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Les matérialités de la transition énergétique en montagne : pour une approche critique

Northern Argentinian Andes: A Factory of Energy Territories

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Northern Argentinian Andes: A Factory of Energy Territories

Silvina Cecilia Carrizo and Guillermina Jacinto

Introduction

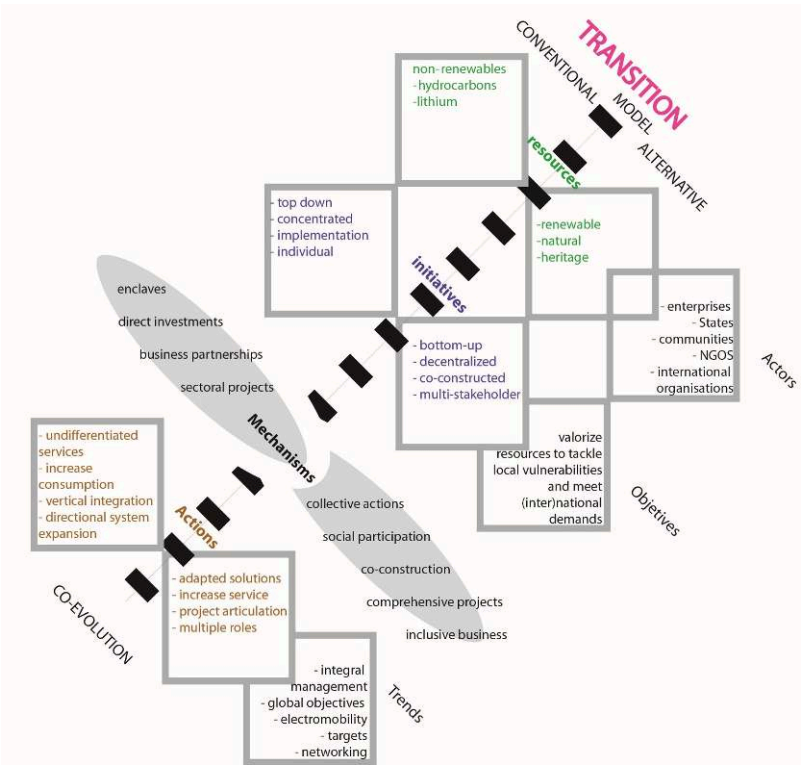
1 The Andes gain new centrality in the energy transition. In northern Chile, northwestern Argentina, and southern Bolivia, where there are exceptional levels of solar irradiation and reservoirs rich in raw materials, local, national and transnational actors are deploying solar projects and exploiting lithium mines. Initiatives of different organizational and material forms are conceived and implemented. The materialization of infrastructure and equipment associated to energy, mining, and industrial activities, as well as the services required by the works and operations affect landscapes, and socio-spatial dynamics. As a result, processes of (re)territorialization emerge, which redefine trajectories and identities of mountain environments. In the Argentine Northwest, the province of Jujuy represents a space that acts as a factory of territories of variable geometry, built on a wide array of possibilities for the materialization of energy projects.

2 The territories of Jujuy test and foster several projects. From the end of the 20th century onwards, in rich and diverse geography, the exploitation of energy resources has been adapted to different needs and socio-economic conditions. Energy production projects leverage the modularity and versatility of solar technologies, and respond to local and extra-local interests, with different scales and destinations. Small and medium-sized installations oriented to productive or residential uses flourish, integrating dispersed or low-income populations. These *in situ* supply projects coexist spatially and interact with large energy, mining, and industrial plants. These mega projects of national and foreign capitals respond to external demands. By articulating the needs and potentials of both types of projects, the valorization of local resources could contribute to an equitable distribution of the benefits of their exploitation.

3 Under the slogan, "Jujuy Energía Viva" (Jujuy Living Energy), the province and its population are especially committed to the solar resource as a structuring element of energy policy, and promote its use in different ways. Governments, non-governmental organizations, academic institutions, and companies participate in co-construction processes. Diverse management models encourage the development of new infrastructures and equipment that allow the flow of resources and the implementation of inclusive and efficient socio-technical systems.

4 Energy transitions are complex and comprehensive transformation processes, which involve not only technical changes in the ways of producing, supplying, and consuming energy, but also changes in cultural practices and socio-spatial organizations (Duruisseau, 2014). The growing use of renewable resources does not imply the direct or immediate substitution of hydrocarbons, predominant in the Argentinian and global energy mix. That is why structural changes in the way of obtaining energy services, -which affect economies and habitat- coexist with historical systems that are still in place and continue to dominate the organization of socio-technical networks (Malm, 2017; Nadaï, Wallenborn, 2019). In addition to centralized structures –well-known and widespread-, distributed systems –less articulated and less visible- complete or improve services of the centralized structures. Reciprocally, making traditional systems more efficient may act as a lever for the valorization of renewable resources and as a complement to achieve universal access to safe and modern energy services, in pursuit of inclusion. The struggle between these models - conventional or traditional and alternative or disruptive – favors the (re)invention or re-articulation of forms of exploitation, and expands the spectrum of material and organizational possibilities for conceiving and implementing projects (Figure 1).

Figure 1. Energy transition checkerboard



Own elaboration

5 Restructuring energy systems entails socio-spatial (re) configurations as a result of changes in the sources and organizational models of energy production, access, and consumption. Each process generates multiple externalities. The linkages between actors and the social appropriation of technologies become crucial to understanding how initiatives of diverse origins are territorialized. Plural territorialities express complex forms of interaction between global and local logics, in relation to resources.

