

Energy communities of repair in remote infrastructures: a study of Puerto Edén in the Chilean Patagonia

Comunidades Energéticas de Reparação em Infraestruturas Remotas: um estudo de Puerto Edén na Patagônia chilena

Gloria Baigorrotegui ¹

Dominique González ²

Cristian Parker Gumucio ³

¹ PhD in Philosophy of Science and Technology, Associate Professor, Institute of Advanced Studies, University of Santiago de Chile (Usach), Santiago, Chile
E-mail: gloria.baigorrotegui@usach.cl

² Master's degree in Social Science, Research Fellow, Fondecyt 1200076 Project, Institute of Advanced Studies, University of Santiago de Chile (Usach), Santiago, Chile
E-mail: dominique.gonzalez@usach.cl

³ PhD in Sociology, Titular Professor, Institute of Advanced Studies, University of Santiago de Chile (Usach), Santiago, Chile
E-mail: cristian.parker@usach.cl

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ABSTRACT

Energy communities contribute to the justice of energy transition efforts to enhance the democratisation of contemporary energy policies. We ask what kind of circumstances and practices facilitate the continuity of energy access in remote communities with lagging infrastructures. To answer this question, we propose an approach to researching energy communities of repair based on a study of Puerto Edén, a remote island in the Chilean Patagonia. Since 2020, research has been carried out in this locality using an ethnographic and interactive methodology from a Science and Technology Studies (STS) perspective through systematic fieldwork. The results demonstrate the challenges these communities face as they address deficiencies in governance, providing provisional and definitive solutions. Abandonment of renewable infrastructure could be avoided if historic energy repair communities in remote locations are identified and involved in just energy transition programs.

Keywords: Energy Communities. Maintenance and Repair Studies. Remote Infrastructures. Science and Technology Studies. Puerto Edén.

RESUMO

As comunidades energéticas contribuem para a justiça dos esforços de transição energética que visam reforçar a democratização das políticas energéticas contemporâneas. Perguntamos que tipo de circunstâncias e práticas facilitam a continuidade do acesso à energia em comunidades remotas com infraestruturas atrasadas. Para responder a essa questão, propomos uma abordagem para a investigação de comunidades energéticas de reparação baseada num estudo de Puerto Edén, uma ilha remota na Patagônia chilena. Desde 2020, são realizadas pesquisas nessa localidade utilizando uma metodologia etnográfica e interativa, na perspectiva dos Estudos de Ciência e Tecnologia (CTS), por meio de trabalho de campo sistemático. Os resultados demonstram os desafios enfrentados por essas comunidades ao enfrentarem as deficiências de governança, fornecendo soluções que são ao mesmo tempo provisórias e definitivas. O abandono de infraestruturas renováveis poderia ser evitado se comunidades históricas de reparação energética em locais remotos fossem identificadas e envolvidas em programas de transição energética justa.

Palavras-chave: Comunidades energéticas. Estudos de manutenção e reparação. Infraestruturas remotas. Estudos de Ciência e Tecnologia. Puerto Edén.

1 INTRODUCTION

Policies on energy communities in Latin America have been driven by discussions about people in the energy transition in the Global North (Bielig *et al.*, 2022; Felice *et al.*, 2022; Lowitzsch, 2019), mainly grassroots initiatives contributing to the spread of renewables (Doci *et al.*, 2015). They have also been inspired by lessons from Latin American civil society, strengthened by development cooperation projects, and are currently focused on economic decarbonisation models under the Sustainable Development Goals (Baigorrotegui, 2018b).

Promoting such policies has favoured just energy transition policies intended to reduce energy poverty and open the energy market to self-production and distributed generation (Hoicka *et al.* 2021). However, in general, citizenship—articulated in a collective, horizontal, supportive, and self-managing manner—is marginal and often managed under centralised and privatised systems that do not take pre-existing communities (Meyerson *et al.*, 2019; Verdezoto *et al.*, 2021) or local actors and their knowledge into account (Parker, 2020). Women play an important role in maintaining renewable energy technologies (Cecelski, 2000) and the communal viability of towns. Indeed, there is no doubt about the importance of cultural, collective economies in material place and time, especially where private initiatives are less lucrative and the State is almost non-existent (Svampa; Bertinat, 2022) and sometimes counterproductive for the community. So, why is it important to pay attention to these particularities? The temporal and material dimensions of repair and maintenance practices in energy communities are currently underrepresented in the literature (Lode *et al.*, 2022).

