JUST ENERGY TRANSITION IN AMAZONIA AND THE HYDROPOWER PLANTS

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The effects of climate change have been studied and publicized by experts, civil society movements and organizations, international organizations, and felt in different ways around the world. To combat climate change, an energy transition to renewable sources is necessary, in addition to other policies and measures, including combating deforestation and forest degradation. In the Amazon, the energy transition has driven the expansion of hydroelectricity, in some cases, such as in Brazil, the region being considered the new energy frontier. However, the energy transition cannot ignore social inequalities and environmental impacts, it needs to be just, leaving no one behind. And this challenge of a just transition that faces the Amazon region, a provider of hydroelectric energy, but with a large part of its population without access to energy, or with access to energy from thermoelectric plants. This article seeks to discuss the challenges of a just energy transition in the Amazon, taking into account the difficulty of accessing energy in the region and the expansion of hydroelectricity, with its socio-environmental impacts.

Keywords: Amazonia; justice; energy; transitions; hydropower.

TRANSIÇÃO ENERGÉTICA JUSTA NA AMAZÔNIA E AS HIDRELÉTRICAS

Os efeitos das alterações climáticas têm sido estudados e divulgados por especialistas, movimentos e organizações da sociedade civil, organizações internacionais, e sentidos de diferentes formas em todo o mundo. Para combater as alterações climáticas, é necessária uma transição energética para fontes renováveis, além de outras políticas e medidas, incluindo o combate à desflorestação e à degradação florestal. Na Amazônia, a transição energética impulsionou a expansão da hidroeletricidade, em alguns casos, como no Brasil, sendo a região considerada a nova fronteira energética. Contudo, a transição energética não pode ignorar as desigualdades sociais e os impactos ambientais, precisa ser justa, não deixando ninguém para trás. E esse desafio de transição justa que enfrenta a região amazônica, fornecedora de energia hidrelétrica, mas com grande parte de sua população sem acesso à energia, ou com acesso à energia proveniente de termelétricas. Este artigo busca discutir os desafios de uma transição energética justa na Amazônia, levando em consideração a dificuldade de acesso à energia na região e a expansão da hidroeletricidade, com seus impactos socioambientais.

Palavras-chave: Amazônia; justiça; energia; transição; hidroeletricidade.

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TRANSICIÓN ENERGÉTICA JUSTA EN LA AMAZONÍA Y CENTRALES HIDROELÉTRICAS

Los efectos del cambio climático han sido estudiados y publicitados por expertos, movimientos y organizaciones de la sociedad civil, organizaciones internacionales y sentidos de diferentes maneras en todo el mundo. Para combatir el cambio climático es necesaria una transición energética hacia fuentes renovables, además de otras políticas y medidas, incluida la lucha contra la deforestación y la degradación forestal. En la Amazonía, la transición energética ha impulsado la expansión de la hidroelectricidad, en algunos casos, como en Brasil, región considerada la nueva frontera energética. Sin embargo, la transición energética no puede ignorar las desigualdades sociales y los impactos ambientales; debe ser justa y no dejar a nadie atrás. Y este desafío de una transición justa que enfrenta la región amazónica, proveedora de energía hidroeléctrica, pero con gran parte de su población sin acceso a la energía, o con acceso a la energía de las termoeléctricas. Este artículo busca discutir los desafíos de una transición energética justa en la Amazonía, teniendo en cuenta la dificultad de acceso a la energía en la región y la expansión de la hidroelectricidad, con sus impactos socioambientales.

Palabras claves: Amazonia; justicia; energía; transición; hidroelectricidad.

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1 INTRODUCTION

The effects of climate change have been studied and publicized by experts, civil society movements and organizations, international organizations, and felt in different ways around the world. To combat climate change, an energy transition to renewable sources is necessary, in addition to other policies and measures, including combating deforestation and forest degradation. In the Amazon, the energy transition has driven the expansion of hydroelectricity, in some cases, such as in Brazil, the region being considered the new energy frontier. However, the energy transition cannot ignore social inequalities and environmental impacts, it needs to be just, leaving no one behind. And this challenge of a just transition that faces the Amazon region, a provider of hydroelectric energy, but with a large part of its population without access to energy, or with access to energy from thermoelectric plants.

