUST' AND 'SUSTAINABLE' ENERGY TRANSITIONS AND GLOBAL PATHS

Sun *et al.* (2023) argue that a 'sustainable' and 'just' energy transition is also political and social, in addition to its technological and ecological components. Ramírez-Tovar and Schneider (2023) point out that the inclusion of new actors suggests changes in the systems' structures and interactions, especially in the active participation of citizens. Likewise, Lampis *et al.* (2022) call for better and more effective mechanisms of local democracy. Cunha *et al.* (2021a) posit that to achieve favourable, 'just'

and 'sustainable' outcomes in the energy transition, there is a need for robust engagement from public institutions, citizens, and civil society.

Two global agendas pursue sustainable development paths: The Climate Paris Agreement (2015) and the United Nations Sustainable Development Goals (SDGs). Both initiatives share energy goals closely tied to social and environmental matters. Addressing these issues is pivotal in achieving a fair energy transition towards a low-carbon society (Cunha *et al.*, 2021a). While the United Nations Sustainable Development Goals "SDG7 calls for affordable, reliable, sustainable and modern energy for all by 2030" (Se For All, 2023), the Paris Agreement is strongly linked to decarbonization to restrict the rise in worldwide mean temperature levels, which implies that the GHG concentration will remain below 450 parts per million (ppm) CO_2-equivalent (IPCC, 2014); in May 2023, it was 424 ppm (CO2 Earth, 2023).

The 'just transition' term emerged into the global agenda after it was set in the Silesia Declaration on Solidarity and Just Transition adopted at the Conference of the Parties (COP) 24 in 2019 and the Just Transition Declaration of COP 26 in Glasgow in 2021 (Alarcón, 2023). In this context, it focuses on support workers, communities, and regions particularly vulnerable to the effects of moving away from carbon-intensive economies—for example, the coal industries—to greener ones (ILO, 2021). Promoting a 'just energy transition' and respecting populations and ecosystems is still on the COP 27 agenda (COP 27, 2022).

2.2 CRITICAL PERSPECTIVES ON THE 'JUST ENERGY TRANSITION'

Outside the COP context, the term 'just transition' extends beyond its focus on labour-oriented goals. Indeed, in the academic realm, it encompasses a broader range of topics (Alarcón, 2023), including the commons, harmonious human-nature relationships, race, colonialism, gender and governance (Dunlap; Tornel, 2023; Sovacool *et al.*, 2023; Svampa, 2023; Wang; Lo, 2021). Other perspectives shaping a just energy transition are derived from the framework of 'energy justice' (Jenkins *et al.*, 2016; Mccauley; Heffron, 2018).

Lander (2023), Bertinat and Chemes (2022) and Svampa and Bertinat (2022) pointed to energy transition as questioning current social relations and human-nature relations. Bertinat and Chemes (2022) have two distinct narratives regarding the contemporary energy transition. The first is a capitalist-technocratic narrative that considers energy as a commodity, known as the 'corporate energy transition.' The second narrative critiques the current socioeconomic global model for its responsibility for the ongoing socioecological crisis. There is a dedication to achieving a socioecological transition founded on solid or superstrong sustainability and pursuing an energy transition centred on socioenvironmental, participatory, and cooperative justice rooted in the anti-capitalist and socioecological transition manifesto. This perspective has given rise to the 'popular energy transition'.

This research highlights the significance of social involvement and governance within local ECs and cooperative schemes. Hence, the text does not examine labour perspectives on 'just transitions' and deems these dissenting opinions.