6 The necessary energy transition gives rise to new issues linked to the challenges posed by raw materials and technologies:

1. control of resources and techniques,
2. the possibility of affecting sectoral interests or dependence on the systems in operation, and
3. environmental, social, and territorial impacts. Understanding the energy transition as a long process, and analyzing its materiality from a critical perspective calls for the study of the material dimension of the construction and operation of networks and territories. It also involves exploring energy production, services, and consumption, as well as the modes of appropriation and perception of resources, infrastructures, and technologies. When studying the "physical imprint" of the transition (materials, dimensions, spaces), cultural values -determinant of these processes- deserve to be considered as well. (Deshaies, Mérenne-Schoumaker, 2014*). How much does your building weigh Mr. Foster?*[1] (Carcas, López Amado, 2010) is the question that challenges the prominent architect Norman Foster, who questions himself about the conception of the work, and puts human beings and sustainable development in a predominant place.

7 This paper aims to explore the materialities of the energy transition in the northern Argentinian Andes, examining the experiences in the province of Jujuy. The analysis puts into perspective research with a solid empirical basis. Over the course of 15 years, successive studies on the Argentinian Northwest, considered from different points of view -regional integration, hydrocarbon territories, and public policies-, have led to a wealth of research results. A dozen research missions have been vital to generating knowledge, and have enabled us to come into contact with projects, jobs, actors, and energy strategies. Fieldwork was carried out in Salta and Jujuy (2004, 2005, 2009; 2014, 2018, 2019), Bolivia (2004, 2019), and Northern Chile (2008, 2018). Visits were made to companies, localities, and government agencies in various locations, such as San Salvador, Susques, and Tilcara. They enabled the collection of primary data through direct observation and semi-structured interviews with a vast universe of key informants (heads of the leading operating companies, and officials of national and provincial agencies responsible for energy projects). Thus, we learned about developments in infrastructures, services, and equipment, and about the situation of operations and flows. Interviews with representatives of planning agencies revealed the actions and challenges faced by the territories (location of new economic activities, interactions between energy-mining projects and communities, housing and equipment provision, among others). Secondary information was also collected, -in particular data from companies, public administration agencies, civil organizations, as well as from academic papers-. Statistical and spatial data was processed using geographic information systems, making it possible to produce thematic cartography on territorial, regional and local transformations. Fieldwork allowed the reflections to mature and enrich the production of data and bibliographic analysis. The photographic records obtained in the field missions illustrate the texts, and present evidence of materiality of the energy transition.

8 Seeking to explain the materiality of the energy transition in mountain areas and focusing on the territories of Jujuy, the text is structured in three sections. The first one illustrates the mosaic of mountain territories at stake in the face of the various energy projects that arise on the checkerboard of possibilities opened up by the energy transition. The second section presents innovative energization experiences, which harness renewable resources to address the needs of vulnerable populations, mainly settled in the La Puna region. The third section deals with large production and extraction projects that valorize energy resources, and thus inscribe a strategic territory -for its mining-energy potential- in national and global dynamics of transition. The final reflections center on the energy transition in mountain areas. Its materiality in the northern Argentinian Andes combines different scales and forms, thus defining plural territorialities.

An archipelago of mountain territories amidst the transition

9 Crossed by the Tropic of Capricorn, the Argentine Northern Andes may be considered areas of extremes for the characteristics of their climates and terrains. A significant amount of population concentrates in sub-Andean foothills and sierras. There, provincial capitals with diversified functions and other smaller urban centers provide services to the agricultural, industrial, mining, and tourism sectors.

10 In Jujuy, the valleys and Yungas areas concentrate 88.7% of the provincial population (672,260 inhabitants, National Institute of Statistics and Census –INDEC-, 2010), of which 93.3% are urban (Ministry of the Interior, Public Works, and Housing, 2018). The cities are lined up along the main road axes that connect them to other provinces and countries, such as Chile (West), and Bolivia (North). In the mountain and Puna areas, where population density is low, traditional agriculture persists as a subsistence activity. On the southern edge of the Inca Empire, it was incorporated into the mining circuits of Potosí (Viceroyalty of Peru) as a transit area for livestock from the Pampas. It thus became a strategic space for the colonial organization. These Andean territories have lost centrality throughout history. At the beginning of the 21st century, sociodemographic indicators show high rates of infant mortality, illiteracy, and unsatisfied basic needs. Access to services and facilities is low. Nevertheless, a rich ethnographic and cultural diversity is rooted in their communities.

11 Since ancient times, Northwest Argentina has built a mountain identity based on age-old practices and the richness of its heritage. Socio-economic models have defined a territorial profile centered on agro-industry (sugar, tobacco, legumes, citrus, and cellulose) in the South and East, iron and steel in Altos Hornos Zapla and Palpalá, and mining in the Puna and Quebrada regions. National and international tourist and heritage circuits give visibility to these Andean territories, unique for the character of their landscapes and the singularity of their cultures.