This article seeks to discuss the challenges of a just energy transition in the Amazon, taking into account the difficulty of accessing energy in the region and the expansion of hydroelectricity, with its socio-environmental impacts. The first part discusses the fair energy transition based on the literature on the subject. Next, data on the lack of access to energy in the Legal Amazon are presented. The third part presents a discussion of energy integration in Amazonian countries, as well as discussing hydroelectric expansion and energy transition projects in Brazil, Bolivia, Colombia, Ecuador and Peru. And finally, the socio-environmental impacts of hydroelectricity in the Amazon are examined and the discussion on policies not only aimed at the increasing expansion of energy supply, but also demand management policies such as energy efficiency, as alternatives to reducing the pace construction of hydroelectric plants in the Amazon.

2 ENERGY TRANSITION, ENERGY JUSTICE AND JUST ENERGY TRANSITION: THE ISSUE OF SUSTAINABILITY OF RENEWABLE ENERGY

The planet has entered a new historical period, the Anthropocene, in which human beings are the main cause of the transformation of the Earth system (Crutzen, 2002; Steffen, Crutzen and McNeill, 2007). The historical expansionism of human activities, accelerated in recent centuries, is destabilizing the natural balance of the Earth system, as the impacts on the local, regional and global environment are predominantly negative (Altvalter, 2017). The continuous emission of greenhouse gas (GHG) into the atmosphere is an externality resulting from the burning of fossil fuels and the main origin of climate change. The change in the concentration of gas in the atmosphere is linked to the increase in energy consumption (Margulis, 2017). Furthermore, the global climate[4] is increasingly dangerous as human activities approach the planetary boundaries (Rockström et al., 2009).

The use of fossil energy plays a key role in the transition from agricultural society to modern society. In general terms, it can be observed that the modernization resulting from the industrialization process occurred with asymmetric interactions between the North-South. The North went through a historical process of power accumulation based on the destruction of nature with the specific objective of producing goods with high added value, while the South provided primary products of agricultural, livestock, mineral and energy origin to supply industrial production, defining the global environmental policy. It's important to highlight that the arenas of interaction between North-South are multifaceted and are not limited to the positioning of international economies, but also involve the political, social and environmental compositions of modern bureaucracies. Among the main sources of fossil energy, oil has played a prominent role in capitalist development over the last hundred years. On the other hand, reaching the peak[5] and the limit of oil production will have an intense effect on the international system, inasmuch as it may change power relations between the North and South. Because of that, oil is an energy source that will soon be exhausted and is the main cause of climate change driving the urgency of the energy transition.

4. Beck (2009) points out that climate change is one of the dimensions of the global risk society.

5. Hubbert (1967) argues that, as oil is a non-renewable resource, its production will eventually reach a peak and decline.

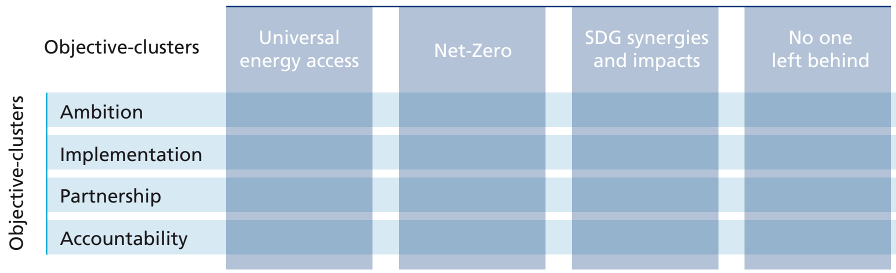
The transition to lower-carbon sources of energy will produce and, in many cases, perpetuate pre-existing sets of winners and losers. The winners are those that will benefit from cleaner sources of energy, reduced emissions from the removal of fossil fuels, and the employment and innovation opportunities that accompany this transition. The losers are those who will bear the burden and have unequal access to new opportunities (Carley and Konisky, 2020). The North has been winning while the South has been losing in the energy transition due to the reasons that we will detail in this study. Not everyone will benefit from the energy transition without efforts to ensure an equitable transition. Thus, there is an urgent need to incorporate distributional considerations into climate agreements through concepts such as common but differentiated responsibilities and intergenerational equity. The dynamics of the energy transition are complex and that is why we will integrate the concept of energy justice.