2.3 THE CHILEAN AND BRAZILIAN ENERGY TRANSITIONS

The starts of the energy transition processes in both countries have similar drivers. At the end of the 20th century and the beginning of the 21st century, both countries faced critical junctures triggered by droughts and weaknesses in the fossil fuel supply. This compelled them to diversify their electrical matrices to increase energy security. Concurrently, sustainable transitions and the decarbonization of economies gained global attention, and local socioecological conflicts sparked opposition to conventional large-scale projects (large hydropower and fossil fuels). Then, NCREs and DG emerged

as alternatives in the political sphere and materialised in public policies and regulations such as the Quotas Law and the Proinfa plan—in Chile and Brazil, respectively. At the beginning of the 2020s, both nations approached a production milestone of generating one-quarter of their annual electricity supply from NCREs, excluding hydro (Castillo *et al.*, 2022). In a second wave of reforms, from the 2010s onwards, both countries considered on-grid ECs (Poque González *et al.*, 2023b).

Table 1 depicts the indicators related to SDG 7 in Chile and Brazil. Compared to global levels, the two countries display commendable progress in achieving cleaner, more efficient energy systems and addressing social concerns (indicators 7.1.1; 7.2.1; 7.3.1; 7.b.1). Although assessments of progress on indicator 7.2.1 show satisfactory performance, a holistic examination of the energy systems in both countries reveals a significant dependence on fossil fuels (Castillo *et al.*, 2022). These circumstances pose some dilemmas. On the flip side, the burgeoning and pervasive presence of renewables in power grids bolsters the case for the electrification of economies to achieve low-carbon or net-zero economies. Nevertheless, large-size renewable energy facilities face conflicts and challenges (Poque González *et al.*, 2023a), which cannot be measured by the SDG 7 indicators (Galbiati *et al.*, 2022).

Thus, both national cases offer an opportunity to examine how local solutions can aid just energy transitions within their political and sociotechnical contexts (Lazaro *et al.*, 2022; Merino; Montero; Dastres, 2020). Nonetheless, caution is warranted, as while establishing DG structures is viewed as a possible enabler of more equitable and democratic energy systems, past research cautions against overvaluing DG proliferation as a panacea (Pavanelli *et al.*, 2022).

Table 1 | National SDG 7 profiles

SDG7	*Parameter*	*Chile*	*Brazil*	*Global*
7.1.1	2021 Share population with access to electricity (%)	~100	~99	91
7.2.1	2020 Share of renewable energy in total final energy consumption (%)	26.7	50.1	19.1
7.3.1	2020 Energy intensity level of primary energy(a)	3.6	4.0	4.6
7.a.1	2021 International financial flows (USD million, 2020 PPP)	36	414	10,775
7.b.1	2021 Renewable electricity generation capacity (Watts per capita)	764	746	268

Source: Data from ESMAP (2023).
(a) Megajoules per GDP, expressed in constant 2017 purchasing power parity (PPP).

2.4 ENERGY COMMUNITIES

An EC is "a group of citizens producing, managing, and using their energy in a defined local, geography, or place; customarily, in a distributed modality, and based on renewable sources (solar, wind, water, biomass, geothermal) and/or energy conservation/efficiency methods/technologies" (Poque González; Viglio; Ferreira, 2022, p.157). Among the elements motivating the development of ECs, the literature distinguishes at least four spheres: economic (Salm; Hille; Wüstenhagen, 2016), social (Curtin; Mcinerney; Johannsdottir, 2018; Mirzania *et al.*, 2019; Mundaca; Busch; Schwer, 2018), ecological (Holstenkamp; Kahla, 2016), and political (Mirzania *et al.*, 2019).

ECs have become attractive alternatives to large, centralised, and property-closed traditional energy systems—they are not exclusive and can coexist with conventional energy systems—since they are run by and for the welfare of the local population, triggering widespread social engagement (Poque González *et al.*, 2023b). ECs can assume two modalities: on-grid and off-grid. As generally used in power systems (Sergi *et al.*, 2018), on-grid ECs are grid-connected power projects implying bidirectional power fluxes, whereas off-grid ECs are not connected to the national grid and comprise isolated systems. In LAC, ECs are a long-standing practice seen as a respectful way to relate people to energy (Baigorrotegui; Chemes, 2023).