12 The Quebrada de Humahuaca has been the axis of connection between territories and cultures, a region of contact between Andean and cosmopolitan spaces. This rift valley, crossed by the Grande river, extends along 155 km (96 miles) in three departments (Tumbaya, Tilcara, and Humahuaca) that have a total of 34,000 inhabitants (INDEC, 2010). This administrative organization is juxtaposed with the division of the territories

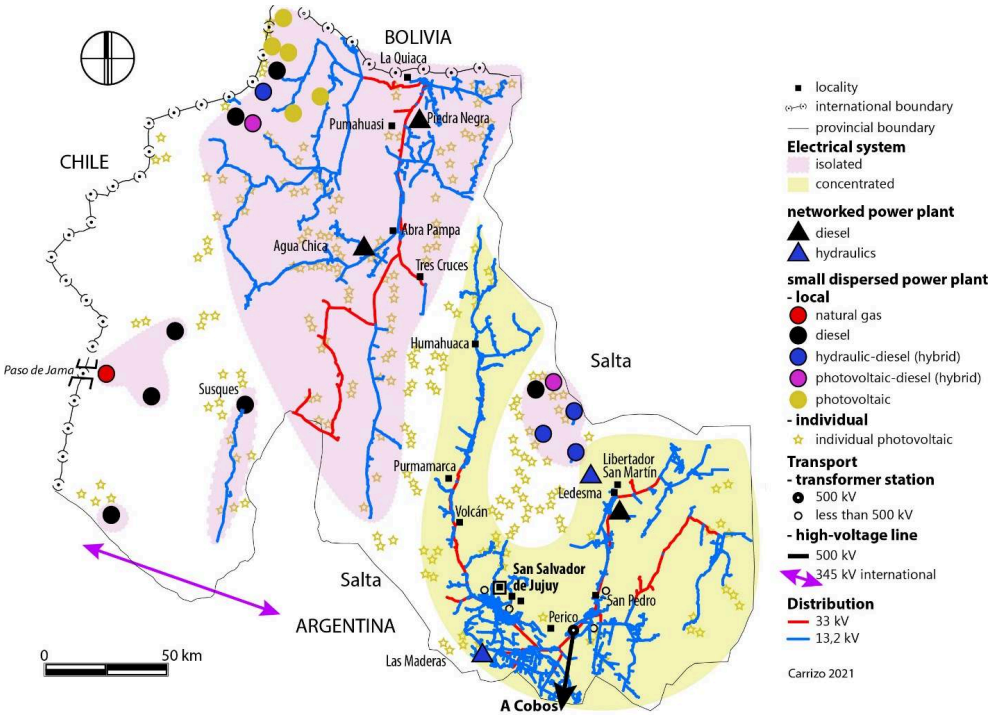
of the native peoples (legal status recognized by International Labour Organization Convention 169, 1989). Settlements are concentrated in localities such as Purmamarca and Humahuaca, amidst horticultural landscapes, organized around oases. Throughout their long history, they show traces of commercial flows during the Inca and Spanish empires, and later ones linked to tourism, energy, and mining.

13 The Puna region, an immense succession of high plateaus at 3,500 meters above sea level (11,500 feet), includes mountain systems, volcanoes, lagoons, and salt flats, surrounded by mountains over 6,000 meters (20,000 feet) high. The margins of torrential watercourses are inhabited by communities subjected to water deficits (no rainfall or less than 200 mm -7.87 inches-) and daily temperature ranges of up to 20 degrees Celsius (68 Fahrenheit), with strong winds. In this extremely arid environment, economic activities are limited to subsistence agriculture and extensive livestock farming. The density of human settlements is low, and housing conditions are precarious. The harshness of the spaces and their location pose challenges for guaranteeing the well-being of the communities. In Jujuy, the extraordinary energy and mining resources attract the localization of large mining-energy projects that affect the fragile environment[2] as a result of the construction of infrastructure - gas pipelines, electric networks, and roads-. The mountain areas are thus undergoing a profound transformation. The valorization of tangible (mining, energy) and intangible resources (lifestyles, identities, representations, values) installs new activities and renews others, injects flows and redirects others, revitalizes communities, and repositions territories in the circuits of the global economy. Islands with the accelerated growth of extractive and productive activities of global significance emerge in vast areas where social and environmental vulnerability is exacerbated.

14 The rich and diverse, though fragile mountain geography explains the emergence of segmented territories where diverse energy projects are underway. These projects open up possibilities that raise questions about the challenges to be faced. Andean lifestyles and symbolic representations are being reconfigured in consonance with modernization, deconstructing and restructuring practices, communities, and landscapes. Tensions, adaptations, and hybridizations shake up the old structures and give new meaning to these spaces, in which tradition and modernity, ancestral and regional ways of life, and accelerated, global economic dynamics seek to coexist. At the same time, Quebrada and Puna become a mosaic of experiences of the energy transition, with variable geometry: with solutions adapted to conditions of poverty (section 2.) and with mega-projects that respond to (inter)national demands (section 3.).

15 The new energy projects are incorporated into an archipelago of territories, made up of the facilities of 3 historically differentiated systems (isolated, concentrated, dispersed) that tend to connect. In the North of the Province, the isolated system serves 10,000 users (5%) through a regional network. The concentrated system serves 186,000 customers (93%) through a network connected to the National Electric System. In almost inaccessible places (Puna, ravine, Yungas, and valleys), the dispersed system satisfies the individual demands of 2% of the users.