While the study of Energy Communities has often been context-specific, generic aspects centred on techno-economic dimensions overemphasise the need to generate a typology of energy communities that encourages their promotion (Baigorrotegui; Lowitzsch, 2019; Dudka; Moratal; Bauwens, 2023) in public policy. In the same way, STS contributions concerning infrastructures (Leigh Star, 1999; Star; Griesemer, 1989) and repair-maintenance studies (Cejka; Reihs; Fina; Stefan; Hauer; Zeilinger, 2022; Jackson, 2004) highlight the challenges of conceiving them as units or products replicated all over the world. In short, it seems that other types of notions are needed to think about their singularity.

Understanding energy as something beyond electricity, which is quite evident in rural territories, opens the door to possibilities of exchange and differentiated promotion and valorisation. The state's challenges in facing these issues bring to the fore what is understood by community and collective actions in the Global South, where negotiations, contracts, and consumption are important but insufficient in recognising the localised promotion of energy communities. In this regard, Colombian

grassroots organisations seek to influence national energy plans by coining the term Community Energies, understood as:

[...] the body of knowledge, practices and processes of socio-environmental transformation in the production and consumption of energy and food, that promote [...] dignified living conditions [...], respect all forms of life on the planet and contribute to mitigating the climate crisis, in the construction of peace and rebuilding social cohesion (VVAA, 2023 [personal translation]).

This definition diverges from the concept of energy community, understood as a successful business model (Vernay *et al.*, 2023) since it is situated in a daily life where collective actions and implicated people transcend prices, tariffs, and operating standards. The risks of malfunction, breakage, and forgetfulness remain high and discouragingly predictable in Latin America (Coss-Corzo, 2020). Nevertheless, remote energy infrastructures' risks of critical breaks, improvisations, acute inefficiencies, and abandonments (Velho; Ureta, 2019) are disregarded.

Some studies of energy poverty depict energy communities within informal economies (Kumar; Aiken, 2020) and vulnerable communities (Lai, 2021), where the colonial, white, and Eurocentric prism marginalises inhabitants even more (Lohman, 2023). Much research must be done to recognise the historical and powerful communities facing weak, broken, and quasi-abandoned energy infrastructures.

In this understanding of energy communities, justice is constituted with care, which is an irreducible task (Puig de la Bellacasa, 2017). Through this lens, we can observe the diverse and complex dimensions of energy communities in Latin American societies, described as —*abigarrada*— meaning jumbled or disjointed (Baigorrotegui, 2018b). This term highlights the difficulty of standardising energy communities and the impossibility of reducing them to promotional protocols based on universal conventions and canons.

Considering their fragile circumstances, inconsistent accessibility, failure to adhere to operational standards, deficit of replacement parts, and lack of a documented history of prior operation, we ask, what circumstances may or may not enable the continuity of specific energy communities on remote islands?

2 METHODOLOGY

The methodology used to advance the understanding of this remote energy community has been primarily qualitative (Creswell; Poth, 2018; Vasilachis, 2007). Our methodology stands out for its creative, participatory, and engaged approach with ethical implications (Cerrillo, 2009), which incorporates diverse disciplinary perspectives and asks for informed individual and group consent. It is grounded in iterative processes of induction and critical theoretical reflection, combining conventional methods and techniques of qualitative research with innovative approaches to speculative design. In the context of social sciences focused on the environment and sustainability, our approach is very close to "sustainable science and co-creative research praxis" (Franklin, 2022).

We have prioritised the ethnographic and phenomenological observation of the locality to conduct a "thick description" (Geertz, 1994). Throughout this process, we have observed and interacted with residents, social groups, and their ways of life, as well as energy infrastructures and the socio-technical, socio-ecological, and geographic contexts surrounding them.

In this project, two community delegates were brought into the fold due to the enthusiastic engagement of the Mapuche-Huilliche Lafken Mawida¹ and the Artisan Fishers Union in Puerto Edén. In collaboration with these delegates, two research projects were awarded public funding for research in social sciences and engineering for local energy systems. Furthermore, since March 2020, an interdisciplinary team has communicated with key informants in the locality of Puerto Edén, including leaders, residents, and

professionals responsible for implementing public policy in the Magallanes region of western Chilean Patagonia. An active and proactive dialogue with residents has allowed us to understand their ways of existence. This approach has been applied in various field research projects as part of a dynamic methodology that involves continuous and proactive interaction with the local community.

Fieldwork planning was meticulously carried out after data and background information about the locality of Puerto Edén were systematically collected. We conducted four visits to the town of Puerto Edén over four consecutive periods between 2020 and 2023. Each visit lasted an average of 10 days or more.

During these visits, we conducted systematic ethnographic and phenomenological observations, complemented by active participation in local activities and a series of interviews with a qualitative sample that included key informants, community leaders, and ordinary residents from various subgroups of the Puerto Edén community. Among those selected were key individuals involved in the maintenance and repair of the small-scale hydroelectric turbine and the current generators.