Energy justice is a vision-led, unifying and place-based set of principles, processes, and practices that build economic and political power to shift from an extractive economy to a regenerative economy. This means approaching production and consumption cycles holistically.[6] The literature on energy justice presents three fundamental principles: distributive justice, recognition justice and restorative justice. The first principle concerns the distribution of benefits and the guarantee that some populations do not receive an excessive share of the burden due to the energy transition. The second one focuses on who is included in energy decision-making processes, ensuring that they are fair, equitable and inclusive. The last principle prescribes efforts to recognize historical inequalities (Carley and Konisky, 2020). essential to the notion of poor people's environmentalism[7] (Martinez-Alier, 2007). In a nutshell, energy justice intersects with the energy transition to establish the importance of planning, implementing and evaluating energy systems. In fact, these principles describe where we are heading and indicate that the private and public sectors need to act together to ensure the distribution of well-being.

Aligning the energy transition with energy justice can effectively guide the partnerships, transformative actions and investments needed to achieve a more inclusive and equitable future. The possible transformative changes for each group of objectives are summarized in figure 1.

6. Available at: https://climatejusticealliance.org/just-transition/.
7. It is a term used for social concerns and forms of social action based on a view of the environment as a source of livelihood.

FIGURE 1
A framework for just, inclusive and equitable energy transition



Source: UN (2023).

Universal access to energy: access to energy is a basic condition to ensure that no one is left behind, enabling all individuals and communities to benefit. Prioritizing renewable energy is essential to promote access to clean sources of energy, depending on countries' energy transition strategies. Paltsev (2016), when analyzing the geopolitics of renewable energy, argues that changes in long-term power relations may occur, related to the appropriation of technologies related to different areas of use of renewable energy. Renewable energies have the following characteristics: potential to be decentralized, especially in the case of solar energy; but it is also intermittent, as is the case with hydroelectric reservoirs and (solar) batteries; dependence on rare earth metals (batteries etc.); with the possibility of cartelization around rare metals. New technologies may also present high costs due to the need to cover financial investments and may result in increased energy insecurity among needy populations.

Net-zero emissions: a fair energy transition is essential for the decarbonization of economies and meeting the 1.5°C target of the Paris Agreement. The deployment of renewable energy is lagging behind and must be significantly accelerated through the phase-out of fossil fuels. However, the growth of the North depends on these cheap resources and global inequality to function (Ropke, 2015) and the perspective of these countries is that development is the main cause of environmental problems. Meanwhile, in the South, development essentially becomes a cure for its main environmental problems (Najam, 2015). As a result, the achievement of the objectives established in the Paris Agreement are hampered as long as there is no understanding of the South's particular motivations in promoting a just global environmental policy.

Synergies and impacts of the Sustainable Development Goals (SDGs):[8] achieving the SDGs must be placed at the center of energy transition strategies in all countries. While the costs of transitioning to a sustainable energy system are offset by the social and economic benefits, it is crucial to ensure that the energy transition is designed sustainably to improve people's livelihoods. But it is worth pointing out that potential new employment opportunities and decision-making are unevenly distributed across populations and marginalized groups, such as women and people of color. Therefore, economic diversification programs, technology access programs and collective action initiatives can be created to establish a just energy transition (Carley and Konisky, 2020).

No one is left behind: participation and involvement are not only a means to achieve efficient results, but also universal rights. Political and programmatic decision-making processes for the energy transition must adopt an integrated, inclusive and participatory approach, with vulnerable and marginalized groups including children, youth, women, people of color, local communities, indigenous peoples and other vulnerable populations participating as decision-makers, innovators and winners.