Since the main objective of studying ECs is to analyse their contributions to the 'just' and 'sustainable' energy transition, we will concentrate on on-grid ECs. This is because, in South American nations, off-grid[2] ECs typically stem from the need to provide electricity to individuals in isolated regions without access to electrical power. This goes beyond a sustainable sense and is often not a choice but the sole option. Note that South American EC projects (on-grid and off-grid) have assumed the format of cooperatives, small private companies, or they have remained managed by bodies at the state or municipal level (Poque González; Viglio; Ferreira, 2022).

2.4.1 ENERGY COOPERATIVES

A cooperative is a self-governing group of individuals who unite voluntarily to fulfil their daily economic, social, and cultural requirements and ambitions through a collectively owned and democratically run venture (Schneider *et al.*, 2019b). The philosophy of cooperativism advocates the transformation of communities to make them fairer and more equal. Additionally, cooperatives play a vital role in fostering local development, as they prioritise the well-being of members, employees, and the wider community. Since its emergence in the 19th century, cooperativist guiding principles centred on democratic participation, solidarity, independence, and autonomy (Lima, 2018).

A cooperative for energy production involves collaborating with individuals who have a shared desire to produce their energy but cannot do so independently or have chosen not to (Lima, 2018). Usually, such cooperatives are run by and for their members, with decisions following the principle of one-member-one-vote (Schneider, 2020). According to Lode, Coosemans and Ramirez Camargo (2022), energy cooperatives provide an innovative approach to transforming the centralised energy system towards a more decentralised one that serves environmental, economic, and social purposes.

3 METHODOLOGICAL PATHWAY

The work is divided into three steps, beginning with a qualitative analysis of the political definitions enabling on-grid ECs in both countries. We examine the regulatory frameworks governing Chilean and Brazilian ECs, as outlined in current energy laws and resolutions related to DG. These frameworks include Law No 21118 in Chile (Ministerio de Energía, 2018) and Brazil's Normative Resolution No 687 of 2015—REN 687/2015 (Aneel, 2015). This allows us to decipher the type of arrangements or schemes every regulation considers—by size and source. Then, similar to Sokolowsky and Heffron (2022), we can examine whether these initiatives align with local, national, and international energy and climate goals.

Second, in a mainly quantitative phase, using secondary data from public institutions, we want to know how the implementation of both regulations has evolved regarding the collective infrastructure added to the systems. This involves counting the number of on-grid ECs and the capacity added to the grid concerning each regulation. We then requested public information from Chile's Electricity and Fuels Superintendency (SEC, 2023a, 2023b) and collected it from the BI platform of the Brazilian National Electric Energy Agency (Aneel, 2023). This analysis takes a medium-term view, as both regulatory frameworks were implemented in the last decade, and the aim is not to forecast further scenarios but to analyse the present state of development. We explore what economic sectors are implementing on-grid ECs, how many projects are installed, and which energy sources are used.

In the third phase, a particular focus is given to energy cooperatives as we try to map the development of these projects and their main characteristics. As this is an emerging issue, data are becoming available through initiatives such as the Plataforma de Energia Cooperativa, which monitors the development of energy cooperatives in Chile, Brazil, Mexico and Colombia and provides information on this stage of this work (Energía Cooperativa, 2023). We flesh out this phase with the most recently published

literature in English, Spanish and Portuguese, including Chilean and Brazilian national publishers and authors, available on Google Scholar and grey literature.

Finally, Section 5 presents information from an additional phase where previous results are discussed and analysed within an interdisciplinary framework. This includes exploration at the national and local levels, emphasizing the 'just' and 'sustainable' dimensions of energy transitions. This article employs predominantly secondary sources, which are appropriately referenced. As such, there are no ethical infringements or transgressions.

4 RESULTS

This section develops the three steps of our methodology: recognizing the institutional frames for on-grid ECs, evaluating the linked infrastructure installed since the start of regulations, and mapping the emerging energy cooperatives.