Since March 2020, our interdisciplinary team has been in touch with key informants from Puerto Edén and the Magallanes region government employees. Monthly meetings, lasting about an hour each, were conducted with our informants and the teacher from the town's public school using remote platforms on mobile phones. This engagement with the community allowed us to understand the importance of repair and maintenance rather than implementing a completely new local energy system.

Additionally, training was provided to two local operators at the sponsoring university (the University of Santiago de Chile), and communication regarding residents' concerns about complying with their development plan continues to be facilitated.

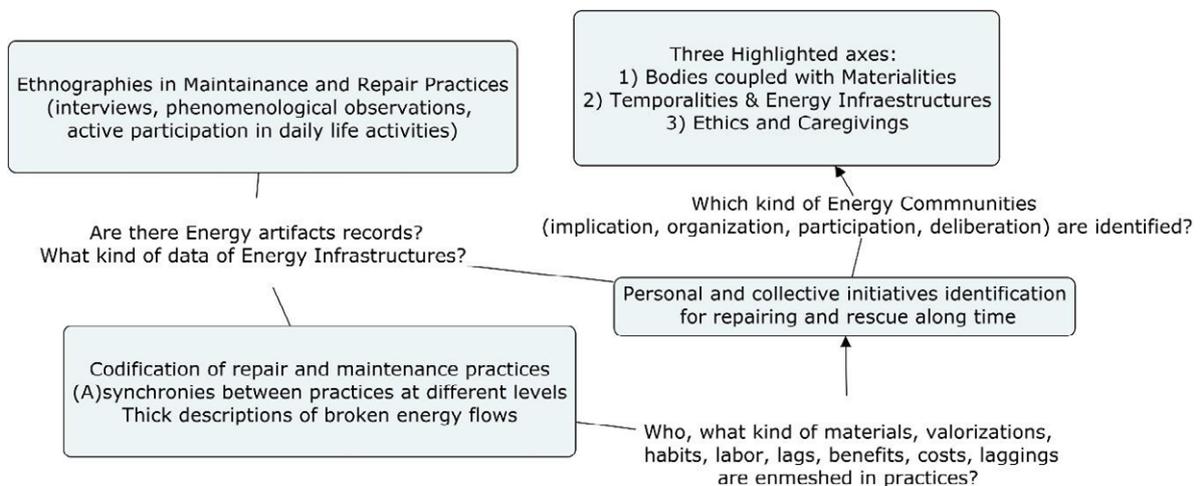


Figure 1 | Methodology of maintenance, repair practices, and energy Communities in Puerto Edén

The outcomes of this methodology (Figure 1) reveal three interpretive themes: 1) Bodies coupled with materialities, 2) temporalities and infrastructures, and 3) ethics and caregiving to overcome a common energy breakdown. Through these lenses, it is possible to recognise the abysses in these types of infrastructures and adopt certain practices where stability is established through provisional-definitive solutions.

In this way, those seeking to create more just, equitable, and energetically robust energy policies may find clues about the way of life and experiences of maintenance and repair of energy infrastructure in these remote energy communities.

3 THEORETICAL DISCUSSION

One of the premises of infrastructural studies is that when energy infrastructures work well, they are almost imperceptible. Thus, infrastructural breaks are key to studying their relational semiotic power (Leigh Star, 1999). In this way, the work of bringing infrastructures and their vitality to the forefront becomes evident when something goes wrong and even more so when the common is at stake (Star; Griesemer, 1989) and the effects of global warming become more acute.

When cracks, breaks, and crises produce long waiting times and anxiety in a town, especially where heat sources and shelter from inclement weather are all-important, people start to get restless. In these situations, the actions of communities of practice in general, and experts in particular, are not always available (Cross; Murray, 2018). When inspections of energy infrastructures are weak and are carried out remotely, compliance with contracts is at risk, price and interest changes and inspections of contractual agreements are not effectuated. Dropouts, as a prelude to dismissed, postponed, or forgotten negotiations, show that what is at stake is of little or almost no value to those responsible for making decisions concerning remote locations with few voters.

On the other hand, those who live near these infrastructures are affected in many ways since their proximity demands the involvement of their bodies, time, and creativity to find a way out of the emergency. This coexistence includes using and misusing things, parts, systems, bodies, limbs, and species (Ahmed, 2020).

3.1 PRACTICES OF REPAIR IN REMOTE LOCATIONS

The emergencies presented by climate change are inevitably intertwined with the energy that flows and crisscrosses specific territories and maritories. Clearly, the challenge of providing uncommodified energy sources closer to home, in accordance with socio-ecologies, is crucial. Remote locations depend on foreign science and technology, particularly in the Global South's economies. The corporal and rhythmic practices of repair and maintenance of artefacts and equipment (Danis; Pontille, 2015) designed in other places are demanding and exceed the canons, standards, and conventions expected as normal operating ranges (Zunino; Gruschetsky; Piglia, 2021).