The Amazon basin, shared by seven countries – Brazil, Bolivia, Colombia, Ecuador, Guyana, Peru and Venezuela – is home to the largest continuous tropical forest and is considered the largest river basin in the world. The discussion about a just energy transition in the region cannot be started without presenting some aspects of its GHG emissions. The recent history of the region reveals the harmful impacts of the construction of hydroelectric plants, deforestation and reduction of biodiversity, intensified since the 1970s. In the specific case of Brazil, the majority of GHG emissions are the result of forest fires and the advance of deforestation to increase pasture and agricultural areas, as well as hydroelectric projects in the Amazon region. On the other hand, climate change reduces the basin's hydrological cycle, increases average temperature indices, worsens the well-being of populations, especially in the region, and does not make the energy transition just, inclusive and equitable.

Policies to combat deforestation and environmental manipulation are essential measures to protect the most vulnerable populations and contain the advance of climate change. In Brazil, there are numerous measures to use

8. The SDGs succeeded, in 2015, the Millennium Development Goals (MDGs), defined by the Millennium Declaration, in 2000, by the United Nations General Assembly. The MDGs implied a development agenda focused on reducing poverty in line with other strategic priorities (Hickmann et al., 2022). The SDGs, on the other hand, are centered on economic, social and environmental interconnections by establishing interlinked development goals. However, the literature shows that the SDGs have the capacity to promote sustainable development only in countries that have a certain availability of resources, administrative capacity associated with a certain level of economic development, in addition to support from international donors (Bogers et al., 2023). In general, the SDGs represent the adoption of global governance that has had little effect on many developing countries, as many obligations have been to their respective domestic policies.

renewable energy sources, such as hydroelectric, wind, solar, biomass, among others, with the aim of advancing the energy transition. Hydroelectricity features prominently in the country's energy matrix and has been considered by experts for years as one of the most sustainable alternatives to replace fossil energy. However, recent research challenges these statements by demonstrating that the Amazon basin declines with several environmental impacts and the population suffers from inequalities in access to electrical energy. This study harnesses the potential to advance understanding of the adverse consequences of the energy transition in the Amazon region and establish the importance of equity and justice in the planning, implementation and evaluation of energy projects to shape a just energy transition. It is worth highlighting that there are gaps in understanding the depth of inequalities associated with the energy transition, mainly in the replication of national dynamics that deepen inequalities between the region and the rest of the country. Therefore, the present study also aims to contribute to the literature through the analysis of the just energy transition in the Amazon region and in hydroelectric plants.

3 JUST ENERGY TRANSITION AND THE CHALLENGES IN THE BRAZILIAN AMAZON

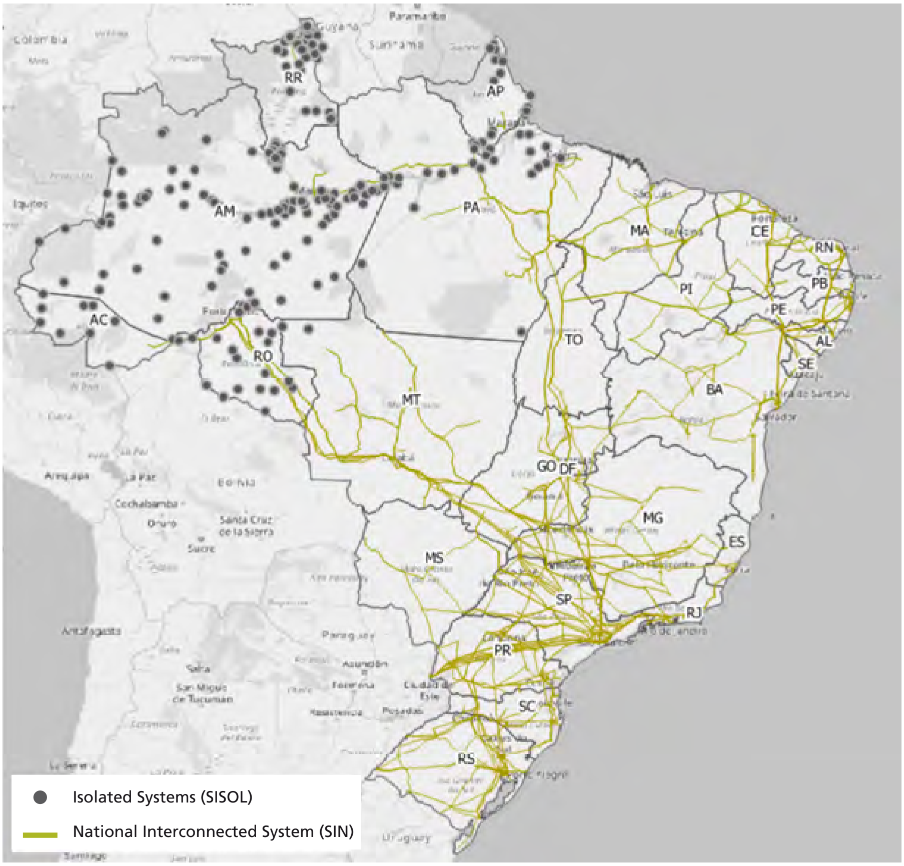
Brazil's Legal Amazon was instituted by the Complementary Law No. 124, January 3, 2007, article 20 and it represents Superintendency of Development for the Amazon (Superintendência de Desenvolvimento da Amazônia – Sudam) area of operation, whose mission is to promote the inclusive and sustainable development of the Legal Amazon.[9] This territory encompasses 772 municipalities in nine federal states, 5.015.146,008 km^2 or 58.93% of the Brazilian territory.[10] Also, in this territory are located four Brazil's main hydropower plants Belo Monte, Jirau, Santo Antônio e Tucuruí, being responsible for more than 27% of national electricity generation in 2021 (Schutze and Holz, 2023).