4.1 POLITICAL DEFINITIONS

Chile and Brazil recently developed institutional bodies to govern collective on-grid projects. Thus, in Chile, on-grid ECs are defined as '*collective owners*', and in Brazil, they are defined as '*shared generation*'. Since 2018, Chilean residential power generation legislation has incorporated '*collective owners*' of NCREs or efficient cogeneration infrastructure—smaller than 300 kW. Since 2015, Brazil has used the term '*shared generation*', which refers to the confluence of consumers into the same concession area through a cooperative or consortium with micro—equal to or smaller than 75 kW—or mini—above 75 kW and equal to or smaller than 5 MW—DG infrastructure (Aneel, 2015; Ministerio de Energía, 2018). An update of these standards recently limited the upper limit for mini-generation to 3 MW for intermittent sources and for assessing payments for the power fed into the grid (BRASIL, 2022). Chile and Brazil had previously established DG regulations (Aneel, 2012; Ministerio de Economía, 2006); however, collective systems only surfaced after the frameworks were enhanced (Poque González *et al.*, 2023b).

Figure 1 presents the institutional frames and the allowed size for on-grid ECs in Chile and Brazil. Note that, institutionally, Brazil has only one frame for DG, whereas Chile has two frames for DG; the first is focused on the industrial sector—small means of DG—while the second is focused on the residential sector—net billing. Chilean on-grid ECs are inside the residential frame (Poque González *et al.*, 2023b). In the Brazilian case, on-grid ECs—*shared generation*—can assume the format of consortiums or cooperatives. A consortium gathers enterprises that make a business agreement to benefit from the sharing system. Additionally, individuals who wish to gather voluntarily can constitute cooperatives (Schneider *et al.*, 2019a).

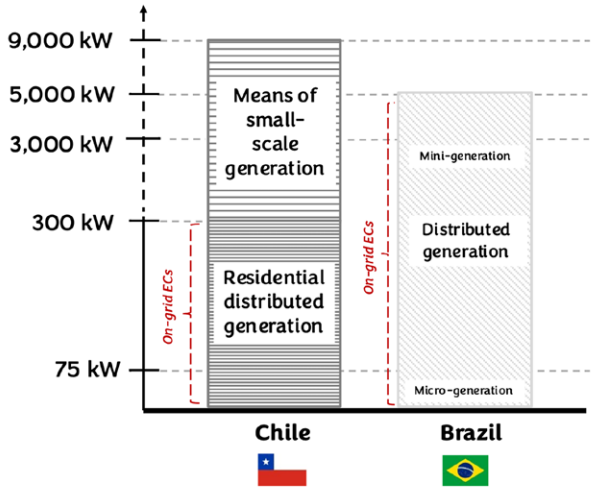

Figure 1 | Chilean and Brazilian political institutional frames for on-grid ECs.

4.2 ON-GRID ENERGY COMMUNITIES IN CHILE AND BRAZIL

It is pertinent to examine the current state of DG in Chile and Brazil, focusing specifically on the installations associated with on-grid CEs, '*collective owners*' and '*shared generation*', respectively. Due to the primary focus of this research on social engagement in specific projects, we emphasise the economic sectors implementing them.

Until September 2023, the residential-DG installed capacity in Chile was 202.7 MW (SEC, 2023a). According to information provided by the SEC, five projects have been registered since 2021 as '*collective owners*', totalling 119.7 kW, all being solar photovoltaic (SEC, 2023b).

Brazil has had 24 GW installed in 2023 across all DG sectors in over 2 million projects nationwide. Of these, 6,752 projects are '*shared generation*' (on-grid ECs), totalling 667 MW, i.e., 2.8% of all Brazilian DG capacity is *shared generation*. The year 2022 represents a milestone in terms of the installation of new *shared generation* units in Brazil, from 809 new units in 2021 to 2986 units in 2022 (Aneel, 2023).

Regarding the sources of all Brazilian *shared generation* projects, 18 projects are hydropower (adding 16 MW), one project is wind (adding 5 MW), 6,714 projects are solar photovoltaic (adding 632 MW), and 19 projects use biomass (adding 14 MW). Note that economic sectors having on-grid ECs are commercial (1,508 projects), public lighting (one project), industrial (151 projects), public (11 projects), and rural (1,172). The housing sector has 3,909 projects. Another format, which could eventually be a type of on-grid EC, is defined in the Brazilian regulation as a '*multi-consumer enterprise*', but this format has only 326 projects with 9 MW (Aneel, 2023).