Establishing energy infrastructures conceived from afar implies repairs rather than maintenance. For example, in the case of sanitary infrastructure in Mexico City, Coss-Corzo (2020) argues that patches make it possible to drastically differentiate repair practices embedded in decaying infrastructures, where austerity is common and pollution caused by infrastructural breaks is evident. Given the recurring presence of patches, maintenance is not carried out frequently and is often postponed until the possibility of repair becomes impossible, leading to abandonment. Thus, for those who directly benefit from such infrastructure, the possibility of salvaging the here and now, using anything at hand, is the rule and not the exception.

We propose that in a remote territory like Puerto Edén, any energy repair proposal that may or may not consider electricity and heat to some degree would imply the need for 1) Bodies coupled with materialities, 2) Times and synchronised infrastructures, and 3) Ethics and caregiving to overcome a common energy break.

- Bodies coupled with materialities.

If a break or failure occurs, channels must diverge to access the iron, steel, and gear structure, which requires people or groups to coordinate actions and identify anomalies. For example, they may be sensitive to auditory strangeness coming from engines and turbines.

The paralysis of flow and the type of noise signal the degree of severity and what actions and materials are needed. Appropriate tools and implements are used to determine whether the repair may be carried out locally. Depending on the failure, it may be necessary to contact other insiders who can identify and address specific equipment issues or reach out to the community so they can begin plans to prevent potential failures right away to avoid the worst.

- Time management and scheduling repairs

Records of objects' operation are part of their memory. They can help users make the most of failures by teaching them how things and objects may be designed or adapted in place of others. This is extremely important for a timely response. Identifying the possible causes of a malfunction requires experience and intuition. Those who remember and record how something previously worked correctly can provide valuable information for diagnosing and fixing current problems (Denis; Pontille, 2015). The most critical repairs require planning what is necessary to accomplish them, especially for complex machines. This implies scheduling repair stages, timelines, and wait times, identifying ways of implementing repairs, identifying stages of the repair process, and managing demands and consumption that inhabitants cannot exceed. Communicating these timelines to users is crucial. However, in places where nomadic life forms persist, plans constantly need to be updated due to contingent changes in weather conditions and wind patterns.

- Local community training

Users connected to an energy system need to be aware of different situations and the complexity of repairs to recognise how and when the failures of these infrastructures are linked to their daily lives. Those implementing energy systems must initiate dialogue with inhabitants and conduct training regarding the relevance of these tasks. Indeed, the rhythms and intensities in which daily activities are carried out, especially in winter in cold places, influence the demand for the equipment in use.

Malfunctioning of remote devices and systems may last longer than expected. Operating conditions can worsen if this occurs, causing the machines and objects to work in critical conditions. In these events, repairs in remote places require collective efforts to repair the system before it collapses. This generally implies the call for people willing to collaborate to promote open discussions concerning the most plausible solutions and available materials. For example, people chose to collaborate off the grid to give PV panels a second life and reduce the effects of contamination (Cross; Murray, 2018).

The maintenance plans and manuals for the design and operating conditions of machines and systems are references for consultation and recording that experience imbalances and changed conditions when normal usage is neglected. In these situations, other means are adopted to maintain the supply until another solution is found. This is why machines and equipment in remote ecosystems have more unexpected behaviours, and their solutions are very specific.

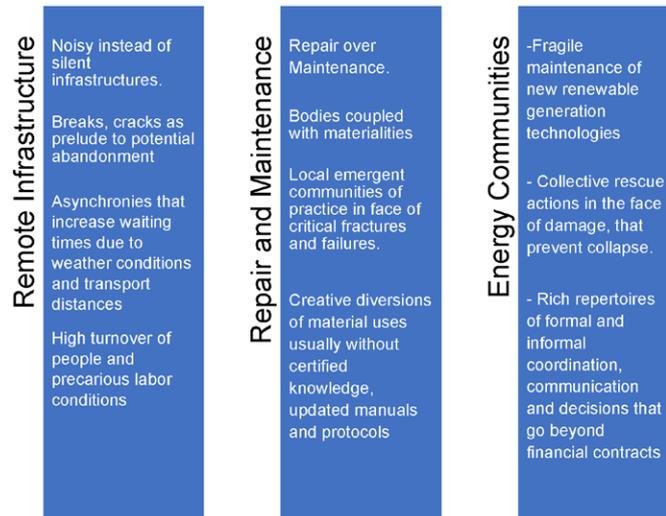


Figure 2 | Intertwining of energy communities with infrastructure and repairs conceived from remote locations

4 RESULTS

Puerto Edén is in one of the remote populated areas amidst the channels of the Magallanes Region and the Chilean Antarctic (49°07'34"S 74°24'48"O/-49.126196, -74.41326). From the perspective of Chilean public policy of regional integration, it is highly isolated due to its location within the Patagonian Archipelago on the eastern coast of Wellington Island, in the province of Last Hope.