Map 1. Archipelago of energy territories



Own elaboration

16 This archipelago shows the evolution of energy systems and the resilience of the North Andean territories. The successive predominance of different technologies, resources, and organization models defines three moments: until 2008, regional or national grid systems; 2008-2018 dispersed installations; from 2018 onwards, coexistence of services to dispersed populations and megaprojects. This periodization is linked to the energy transition process that characterizes the end of the 20th and the beginning of 21st century (Graph 1). It represents the steps forward in the path from a conventional model with a predominance of concentrated systems and massive exploitation of non-renewable resources, to one based on dispersed and participatory initiatives, with on-site use of renewable resources. Along this path, projects that respond to different logics and technologies continue to emerge, thus old and new forms of production and consumption of energy products and services coexist. This creates a mosaic that illustrates how each model persists over time and shapes new ones, while also adapts to them.

Readapted solutions to energy poverty

17 In Jujuy, the limitations in infrastructure and services, and the economic difficulties of the population, lead to considerable energy deficits. In isolated or difficult-to-reach areas, 4,000 households have minimal electricity services, and 17,000 families (10%) depend on firewood for cooking[3]. To reduce energy poverty, improve services, and enhance the value of local resources, projects have been implemented by non-governmental organizations, companies, and various civil society groups, as well as by national, provincial and municipal institutions (Durán, Condori, 2016; Carrizo, Jacinto, 2018; Carrizo *et al.*, 2019). Collective projects that promote energy efficiency strategies

and the incorporation of renewable energies are multiplying. These initiatives promote a reduction in firewood use to improve the living conditions and the health of families. In doing so, they also contribute to reducing environmental pollution, deforestation, and degradation of the environment, which is essential for subsistence economies.

18 On a small scale or as part of large-scale programs, numerous energy initiatives have been implemented to meet the needs of different population groups, mainly those that live in isolated areas. The projects and their implementation processes have managed to overcome obstacles and achieve successes, but they have also encountered problems or caused damage, which new initiatives seek to avoid. Many of the difficulties detected can be explained by the poor or lack of attention given to training users on the technologies to be adopted and to monitoring the projects in order to report problems. This has been a significant constraint that has affected, in particular, equipment and system maintenance, and, as a consequence, the continuation of some initiatives over time. Lessons learned in previous and ongoing experiences have led to proposals that seek to avoid repeating the same mistakes, and to enhance the benefits of some alternatives in order to move forward in a sustainable manner.

19 An increasingly comprehensive vision of services is being incorporated into projects and programs, which are becoming more cross-cutting, less sectoral, and more extensive in the face of socio-economic and housing challenges. Energy services are conceived in relation to users, and to the potential access to other services, such as water and waste treatment. Energy efficiency is gaining an increasingly prominent place in housing or product design. The aim is both to provide residential energy services, and to reduce the burden of energy costs for households by increasing their capacity to manage energy. By raising awareness of the technical alternatives for rational and efficient energy use, and of the opportunities offered by public plans and programs to substitute energy sources, the living conditions of vulnerable groups may be improved.

20 The effort to provide energy - initially focused on delivering essential electrification services - can contribute to diversifying the supply of services, such as water, which can be supplied with solar technology. This has been one of the lessons learned through the PERMER (Program for Renewable Energies in Rural Markets). Initiated, as a pioneer experience, in Jujuy in 1999, it is an important referent in terms of providing services to dispersed population not connected to electricity grids. Through PERMER, more than 4,100 photovoltaic systems have been installed. The population has thus overcome the need to use precarious, polluting, and risky energy sources. The new energy services are combined with other services such as communications. The financing of the program is shared between the Nation, Province, distributor, and users[4]. In this framework of energy co-construction, throughout 20 years of work, the population's cooperation has made it possible to overcome geographical, communication, and technical difficulties. This is the case for places that are difficult to access, not widely known, and unfrequented, where local help has been essential to reach the locations by mule or helicopter, set up the installations, and ensure their maintenance.

21 Other experiences of co-construction for the energization of territories aim at the self-sufficiency of small communities located in remote areas. Micro-grids powered by photovoltaic plants, some of which are equipped with lithium-ion batteries, are being built by linking programs and actors, of local and national scale, that promote the adoption of tailor-made technologies[5]. Villages, such as Pozo Colorado near Salinas

Grandes, were equipped with micro-grids and solar plants during the first decade of the 21st century, within the framework of PERMER. In 2020, Olaroz Chico -close to the salt flats where lithium is extracted, and to Cauchari, photovoltaic plant of 300 MW- was the first to benefit from a micro-grid with a lithium-ion battery storage system. La Ciénaga and El Angosto are two other solar villages that have achieved electricity supply from autonomous photovoltaic plants, replacing the diesel-fired power plant.

22 Photovoltaic modules are part of the Jujuy mountain landscape, with scattered houses and shelters (Photo 1). In larger towns and in social housing neighborhoods, solar water heating equipment is also becoming a distinctive feature (IVUJ, 2018) (Photo 2). These are locally manufactured solar water heaters[6], resistant to the conditions of the Puna and high mountain environment, easy to repair, low cost, and built with national components. The assembly is carried out by local workers. Numerous families can provide themselves with an essential service in this inexpensive way. However, the experience has encountered a few difficulties in the appropriation of the technology, which could be overcome with communication strategies that would allow the population to use the equipment effectively. At the same time, the diffusion of information about solar water heaters, the benefits of the technology, and the possibilities of accessing it, would expand the reach of the programs and solar thermal use (GarcíaHuamaní, 2019).