4.3 ENERGY COOPERATIVES—AN EC SCHEME AS A CHANNEL FOR POPULAR PARTICIPATION?

In both countries, energy cooperatives are a form of EC that assumes institutional cooperation in self-governance. The Energia Cooperativa (2023) platform currently recognises four on-grid energy cooperatives in Chile, totalling 163 kW of capacity and involving 480 individuals (Table 2). Presently, Petorca Sustentable and Coopeumo are operational. The Petorca Sustentable project involves the Municipality of Petorca and 18 other beneficiaries whose health depends on electricity. The Coopeumo initiative comprises nine injection recipients and 328 affiliated individuals and entities.

Its energy-sharing mechanism benefits the agricultural Coopeumo Cooperative establishments and public institutions such as schools and health centres within Pichidegua Municipality (Energía Cooperativa, 2023).

Note that energy cooperatives are incipient in Chile and concentrated in the central region. From the Energia Cooperativa (2023) platform, we identify that all projects have a wide range of institutional engagement, from private to public actors, but municipalities are always involved, demonstrating the importance of local governments. Likewise, all projects possess societal purposes.

Table 2 | Chilean energy cooperatives

Name	*Date*	*Size (kW)*	*Source*	*Location*
Petorca Sustentable	2021	66.3	Solar PV	Petorca, Valparaiso Region
Planta Solar Comunitaria de Tiltil	2023	50	Solar PV	Santiago Metropolitan Region
Energía Solar Comunitaria Nueva Zelandia	2022	12	Solar PV	Santiago Metropolitan Region
Cooperativa Coopeumo	2021	32	Solar PV	Pichidegua, Region of the Libertador General Bernardo O'Higgins

Source: Data from Energía Cooperativa (2023).

In Brazil, Schneider (2020) identified 19 cooperatives totalling approximately 26 MW (16 using photovoltaic infrastructure) in 2020. As of 2023, the Energia Cooperativa platform includes 24 on-grid energy cooperatives (Table 3). In contrast to Chile, some Brazilian energy cooperatives—at least COOGD, Cooerma, Coopsolar, Photon, Ciclos, Enercred, Renovaeco, Sun Mobi, Hadar do Sol, Sinergi, Paraná Energía, Cogecom and Alka—focus on reducing electricity bill payments by involving cooperatives that supply energy and generate credits, mainly in urban areas. These initiatives were mainly the work of civilian organizations without government support (Energía Cooperativa, 2023)

On the other hand, another example of community involvement is the Percília e Lúcio cooperative. It is the first solar energy cooperative in Brazil's favelas. More than 30 families have benefited from the power plant in the Morro da Babilônia shanty town in Rio de Janeiro. The creation of the cooperative was initiated by Revolusolar, a nonprofit association promoting the sustainable development of low-income communities through solar energy (Oliveira, 2022). Similarly, the Bem Viver Cooperative aims to practice rural-urban solar solidarity by involving family farming groups and communities (Bem Viver Cooperativa, 2023).

Table 3 | Brazilian energy cooperatives

Name	*Date*	*Size (kW)*	*Source*	*Location*
Cooperon			Solar PV	Porto Velho-RO
COOGD	2016		Hydro	Vilhena-RO
Coober	2016	75	Solar PV	Paragominas-PA
Cooerma	2019	75	Solar PV	Açailândia-MA
Coopetro Energia				Natal-RN
Coopsolar	2020	75	Solar PV	João Pessoa-PB
Cooperativa Bem Viver	2021	63	Solar PV	Matureia-PB
Photon			Solar PV	Itabaiana-SE
Cooperativa de Energías Renováveis do Nordeste	2021		Solar PV	Feira de Santana-BA
Coesgo	2021		Solar PV	Goiânia-GO