Despite its magnitude and electric generation power, this territory only consumed 11% of the electricity generation, and more than 14% of the population is not connected to the National Interconnected System (Sistema Interligado Nacional – SIN). Of these, almost three million people are supplied by local plants that are part of the Isolated Systems (Sistemas Isolados – SISOLs), that is, not belonging to the SIN (Schutze and Holz, 2023). It is still worth mentioning that data from Leite e Sousa (2020) points to even more contradictory information, almost one million people in Brazil's Legal Amazon do not have permanent access to electricity, receiving electricity for only a few hours and arising from fossil fuel-based generators.

9. Available at: https://www.gov.br/sudam/pt-br/acesso-a-informacoes/institucional.

10. Available at: https://www.ibge.gov.br/geociencias/cartas-e-mapas/mapas-regionais/15819-amazonia-legal.html?=&t=o-que-e.

FIGURE 2
SIN and SISOLs



Source: Leite and Sousa (2020).
Obs.: Figure whose layout and texts could not be formatted and proofread due to the technical characteristics of the original files (Publisher's note).

It is important to highlight that the plants part of the SISOLs are, mainly, thermal power plants that mainly use fossil fuel, thus emit more greenhouse gas. To exemplify, in 2021, the consumption of electricity produced by the Sistemas Isolados represented only 0.6% of total consumption in Brazil. However, they emitted the same amount of greenhouse gas as 10% of plants part of SIN (Schutze and Holz, 2023).

Another contradictory data is, between 2012 and 2021, Legal Amazon duplicated its electricity production and, in the same period, the rest of Brazil only increased by 2% and the scenario of uneven consumption remained (Schutze and Holz, 2023), allowing us to affirm that Amazon provides and exports necessary electrical energy for Brazil outside the borders of the Legal Amazon.

When analyzing the consequences of this inequality in the daily lives of the population of the Legal Amazon, we come across situations that seem to be unimaginable for the inhabitants of large cities supplied by electrical energy produced in the Legal Amazon. According to the Connectivity in Schools Panel (Painel Conectividade nas Escolas) survey accomplished by the National Telecommunications Agency (Agência Nacional de Telecomunicações – Anatel), four federal states have more than 10% of the schools without electricity (Acre: 35.3%, Roraima: 21.5%, Amazonas: 19.9%, Pará: 12.2%) and, in six federal states, schools have no internet access (Acre: 46.0%, Amazonas: 40.9%, Roraima: 36.1%, Pará: 27.9%, Amapá: 27.5%, Maranhão: 11.9%).[11] The most obvious common characteristic between states with schools without power and internet access is their location, all of them belong to the Legal Amazon.