Puerto Eden's location on the eastern coast of Wellington Island has the particularity of being located inside the Patagonian archipelago of Magallanes, with a geographical condition described as "territorial vulnerability" (Ferrada, 2013). This is due to the climatic characteristics of the archipelago and its distance from its administrative centre, the city of Puerto Natales—the largest commune in Chile—which is located about 27 hours away via barge (approximately 500 kilometres to the southeast). The usual modes of transport to the communal urban area are ferries and barges that arrive twice a week or helicopters in cases of emergency. This impacts residents' access to products and services; establishing a dwelling is considered "extreme" under such circumstances (Matus, 2008).

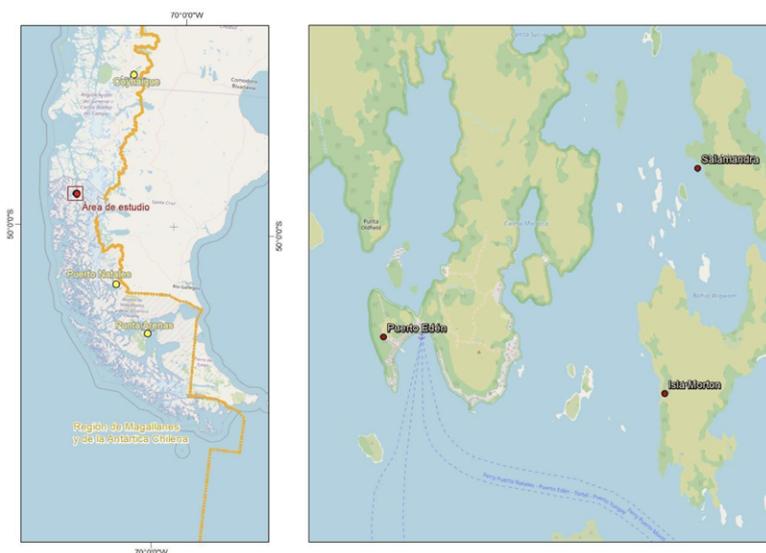


Figure 3 | Location of Puerto Edén in southern Chilean Patagonia

Source: Fondecyt Project. Prepared by the authors.

Puerto Edén is geostrategically relevant for the Chilean State, which colonised the area after the installation of an Air Force base in 1936 for the supply of fuel for hydroplanes. In 1969, it was refounded and annexed to the national population system after the navy established the settlement of the Kawèsqar indigenous population and after the arrival of Mapuche-Huilliche fishing families and other artisanal fishermen (Martinic, 2004).

In 2020, Puerto Edén was declared a lagging area according to the Provincial Development Plan of Última Esperanza (Subdere, 2021). Technological gaps, fragility in energy infrastructures, and high mobility costs persist due to Puerto Edén's remote condition. Electricity is essential for communication with the municipal administration in Puerto Natales.

Likewise, since there is no sustained electric power distribution, the most relevant common-use infrastructures, such as a wooden walkway, houses, and the local school, have prompted the involvement of inhabitants—mainly due to the extension and geographical characteristics of the area—in care and repair work when this infrastructure fails. As a result, energy-community management is visible in real instances of breakage and breakage prevention (Baigorrotegui, 2018). However, these efforts are not maintained over time, nor do they aspire to a decentralised territorial administration in energy matters (Baigorrotegui; Valenzuela; González, 2023).



Figure 4 | Landscape of Puerto Edén. Fondecyt MaReCe, august 2022.

The state of Minas Gerais also has a strong silviculture sector. Having its origins in the steel and iron industries' stimulation in the 1970s by the military dictatorship (1964-1985), the lack of coal to fire the sector was presented as an impediment. An incentive project was created, giving a 50% tax reduction to private owners and companies willing to invest in silviculture (CALIXTO *et al.*, 2009). This marked the beginning of the development of the eucalyptus sector in the country. By 2016, more than 2 million tonnes of wood were produced yearly in Minas Gerais (SIDRA; IBGE, 2015b). In the more productive areas, the estimation of the potential energy production from silviculture residues (Figure 5) could reach up to 8 MW with the annual yearly harvest per municipality.

Puerto Edén is considered to have a high degree of territorial isolation, with its population (mainly artisan fishermen) fluctuating seasonally between 155 and 70 people over the last 2 years (Estroz, 2022).

The electrical supply of Puerto Edén is discontinuous, powered by a diesel combustion electro-generator 14 hours a day in two separate time slots. Monthly electricity demand is around 40.300kWh, considering a 100 kWh household consumption average (Estroz, 2022).