Photo 1. Photovoltaic modules in Valle Colorado, Jujuy

Carrizo, 2004

Photo 2. Solar water heaters in social neighborhoods of San Salvador de Jujuy

Carrizo, 2018

23 By making the needs and possibilities of the inhabitants visible, it is possible to adapt projects and extend the benefits obtained. In Susques, a town of 1,200 inhabitants at 3,620 meters (11,800 feet) above sea level (150 kilometers -93 miles- west of Purmamarca along national route 52, on the road to Chile), the PAMI (Comprehensive Health Care Program surveyed the housing conditions of its covered members, mainly older adults. Focusing its actions on highly vulnerable groups, it equipped 20 homes with water tanks, water heaters, and solar cookers. This replaced the use of firewood which comes from the province of Formosa, with high transport costs and causes deforestation. The availability of hot water and warmer homes, using cleaner sources, reduce respiratory ailments and favor thermal comfort. The success rate of this type of programs is higher when the potential beneficiaries understand their advantages, participate in the decision-making, and the particularities of the community (customs and practices) are considered. The population of Susques, initially reluctant to install solar water heaters, agreed to their adoption after recognizing the benefits for their hygiene and health and the possible reduction of fire hazard. Adults and youth who share the home with the elderly, also benefit from the availability of hot water and the use of solar cookers.

24 The information provided to users as well as the demonstration of the advantages of solar technologies are fundamental for the sustainability of the projects, as that arouses the interest of other groups or actors who, in turn, can promote their replication or expansion. In 2021, in La Quiaca, the Secretariat of Territorial Planning and Housing of the Province[7] delivered a prototype house of an energy-efficient model adapted to the Puna environment (Padilla, 2019). The design considered the location and orientation of the lot (to optimize the use of light and solar energy), the

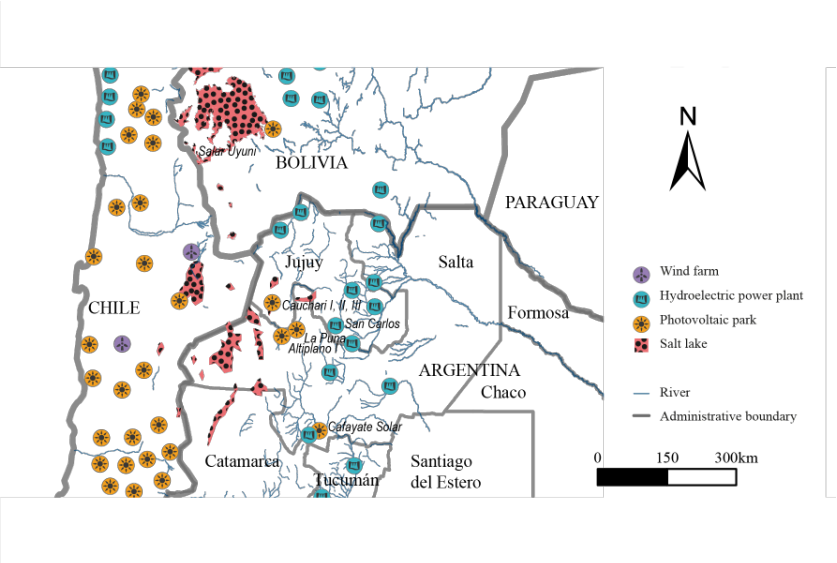
construction process, and the materials to be used -looking for local, well-known, efficient, and low-cost options-. Adobe was used as traditional material and technique, which contributes to thermal comfort. For thermal conditioning, in addition to insulating the envelope, a Trombe wall[8] and geothermal energy was adopted. For the choice of equipment, the aim was for it to be highly energy-efficient: pilotless water heater, A-labelled appliances, solar water heater, and LED lighting. The costs of the technology, connection and equipment, are difficult to afford by the beneficiaries. Therefore, the local government and international cooperation agencies contribute with 80% and 20% of the cost, respectively.[9] To make the most of the technical possibilities, the professional teams in territorial planning have been trained and participate in the training of cooperative members who build, audit and evaluate the houses. At the same time, information is provided to the residents of the houses to guarantee the sustainable use of the equipment. The prototype will be monitored for one year to determine the savings in gas, electricity, and water, and to comprehensively evaluate the project's effectiveness. In 2021, it received the Green Latin America Award in the Clean Energy category. (https://premiosverdes.org/es/ganadores-2021/)

25 Solar water heaters, solar ovens and cookers, Trombe walls, and adobe constructions are part of a range of low-tech, simple, and accessible instruments. They are gradually being integrated into the landscapes of Jujuy in pursuit of a sustainable, inclusive transition, capable of mobilizing and articulating local (material and human) resources. The transition becomes a bet on the capacity of territories to invent, adopt and adapt local solutions to situations of crisis or difficulty, whether economic or ecological (Theys, 2017). A large number of collective actions, linked mainly to centralized policies, seek to give mountain communities greater energy autonomy and reduce their dependence on foreign technologies. They seek to involve their populations in the construction, operation, and maintenance of installations, enabling them to cope with their difficulties, acquire resilience and become empowered.