In 2020, Brazil's government launched the More Light to Amazon Program (Programa Mais Luz para Amazônia – MLA) through the Decree No. 10.221, February 5, 2020, with the objective to established the National Program for Universal Access and Use of Electricity in the Legal Amazon (Brazil, 2020). This decree was revoked in August 2023 by the Decree No. 11.628, with the purpose to provide electricity services to the rural population and the population residing in Legal Amazon's remote regions that do not have access to public electricity distribution services. The 2023 decree aims to combat energy poverty, value and respect the culture of local communities, encourage the decarbonization of the region and respect the Amazon biome (Brazil, 2023).

Although this and other government initiatives, the power access of Legal Amazon's communities is far from being ideal and egalitarian, as the data presented above report. In an attempt to assist these communities, the third sector has worked to meet these demands through partnerships with the private sector, mainly. One of the results of the partnership between these sectors is the Solar Community Hub, an initiative of Sustainable Amazon Foundation (Fundação Amazônia Sustentável – FAS), Dell Technologies, Computer Aid and Intel Corporation (FAS, 2023).

Solar Community Hub is made up of containers and a solar-powered system, through this structure more than 1,500 riverside people have access to free internet and education and health services in the community of Boa Esperança, located in the Sustainable Development Reserve of the Amapá river (Amapá) and its surroundings (FAS, 2023). This hub is just one of the initiatives that has been developed by the third sector to cover the lack of access to electricity and internet in the Brazilian Legal Amazon.

11. Available at: https://informacoes.anatel.gov.br/paineis/infraestrutura/conectividade-nas-escolas.

It is also important to highlight that, despite not belonging to the Integrated National System, the environmental and social costs of energy production through hydroelectric plants are suffered by local and native peoples of the Legal Amazon, being placed on the margins of human rights. This is a key point of debate, since this dynamic between energy producers and buyers is not limited only to the Brazilian Legal Amazon. This dynamic of producers suffering the environmental and social consequences brought by hydroelectric plants and the low cost of purchasing energy for buyers is repeated in other South American countries, with Brazil being placed as an important actor in reproducing this dynamic so that it obtains and feeds its National System at low prices and not importing and paying for the environmental consequences to its large urban centers, the majority consumers.

Brazil presents an energy expansion policy that seeks to expand the use of renewable energy despite new pre-salt oil exploration and the recent controversy over the possibility of oil exploration at the mouth of the Amazon river. As part of this expansion, several hydroelectric plant projects are planned, including in the Amazon basin, which has been identified as the new Brazilian energy frontier.

Hydroelectric power plays a crucial role in Brazil's energy landscape, contributing around 56.8% to the electricity matrix in 2021.[12] However, the social and environmental impacts of hydroelectric projects in the Amazon raise concerns, potentially outweighing the benefits. The Amazon basin has become the last frontier for hydroelectric development, hosting 349 existing projects and 557 planned ones. In the Brazilian part alone, there are 201 hydroelectric plants, with an expected surge in demand leading to plans for an additional 380 plants by 2029. Overall, more than 2200 hydroelectric projects are in various stages of development, emphasizing the significance and scale of this energy source in the region (Ferreira and Carvalho, 2021; ICMBIO, 2022; Couto, 2021).

4 ENERGY INTEGRATION AND ENERGY TRANSITION IN THE AMAZONIAN COUNTRIES

Hydroelectric projects in the Amazon have also been part of the historic process of South American energy integration and other infrastructures. According to Fuser and Abraao (2020), the process of integration has evolved into a collection of collaboration agreements, memorandums of intent, and understandings. However, progress has been sporadic and slow, with the potential at bilateral or multilateral levels often confined to conceptual realms. The aspiration to unite Latin American and South American countries for leveraging complementary opportunities in the energy sector has persisted since the inception of early initiatives for regional integration (Fuser and Abraao, 2020, p. 242-243).