In the past, the town of Edén had a micro-hydroelectric plant, which shut down in 2008. Inhabitants remember this plant as an energy solution that granted 24-hour access to the town. The abandonment of the micro-hydro plant is still a controversial story. Lack of information, follow-up, and monitoring of its operations place its failures, maintenance, and repairs in a discursive ambiguity amidst decision-makers, technical reports, and user experiences. Today, the MHP is still awaiting its restoration or replacement.

In 2022, the Regional Government released the Development Plan of Lagging Zones concerning social issues in Puerto Edén, which includes the “Replacement of Micro Hydro Electric Plant” planned for 2024, among 36 other projects.

As of August 2022, Puerto Edén depends on a Cummins Diesel generator (61.149 kWh/august) (Estroz, 2022). Due to the state's interest in maintaining sovereignty in remote places, water and electricity services are made available free of charge to users, as in the case of Puerto Edén. We have evidence of a reverse energy transition that returns Puerto Edén's energy source to fossil fuels with diesel oil tanks regularly delivered to the island.

To reach the engine room of the abandoned MHP, one must take a twenty-minute boat trip from Puerto Edén and trek through the peat for about two hours. Additionally, to maintain the machine's intake, one must hike another four more hours on a trail with steeper slopes. While the construction of this entire generation system was a monumental enterprise, its daily maintenance without supervision threatened its proper functioning. Furthermore, according to some interviewees, some residents boycotted the MHP to establish an oil-dependent supply, which was beneficial for some and easier to operate but more expensive for the municipal budget. Thus, replacing this MHP project is an important part of the lagging area plan and would signify a historic repair of energy paralysis to move towards sustainability.

Although the carelessness of authorities becomes evident in daily experiences in relation to local energy projects, repair also emerges as a local emergency practice that is neither continuous nor seeks to be understood in relation to ready-to-use technological innovations available on the market. Rather, repair practices intersect with temporalities loaded with pauses, interruptions, and waiting periods that adopt the ecological rhythm of specific places.

Puerto Eden and its Repair Communities

Times and Synchronised Infrastructures: Understanding breakage from a historical and temporal perspective allows us to identify Puerto Edén as a territory that is waiting. This pause within which a breakdown or failure occurs leads users to experience the inconsistency between the service expected from the infrastructure and its perceived behaviour. Users' dependence on regional authorities to achieve modern living standards dates back to the first years of the settlement of Edén (Martinic, 2004). For many years, different governments have implemented specific development plans in which the infrastructural pillar was understood as a technopolitical challenge.

As stated by Baigorrotegui, Valenzuela and González (2023, p. 31),

It is in the waiting times, those moments in which collective actions begin to be energised, which carry reminiscences of abandonment for several years, triggers that braid anger and action in the search for transformation through alternative paths (Ahmed, 2022). These actions constitute the repertoire of energy communities entwined in repairing and knowing how to deal with breakages. However, the practices of repair and maintenance of the infrastructures installed in each technopolitical regime fall into municipal management of backwardness, in which some of its inhabitants, positions as official managers of the services, seek to solve with what is at hand, including a public complaint in the regional media. Therefore, there is a correlation between lag, wait, complaint and reparation.

Thus, Puerto Edén is forming a tangled network of negotiations that become entangled and unravelled through links that require cooperation and collaboration. This leads to conflicts, frictions and associations that reduce the interest in calculated exchanges, provoking an observation regarding who/what is affected by what is intended to be repaired in specific moments and contexts.



Figure 5 | Abandoned mini-hydro power plant in Puerto Edén. Fondecyt MaReCe archives, November 2021.

Localities supplied with energy by the state, where users do not pay for the electric bill, are plagued by formal and informal actions, both their own and those of others. These actions reflect users' habits; they are unpredictable, leading to power imbalances that users subvert every time the inadequately maintained infrastructure batters their daily lives with its adversities.

Bodies coupled with Materialities: In Puerto Edén, the turnover of qualified technical personnel that maintain energy infrastructure is very high. Low salaries and adverse conditions due to isolation, especially in the winter season, have meant that technicians only remain in this job position for one or two years in exceptional cases. Although critical failures pressure companies and contractors to travel to the island to deal with crises—often hiring some inhabitants to do maintenance work due to their technical knowledge, despite not being specialists—a present solution is for inhabitants to carry out maintenance on equipment and resolve failures in the face of inaction on the part of public officials.

The training of maintenance specialists, based on the skills of navigation, has facilitated the knowledge of local technical support and mobilised the bodies of inhabitants, organised in lobbying groups or groups of cooperation to restore electricity, heating, etc. Certainly, the lack of timely provision of spare parts causes those concerned and involved in the operation of the energy infrastructure to arrange for provisional repairs, which, due to the delay of the authorities, become definitive.