Mega-projects based on natural and heritage wealth

26 Exceptional irradiation levels and lithium deposits make the northern Andes attractive for energy and mining projects (Map 2). In the Puna region of Jujuy, the presence of salt flats -among which the Olaroz, Cauchari, Salinas Grandes, and Jama stand out- attracts strategic ventures that foster the transition locally, nationally, and globally. This environment of low rainfall, strong winds, and poor stony or sandy soils is thus energized. Historically relegated or excluded by development models, its territories are taking on a leading role in the implementation of energy-producing or energy-demanding mega-projects. Investments lead to the materialization of a growing number of works and infrastructures.

Map 2. Energy-mining projects



Own elaboration

27 The energy transition, and notably electromobility, is driving exploration and exploitation projects for mineral resources, especially for the manufacture of batteries. In the high Andean salt flats, mining fronts are advancing to obtain lithium. Since 2014, the Puna region in Jujuy has contributed to national lithium production (Map 1), which began in 1998 in the Salar del Hombre Muerto (Catamarca-Salta). The Province of Jujuy participates in lithium exploitation through its company JEMSE Jujuy Energía y Minería Sociedad del Estado (State Company for Energy and Mining), which acquires 8.5% of the shares in each of the mining projects.

28 Transnational companies valorize lithium within the framework of national and provincial policies that promote this type of investments. Huge solar evaporation ponds appear abruptly in the Puna landscape (Photo 3). These are ponds in operation or under construction, where evaporation and precipitation of salts take place (during 18-24 months) to obtain "battery quality/grade" lithium. Pipelines for transporting water and other fluids are laid nearby. The facilities are part of the Olaroz (in production since 2014) and Cauchari projects, undertaken by the companies Sales de Jujuy[10] and Minera Exar.[11]

Photo 3. Solar evaporation ponds of Mina Exar

Carrizo, 2019

29 Lithium mining is associated with the proliferation of service and industrial facilities, transport, and energy works, partly financed by public-private partnerships. Gas, electricity, and road infrastructures make the operation of the activities viable, while permanent camps provide the necessary services for the operations. For the workers, accommodation, canteens, medical care rooms, and other service facilities have been built within the mining concessions. On these sites, there also remain facilities built by companies during exploration projects that do not enter the production stage.

30 The salt flats, now revalorized by mega projects, were traditionally exploited by people living in their surroundings. The local communities used the "salt deserts" to extract sodium, for its preservative properties, to use as an ingredient in their pharmacopeia and to sell souvenirs to tourists. Inhabitants of nearby communities such as Susques and Olaroz, Pastos Chicos and Huancar, join the workforce of the lithic projects, which generate more than 700 direct and indirect jobs, mainly in the province of Jujuy.

31 At the local, national, and global levels, the impacts of these large projects on the use of natural resources - especially water - and the degradation of landscapes are being discussed. The sustainability of traditional activities like subsistence agriculture and livestock farming in fragile and water-scarce environments is also affected. Salt extraction affects the balance of water systems, with potential risks of water and soil salinization. While the opposition of the local population to lithium projects has been notorious, the opportunities they open up, in the face of existing dissonances, have weakened and prevented the formation of a unified opposition (Garibay Orozco, 2017).

32 In the region, particularly in Jujuy, the abundance of lithium fosters "the illusion" of influencing the market and producing batteries (Fornillo, Zicari, 2019). Lithium has become a new industrial "engine," linked to national programs that promote electric mobility. At the provincial and federal levels, projects are emerging to add value to lithium and contribute to replacing buses. JEMSE with the Italian company Seri Industrial SpA, in the industrial park of Perico (Province of Jujuy); the Chinese company Gangfeng in the Exar mine and the national oil company, through YPF Litio SA (Argentina's national oil company, Lithium Division), in the Y-TEC technological

pole (Ensenada, Province of Buenos Aires) are planning to manufacture lithium cells and batteries. CONICET (National Council for Scientific and Technical Research) with YPF in Y-TEC and with the Province and the National University of Jujuy, in the CIDMEJu -Centre for Research and Development in Advanced Materials and Energy Storage of Jujuy (Palpalá)-, is working on research, technological development, and knowledge transfer for the extraction and industrialization of lithium. Despite the complexity of the challenge and the reluctance of companies to decentralize production processes, technology, and cutting-edge knowledge, chances of success could be increased by a suitable scientific, economic, and political environment.

33 In the Andes, to the west of the Cauchari and Olaroz salt flats, large-scale investments and projects are underway to exploit the exceptional solar resource. Driven by national and provincial policies, the Cauchari project began commercial operation in 2020. It is one of the largest photovoltaic plants in Latin America. Built at an altitude of 4,200 meters (13,800 feet) above sea level[12], it has more than one million panels on 800 Ha (1,976 acres). This situation corresponds to the first phase of three projects of 105 MW each -Cauchari I, II and III-. The plant's expansion is planned in a second phase through 2 projects - Cauchari IV and V - to add 200 MW. Awarded in the tenders of the National Renewable Energy Plan (RenovAR), the state guarantees the long-term purchase of electricity (20 years), which is injected into the interconnected system (Photo 4).

Photo 4. Solar plant Cauchari

Carrizo, 2019

34 JEMSE, the provincial company, participates in the project with a Chinese loan and issuing a "green bond" in the United States. Significant investments contrast with the staff's low quality of equipment and the gravel roads to access the properties, which are very difficult for small vehicles. With the Cauchari photovoltaic mega plant, the province of Jujuy aspires to become a "positive energy" space, with the double objective

of increasing national energy availability and achieving the goals set out in international commitments in the face of climate change. It responds to the national policy of expanding the participation of renewable sources and reinforces the centralized system.