12. Availabe at: https://www.epe.gov.br/pt/abcdenergia/matriz-energetica-e-eletrica.

The authors propose that energy integration or interconnection initiatives in South America have taken place in three distinct phases. The first phase, from the 1970s to 1980s, was characterized by the intense participation of the State in the energy sector highlighting large binational projects, as the hydroelectric plants of Itaipu (Brazil-Paraguay), Yaciretá (Argentina-Paraguay) and Salto Grande (Argentina-Uruguay). The second phase, differently, in the 1980s and 1990s, was characterized by the centrality of private investments and the relative reduction of the role of the State. The priority in the field of energy integration was given to the objective of attracting private capital from North America and Europe to all types of energy projects, including extraction, electricity generation, transport, distribution and sale to final consumers. The last and third phase in the beginning of the new millennium represented the resumption of the state's role in energy integration with the rise of new progressive governments in the region.

In the Amazon basin, in addition to the integration process initiated by the 1978 Amazon Cooperation Treaty, another multilateral integration process that encompasses the Amazonian countries is the Initiative for the Integration of Regional Infrastructure in South America (Integração da Infraestrutura Regional Sul-Americana – IIRSA), which was established in 2000 by the governments of the twelve South American countries aiming to integrate the infrastructure of the South American countries. Almost ten years after its creation, the third meeting of Union of South American Nations (União de Nações Sul-Americanas – Unasul) established the Infrastructure and Planning Council (Conselho Sul-Americano de Infraestrutura e Planejamento – Cosiplan), whose installation took place in 2010. This council, in turn, included IIRSA as its technical forum.

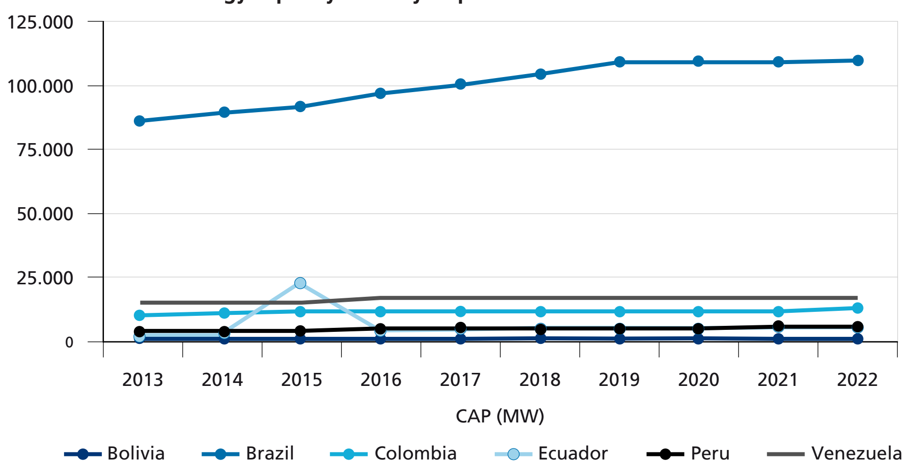
IIRSA would have the purpose of "providing the region with a basic infrastructure in the areas of transport, communications and energy, providing the bases for greater commercial and social integration on the continent" (Couto, 2009, p. 62). According to Wanderley Messias da Costa, it is about "taking advantage of the old and incipient macro-regional circulation network (denser in its southern portion) and the national networks available in the other scales of the member countries" (Couto, 2009, p. 7). The first years of its operation were dedicated to the selection and prioritization of projects to be implemented. These projects are divided into 10 integration and development axes. Among the IIRSA integration hubs that include projects in the Amazon region are: the Amazon Hub, the Guiana Shield Hub and the Peru-Brazil-Bolivia Hub. There are also other axes that in their area of influence include part of the Amazon region, as is the case of the Central Interoceanic Axis.

In addition to physical integration related to transport and communication, a part of IIRSA refers to energy integration, and in the case of the Amazon, the main projects in this area are hydroelectric plants and electrical interconnection.

Although there are large hydroelectric plants already built in the Brazilian part of the Amazon basin, most of this territory is not connected to the national system and depends on the energy generated in local thermal power stations. These generally consist of diesel generators in small towns, thermal power stations in larger cities, or even local hydraulic power plants. Théry and Mello (2005, p. 230-231) state that "there are plans to remedy this situation but the distance and the necessary investments are so immense that it would take years to ensure complete coverage of the country by a well-distributed network".