Name	Date	Size (kW)	Source	Location
Ciclos	2018	240 (a)	Solar PV	Vitória-ES
Percília e Lúcio	2021	26	Solar PV	Rio de Janeiro-RJ
Enercred	2017	6885 (a)	Solar PV	Pedralva-MG
Renovaeco	2020		Solar PV	Santa Rita do Sapucaí-MG
Sun Mobi			Solar PV	Mogi das Cruzes-SP
Hadar so Sol			Solar PV	Vinhedo-SP
Sinergi	2019	855 (a)	Solar PV	Maringá-PR
Ambicoop	2021	2300 (a)	Solar PV-Biomass	Toledo-PR
Paraná Energía			Solar PV	Cascavel-PR
Cogecom	2018	6200 (a)	Biomass	Carambeí-PR
Cobragedi			Solar PV	Curitiba-PR
Alka			Solar PV	Florianópolis-SC
Coopervales			Solar PV	Arroio do Meio-RS
Coopsolar	2020	30	Solar PV	Campinas-SP

Source: Data from Energía Cooperativa (2023).
(a) These projects comprise more than one power plant.

5 DISCUSSION

In both countries, emerging on-grid ECs, incorporating NCREs and small-sized DG formats, appears to be a paradigm shift towards open, participatory, democratic, and decentralised electrical systems that are also sustainable. However, specific nuances have been observed regarding both emergent cases, which have sparked further discussion.

5.1 REGARDING ENERGY COMMUNITIES- ROLE IN THE 'JUST' AND 'SUSTAINABLE' ENERGY TRANSITION

One pivotal issue in our criticism is the conception of 'just' and 'sustainable' energy transition. Thus far, Chile and Brazil have implemented energy transitions that seem institutionally and technically proficient, given the steady increase in NCRE levels over recent decades, searching for decarbonization. Nonetheless, socioecological conflicts linked to renewables—in addition to the large conventional energy sources—and the lack of broad civic involvement challenge the justness and sustainability assumptions underpinning these transitions. Both transition cases could be associated with the concept of 'corporate transition'—following Bertinat and Chemes's (2022) terms. Furthermore, as Carrosio and De Vidovic (2023) defined, integral eco-social policies strive to align social welfare with environmental sustainability; thus, whether this alignment has been fully achieved in these cases could be questioned.

In this sense, on-grid EC regulations are remarkable and innovative as they create a new structure beyond atomised energy systems. However, the just and democratic sense of these initiatives is contingent on the stakeholders' chosen mechanism. Assuming the Bertinat and Chemes (2022) terms, and based on what is exposed in Section 4, ECs, particularly energy cooperatives, might open a chance for a 'popular energy transition', even starting within current paths dominated by corporative trends. Similarly, building on the work of Carrosio and De Vidovic (2023), energy cooperatives in Chile and examples such as the Percília e Lúcio cooperative in Brazil serve as a means of wealth redistribution, as each member from vulnerable populations directly reaps the benefits of generated wealth. Thus, ECs are devices that promote social welfare and environmental care.

When adopting the 'energy justice' perspective (Jenkins *et al.*, 2016), energy cooperatives may at least enhance social recognition. As Schneider *et al.* (2019) pointed out, cooperatives are flexible and inclusive organizations that should follow the one-member-one-vote principle, opening societal engagement opportunities and more democratic energy systems.

5.2 POTENTIALITIES AND BARRIERS

ECs are not new institutions in South America. Despite old experiences in the region—being mainly isolated off-grid systems (Poque González; Viglio; Ferreira, 2022)—with the on-grid Chilean and some Brazilian energy cooperative cases, we understand that widespread societal engagement potential exists. ECs are more than a simple energy structure; they go beyond a technological solution since they involve sociopopular articulation. However, some hindrances to advancing this approach have been noted in Brazil. These include a dearth of technical and institutional expertise, a lack of proper guidance and prior experience, and financial insecurity (Cunha *et al.*, 2021a, 2021b; Schneider, 2020; Schneider *et al.*, 2019b). Moreover, new complexities have emerged since the reform to the Brazilian DG frame—in 2019—which reduced the value of the credits obtained by injecting power into the grid (Netto; Júnior, 2022).