35 The speed of the changes produced by mega-projects triggers deep transformations in the Puna territories. The town of Susques has become the epicenter of these transformations. Susques was successively part of Bolivia, Chile, and Argentina in the territory known by then as “Territorio de Los Andes” before becoming part of the province of Jujuy in 1943. It has played an essential role as a social and symbolic center, in the pastoral context, and in terms of religious faith, because of its 16th century chapel of Nuestra Señora de Belén. Susques also became an administrative center, and later, its hospital acquired regional relevance. Close to the international Paso de Jama, on a bioceanic corridor, it became an obligatory transit route for tourists, travelers, and carriers, which is why it also grew as a commercial and service center (Tomasi, 2012). In the 21st century, it became a "base of operations" for the large mining and energy projects multiplying towards the mountain range. Lodgings, canteens, and minimarkets have been overwhelmed, as have all the sanitary services and communal facilities. The urban fabric expands, and the chapel loses its centrality. In this process, the landscape - historical and cultural heritage - is degraded, with buildings that rise in a disharmonious manner (Photo 5).

Photo 5. Susques Cemetery

Carrizo, 2019

36 Conflicts over the degradation of landscapes and the risks of affecting natural resources are reminiscent of those that arose in the 1990s over the construction of the high-voltage power line connecting Salta and Chile, which serves to transport the electricity produced in the Cauchari Plant. Together with the binational Norandino and Atacama gas pipelines, this line was part of a series of regional energy integration projects, which sought to valorize the natural gas produced in Argentina. Numerous groups mobilized against these projects that affected landscapes and sites of natural and cultural value (Reboratti, 2003). The people's struggle to protect the Quebrada de

Humahuaca led to its designation as a UNESCO World Heritage Site in 2003. This recognition gave it worldwide visibility and produced great attractiveness, with the consequent materialization of numerous infrastructure and equipment projects to serve the growing tourism. The villages underwent a profound transformation: acquired new land uses, expanded in size, became better equipped and denser. Thus Purmamarca, which until the 1980s had the character of a "*ciudad-huerta*," attracted numerous visitors, and the small rural town changed, both in its material and symbolic practices (Tommei, Benedetti, 2014). The form and magnitude of the impacts - excessive visits or uncontrolled access to natural or historical sites, for example - have degraded the landscape and heritage (Novick, Nuñez, Sabaté Bel, 2011).

37 In these sites of high tourist value, the province is implementing synergistic projects that articulate energy resources and enhance cultural and landscape heritage. In a regional integration initiative in the tourism sector, a solar train is being built (Ayroles, 2019) that proposes to connect, making several stops, the towns of Volcán and La Quiaca, 45 km (27 miles) and 285 km (177 miles) from San Salvador de Jujuy, respectively. Towards the international border, the train would seek to connect, in the future, the Salar de Uyuni (Bolivia) -the largest salt deposit in the world and a lithium reserve- and the site of Machu Pichu (Peru). Its implementation would give continuity to an Andean corridor of high cultural value, part of the Inca Trail (Photo 6).

Photo 6. Stockpiled materials for the construction of the train

Carrizo, 2018

38 In Jujuy, mining and energy projects co-evolve, showing the convergence of their territorial transformation processes. The impact of these large-scale projects and their dynamics generate socio-environmental conflicts, which cause opposition (Reboratti, 2019). However, investments, their location, and scale are fundamentally determined by the directionality of national and provincial policies and regulations, aligned with

the valorization of strategic resources for the transition. The materialization of mega-projects that transform socio-technical systems and mountain territories interrelate a number of logics and strategies, associated to state/business/society interdependencies. Spatially, these significant projects are juxtaposed with disruptive projects, which, on a smaller scale, advance "more silently" at different speeds. Stability and change put stress on identities and cultures in traditionally isolated spaces which are today dynamized by innovations, shaken by impacts, and active in opposition and resistance.

Conclusion

39 In the northern Argentinian Andes, new energy territories arise from the valorization of local resources in a transition to sustainability to mitigate global environmental change and reduce poverty. Projects that differ in type -mining, energy, industrial-, size -large, medium, small-, service -photovoltaic, thermal, hybrid-, organizational format -public, private, mixed- are materialized. Innovative distributed systems seek to satisfy the basic needs of vulnerable and dispersed populations, deploying co-construction strategies that valorize solar resources and energy efficiency while favoring training and local employment with new economic activities such as manufacturing of equipment. At the same time, large-scale energy and mining projects reinforce centralized systems, which contribute to reducing deficits and diversifying sources, thus boosting resources and territories.

40 The new energy and mining production sites give rise to the emergence of production centers, that attract investments in infrastructure, equipment, services, and population flows. The valorization of solar and lithic resources increases the visibility and potential of Jujuy's territories. The set of opportunities is heterogeneous and gives rise to a multiplication of activities which, hungry for energy, encourage the deployment of other new projects. Mining companies leverage photovoltaic plants, promote the laying of new power lines, and make plans for their own solar installations. This way, the transition consolidates existing large-scale systems, which, in turn, open up economic opportunities that contribute to small-scale energy initiatives. Energy becomes a linking element between projects which respond to different interests. A complex web of relationships is woven through the actions undertaken. Dialectically, their materialization expresses socio-historical processes and (re)defines them.