Figure 6 | Provisional patch that has become definitive for the wood-burning heater at the school. Fondecyt MaReCe, November 2021.

In this way, those in charge of repairs experience the slowness, routine, and rigour that a remedial action demands in these conditions. At the same time, this makes visible the ethical commitment that maintenance specialists take on, which, for the most part, coincides with the literature concerning their technical creativity in using available materials (Denis; Pontille, 2015) to meet local demands when subject to state abandonment. The community of repairmen from the Eighties evokes those times when Puerto Eden was not as depopulated as it is today. The importance of this collective ethic is still present in the memory of Eden's oldest inhabitants. By taking the initiative on behalf of the people, maintenance specialists seek to revert to repairing methods based on waiting and submitting complaints, understanding that geographical distance and the slowness of government project plans affect forms of resistance to crises. However, users are not alien to contemporary individualism and are thus subject to negotiations in the face of the need for certified expertise in technical repair support.

Ethics and Caregiving to overcome a common energy breakdown: The community rescues the Mini-Hydro Power (MHP) plant.

In 2010, the organised residents of Puerto Edén exposed the management problems of the Municipality of Puerto Natales, as well as the local authorities' lack of technical information regarding the failure of the Mini-Hydro Power (MHP) plant in the local media:

They have not told us what really failed; there is no control, there is no monitoring, there is no follow-up, there is nothing, there are opinions, but there is no real information about what went wrong. (Interview RPA, 05 of August 2019 [personal translation]).

We estimate that the 90-kW capacity MHP was completely inactive in 2008 due to a lack of adequate maintenance, inappropriate material for its operational conditions, abandonment by the external-municipal custodian, and systematic postponement of part replacements (Coyuntura Política, 2010). Five years later, the Municipality proposed to build a new MCH, given the obsolescence of the previous one and due to various failures and damaged, broken, and collapsed facilities. The need for intervention was announced in the local press since the disruption of this infrastructure left the population dependent on the supply of Diesel, with electric supply available between 8:00hrs-15:00hrs and 17:00hrs-00:00hrs.

This news contrasts with the cost that the construction of the MCH in that place signified at the time. Due to the site's inaccessibility, a helicopter was required to transport the turbines and the main facilities. The Center for the Study of Energy Resources at the University of Magallanes noted that the Puerto Edén MHP was the most important in terms of off-grid energy supply in the region. Unfortunately, the replacement of the MCH did not materialise, affecting the energy vulnerability of the area.

Ten years later, the local neighbourhood organisation claims that the infrastructural problem of Puerto Edén is historical and is related to a crisis of the Chilean Subsidiary State, whose actions lag in the territory. However, in our conversations with some of its maintainers, we learned that the challenges and ignorance about the many failures leave no clear diagnosis concerning the most critical role in paralysing the MCH forever. Of course, a community rescue event that occurred when the decline of the river flow endangered the MCH's operation stands out in the memory of one repairman:

I don't know how I convinced people there. I told them look, the same problem happens here because we don't all go (laughs) and a large part of the people there is *chilota* [2], and they assume it as a minga [...] Everything had to be done on foot and on the shoulder, and they had to carry a lot of wood and zinc sheets and build a small dam (Maintainer MCH_a, personal interview 01/28/19).



Figure 7 | Mini-hydro intake in Puerto Edén. Fondecyt MaReCe, November 2021.

After walking for more than three hours over difficult terrain, where gusts of wind can be surprisingly strong and walking itself very difficult. There were parts where the only possible way to continue was to climb over the pipe, which can be seen on the right side of Figure 7. Without a doubt, as a research team, we were surprised to see the remains of this collective work carried out by Puerto Edén's inhabitants.



Figure 8 | Mini-hydro intake in Puerto Edén. Fondecyt MaReCe, November 2021.

As can be seen in Figure 8, pieces of corrugated tin, tree trunks arranged as pillars, and rocks as foundations are visible. This dam of simple and intuitive construction is surprisingly perceived amid an immense uninhabited southern landscape. While walking, abysses emerge, since in any moment of carelessness, it is possible to miss one's step and fall into endless muddy, rocky areas.



Figure 9 | Broken MCH pipe. Photographed by Gloria Baigorrotegui, February 2019.

When we retrace our steps through that marvellous and hidden place, we notice the different types of patching on the entire section of the pipe that now, after rupturing, appears before our eyes as residual pale pieces laying on the peat, threatening to disappear.

This collective work characterises the oldest inhabitants of Puerto Edén. In general, examples of these rescues continue to demonstrate people's strength and ability to accomplish what they consider important. Although outsiders associate the people of Puerto Edén with their constant complaints and public grievances, the truth is that the waiting and complaints are active parts of their stories, interspersed with concerted efforts and determined collective work.