We note that on-grid ECs in Chile and Brazil rely heavily on solar power, which has great potential due to the region's abundant sunlight. However, it may be necessary to explore other energy sources depending on the community's specific needs, local resources and geographies—biomass is an example in the agro environment.

We have more findings as we deepen on some examples regarding on-grid energy cooperatives. When common spaces and infrastructure are used for energy projects—namely, public buildings—benefiting all cooperators, land disputes, such as those emerging in large projects (Comissão Pastoral da Terra, 2021), are avoided. It also demonstrates a potential for greater environmental protection.

Energy cooperatives in Chile are closely associated with municipalities and public institutions, which is a positive aspect of local governance. Nonetheless, it is crucial to scrutinise why citizens hesitate to initiate these projects independently, especially if the motivation is driven by avoiding reliance on certain institutions. It is necessary to investigate this issue further.

On the other hand, Brazilian energy cooperatives are occasionally perceived solely as a means to decrease electricity bills without promoting cooperator social engagement. As Netto and Júnior (2022) pointed out, third parties take on the role of investors in promoting projects where the primary users do not have the appropriate budgets or the means to initiate them. Regarding this phenomenon, Ramírez-Tovar and Schneider (2023) warned that people's engagement may be threatened, as third parties may take a leading role to the detriment of communities. They called this format 'energy by subscription'. It looks like a social, economic and environmental opportunity to reduce energy payments and emissions, but it is not necessarily a driver of social engagement.

6 FINAL CONSIDERATIONS

While the Chilean and Brazilian energy transitions have been touted as successful examples, they reveal that sustainable energy transitions require more than just an increase in NCREs. Currently, the production, management, and demand for energy by citizens and societies at varying levels are crucial aspects of this topic. Therefore, reflecting on the 'just' and 'sustainable' dimensions of energy transitions is essential. When exploring social engagement, the local level is critical. Thus, it is by this point that we see on-grid ECs as a pivotal milestone in Chilean and Brazilian energy regulations.

Sociopopular (re)engagement in energy issues is probably one of the better milestones ECs can bring to these critical times. However, it is essential to concentrate and explore particular cases to avoid wishful thinking. This study investigated the prevailing political definitions of on-grid ECs and the current installations in both countries. Moreover, we revisited documented cases of energy cooperatives to gain insights into their operational practices and challenges. Consequently, we argue that ECs can potentially drive more sustainable energy transitions in Chile and Brazil, even within the parameters determined by the current energy models.

Nevertheless, current regulations are insufficient to guarantee more just and democratic systems with social engagement. From cases such as the Percília and Lúcio cooperatives in Brazil and the four Chilean cooperative cases, we appreciate the emergence of cooperatives as an incipient format that might reinforce community involvement and social articulation within EC development. However, as Ramírez-Tovar and Schneider (2023) highlighted, there are certain Brazilian cases where cooperatives are presented merely as a means for consumers to reduce electricity bills while maintaining their consumer status. Thus, the paradigm shift from consumer citizens to engaged prosumers and to more democratic and just energy systems is not guaranteed.

As a further challenge, there is a necessity for studying Chilean and Brazilian on-grid ECs in situ to understand why and how people engage in those projects, as well as the appropriation of technology, the administration of systems and the limitations and lessons of those experiences. Some literature has started to analyse technical issues; nevertheless, there is a lack of research on societal experience regarding ECs.

NOTES

1| "Electricity would become the main energy carrier, accounting for over 50% of total final energy consumption by 2050 in the 1.5°C scenario" (IRENA, 2023).

2| According to Levy *et al.* (2023), Brazil is a well-known example of an off-grid isolated EC.

DECLARATION OF CONFLICTING INTERESTS

The author declares no potential conflicts of interest concerning this study's research, authorship, and publication.

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