41 The mountain areas, which are sparsely populated, difficult to access, and often isolated, need activities that leverage their resources and make it possible to break the vicious circle of socio-economic marginalization. New mining and energy installations, and the multiplication of flows, are revitalizing the territories, even activating transport projects, among others. Not without conflict and tensions with traditional activities, various initiatives have advanced at different speeds and with dissimilar impacts. Therefore, the territories demand, at the same time, to be protected from the devastating imbalances that could degrade their cultural and natural heritage, their landscapes and valuable resources. Energy territorialization and identity are activated by the various projects that, in their co-evolution, modify the population's quality of life, leave their footprints on the landscape, create jobs, and open up opportunities for local development. Due to the relevance and diversity of the projects, Jujuy becomes a factory of energy territories, with variable geometry, in transition to sustainability.

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NOTES

1. “How much does your building weigh, Mr. Foster?" Documentary dedicated to the biography of the architect Norman Foster -winner of the Pritzker Prize (1999)-, in which the question summarizes his reflections on how to improve the quality of life through design and construction.
2. Since 2005, the Committee for the Sustainable Development of Mountain Regions of the Argentine Republic, establishes actions focused on the defense of springs and the protection of high basins; the fight against soil erosion and desertification; the prevention of mass removal processes; the conservation of wetlands and high Andean biodiversity, the preservation of lifestyles and cultural heritage, among others.
3. 66,000 homes have a natural gas network (38%) and 90,000 homes use LPG liquefied petroleum gas (52%) (INDEC,2010).
4. The Nation finances the feasibility studies and the installation of the equipment; the Province contributes to the financing and the users pay an installation fee and a monthly tariff. EJEDSA Empresa Jujeña de Sistemas Energéticos Dispersos S.A. (Spanish for Energy Company for the Dispersed Population of Jujuy) provides part of the investment, to be repaid through the tariff, and supplies the service, with the obligation to visit the users to check that the equipment is working properly.
5. Pueblos Solares Project, implemented by EJEDSA, financed by the Province of Jujuy.
6. In 2016, the public-private plant Jujuy Solar S.A. began to manufacture solar hot water tanks. The Province participates with 75% of the capital, associating itself with the JuySolar company that contributes the remaining 25% and its previous experience in production and commercialization.
7. Prototypes specific to Valley and Yungas regions were also made in the cities of San Salvador de Jujuy and San Pedro, respectively.
8. "Passive" solar air conditioning system, named after Professor Félix Trombe, who implemented it in the mid-twentieth century. Due to the greenhouse effect and the thermo circulation of the air, a dark solid wall (matt), exposed to the North (in the South hemisphere), accumulates the heat that it traps by means of a glazing, which it has in front. Its return to the interior is made progressively.
9. "My batch in rule" program that seeks to expand and strengthen the domain regularization processes.
10. Partnership between Orocobre (Australian), Toyota Tsusho Corp (Japanese) and JEMSE.
11. Partnership formed by Lithium America Corp (Canadian), Ganfeng (Chinese) and JEMSE.
12. The work was carried out by Power China and Shanghai Electric.

ABSTRACTS

The northern Argentinian Andes are strategically positioned in the energy transition. In the province of Jujuy, solar and mining projects of diverse scale are multiplying. Initiatives aimed at satisfying small demands and reducing energy poverty focus their efforts on dispersed populations and low-income groups. Large-scale photovoltaic power plants in high mountain plains, and lithium mines in salt flats introduce profound impacts on local communities, and on landscapes of high cultural and natural value. The paper aims to explore the materialities of the energy transition in Andean spaces, examining experiences in progress in the province of Jujuy. The analysis puts research results obtained in fieldwork missions into perspective. Fieldwork has enabled contact with projects, constructions, actors, and energy strategies. Direct observation, semi-structured interviews, photographic records, and bibliographic review support the reflections on the materiality and spatiality of the projects. Diverse experiences co-evolve in the territories of Jujuy. For extractive, productive, and service purposes, they show the opportunities that open up in Jujuy, a factory of energy territories of variable geometry.

Los Andes septentrionales argentinos se posicionan estratégicamente en la transición energética. En la provincia de Jujuy, se multiplican proyectos solares y mineros, de escala diversa. Iniciativas orientadas a satisfacer pequeñas demandas y reducir situaciones de pobreza energética, se focalizan en poblaciones dispersas y grupos de bajos ingresos. Megaparques fotovoltaicos en planicies de alta montaña, y minas de litio en los salares, introducen impactos profundos en comunidades locales y en paisajes de alto valor cultural y natural. El objetivo del trabajo es explorar las materialidades de la transición energética en espacios andinos, examinando las experiencias en curso en la provincia de Jujuy. El análisis pone en perspectiva resultados de investigación obtenidos en trabajos de terreno. Estos permitieron el acercamiento a proyectos, construcciones, actores y estrategias energéticas. Observación directa, entrevistas semiestructuradas, registros fotográficos y revisión de bibliografía, sostienen las reflexiones en torno a la materialidad y espacialidad de los proyectos. Diversas experiencias co-evolucionan en los territorios jujeños. Con fines extractivos, productivos y/o de servicio, ellas muestran las oportunidades que se abren en Jujuy, fábrica de territorios energéticos a geometría variable.

INDEX

Keywords: Andes, energy transition, territorialization, materiality, projects
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