ANALYSIS OF RESULTS

Usually, those who live in remote areas live closely and sensitively with and through their energy infrastructures. In places where systems operate under normal ranges, the operation of motors, generators, and boilers may be imperceptible, but this is not the case in other geographic locations. For an outsider, the experience of living in (with) remote infrastructures usually draws attention since waiting, sporadic access to an internet connection, and unstable electricity are common. *Bodies are coupled with breakdowns*: All of these breaks and failures combined can give rise to communities that are affected in different ways when involved in one or more series of breaks.

Remote infrastructures are covered in patches, rust, and wear. They are noisy. Overlooked parts are mended to avoid collapse. Breaks warp *the notion of time* since a break can be linked to isolation, rendering equipment outdated and wearing out both materials and the bodies of those in charge. Undoubtedly, people and families who live in remote places mobilise their creativity in the face of a lack of conventions and standards. With this understanding, new conceptions of innovative, reparative action and reparation arise from such crises and wear and tear, demonstrating the abysmal relationship of these remote infrastructures with urban areas.

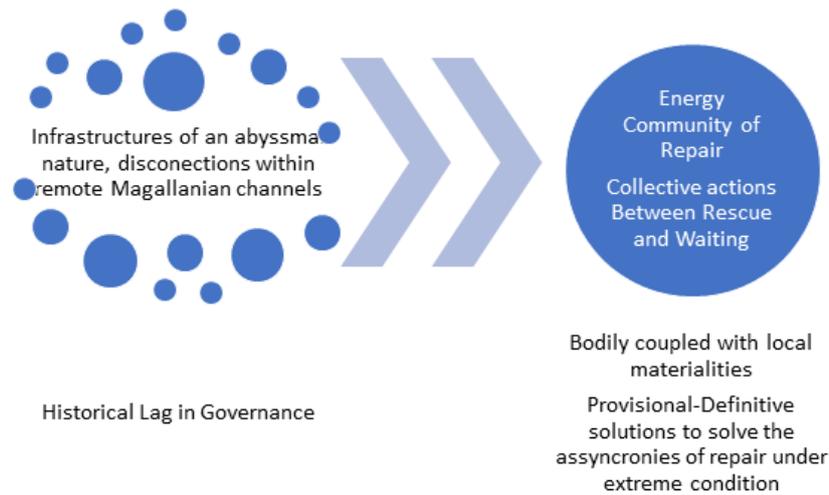


Figure 10 | Energy Community of Repair as conceived by the remote Edenino.

Figure 10 shows the intertwining of energy repair communities where maintenance is improper.

The materials are there to be arranged and to create other creative patches because the existing ones are inadequate. Informal methods widen the scope of possible manipulation in emergencies since memories and records are difficult to compare due to contradictory or non-existent accounts.

Situating ourselves from the remote implies an act of constant repair of records, data, and narratives, as well as once provisional repairs, but through abandonment, have become definitive.

5 CONCLUSIONS

This paper posits that energy communities are not solely associated with renewable electricity generation but also with the long-term maintenance of energy systems in general, particularly in remote locations. To address this, we propose to track situated repair and maintenance practices to investigate particular breakages and the emergence of energy communities of some kind. Thanks to this approach, we expand the concept of energy communities by introducing interpretive axes for energy repair communities, which can partially address the unique challenges of remote island environments. Confronted with various forms of energy vulnerability and the uncertainty of impending collapse, energy repair communities step in to provide support, even when temporary solutions become permanent due to delays in public policy.

This is where the significance of documenting the diverse manifestations of energy repair communities in remote areas becomes part of the process of resisting the oblivion of their existence. These communities distinguish themselves by caring for their physical resources, adapting to challenging circumstances, maintaining essential infrastructures, and adhering to a pragmatic ethical approach to safeguard what is essential for their survival and the common good.

Remote energy repair communities offer valuable insights into learning and adaptation processes and the trials and errors inherent in their continuous efforts to secure energy resources. Their actions require spontaneous and physically demanding responses, often transcending formal memberships or contractual relationships, setting them apart from well-established, lucrative, and systematically maintained energy communities.

Finally, assuming that the principles of justice are entangled in the memories of repair practices, we may conclude that energy communities of repair are a constitutive part of any just energy transition,

especially in remote places. This assumption enriches energy communities' contributions in general and promotes justice for such communities in particular.

NOTES

1| Puerto Eden is a small coastal town with fewer than 80 inhabitants. This town has Chilean residents of both indigenous and non-indigenous origins. Among the latter, there are two indigenous groups: the Kawèsqar, the ancestral and original inhabitants of southwestern Patagonia, and the Mapuche-Huilliche indigenous people, migrants native to Chiloé Island, approximately 725 kilometres to the north of Puerto Eden. The Mapuche-Huilliche Lafken Mawida is the formal organisation representing this last ethnic group.

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