Regarding renewable energy capacity in the Amazonian countries, Brazil has a prominent position (figure 3), since it has the largest area in the basin and also the greatest economic investment capacity, as was the case in Belo Monte hydroelectric power plant with the National Bank for Economic and Social Development (Banco Nacional de Desenvolvimento Econômico e Social – BNDES) investments. In South America there are some initiatives of shared generation and interconnection via transmission line (figure 4).

FIGURE 3
Renewable energy capacity data: hydropower



Source: IRENA (2023).
Authors' elaboration.

Energy integration and the energy transition present some possibilities for synergy with energy efficiency in mind, mainly if considered from the side of proximity and energy transmission. However, it is important to highlight that among the Amazonian countries there are states whose economy is heavily based on the exploration of fossil energy sources such as oil and natural gas, such as Bolivia, Venezuela, Ecuador and Peru. The latter two have been exploring for oil in the Amazon basin for decades, accumulating large related socio-environmental liabilities (Sant'Anna, 2017). Taking into account this historical process of energy integration and energy transition, it is interesting to analyze the issue in the Amazonian countries, highlighting hydroelectricity and specific project cases that illustrate the complexity of the problem presented in this article.

FIGURE 4
Energy integration initiatives in South America

South America	Argentina	Bolivia	Brazil	Chile	Colombia	Ecuador	Guinea	German Federal Republic	Paraguay	Peru	Suriname	Uruguay	Venezuela
Argentina													
Bolivia	S/C												
Brazil	T	S/C											
Chile	T	S/T											
Colombia			S/C										
Ecuador					T								
Guinea			S/C										
German Federal Republic			S/C										
Paraguay	G/T	S/C	G/T										
Peru		S/C	S/C	S/C	S/C	T							
Suriname			S/C				S/C	S/C					
Uruguay	G/T		T										
Venezuela			T		T		S/C						

G – Shared Generation

T – Interconnection via transmission line

S/C – Border countries without connection

Countries with integration studies/projects referenced in their National Energy Plans

Non-border countries

Source: Brazil (2018).
Authors' elaboration.

5 ENERGY TRANSITION AND HYDROELECTRICITY IN FIVE AMAZONIAN COUNTRIES

5.1 Bolivia

Bolivia has in its energy balance 4% of hydroelectric source, with 18.4% of the installed capacity of energy generation by hydroelectric plants with 759 MW. Regarding the generation of electricity, hydroelectric plants account for 29.8% in the country with 3,237 GWh (Olade, 2021).

Bolivia has achieved a 50% reduction in the use of gas for electrical generation, replacing it with renewable sources such as hydroelectric, wind, solar and biomass. This transition is part of the national energy transition strategy. National electrical demand is approximately 1,600 MW, but thanks to investments in renewable sources, only around 3.5 million daily cubic meters of gas are needed compared to the 7 million previously needed. President Luis Arce has promoted this exchange policy in the electricity sector to comply with constitutional mandates and international commitments, reducing winter greenhouse gas emissions. Bolivia has an installed capacity of 1,161 MW of clean energy, including solar, wind, biomass and hydroelectricity. The goal is to add approximately 550 MW of clean energy to the SIN by 2025, incorporating wind, solar, hydroelectric and geothermal projects.[13]

With regard to integration with Brazil, in addition to the tensions that occurred due to the construction of the Santo Antônio and Jirau hydroelectric plants in the Madeira River basin near the border between the two countries, other hydroelectric plants were also planned, either binational or national, with surplus exports to Brazil.

The construction of a binational Guajará-Mirim hydroelectric plant on the border between Bolivia and Brazil, and the Bolivian plant of Cachuela Esperanza, as included in the IIRSA projects of the Peru-Brazil-Bolivia Axis, were planned in the Madeira-Madre de Dios-Beni River Corridor project group.[14] In 2008, the Canadian company Tecsult was hired by the Bolivian government to carry out hydroelectric exploration and navigability studies for the Cachuela Esperanza plant project, as well as to analyze the impacts that could be caused in Bolivian territory by the two Brazilian plants of Santo Antônio and Jirau. The main objective of both the Guajará-Mirim and CachuelaEsperanza plants would be for Bolivia to export surplus energy to Brazil (Bermann et al., 2010), along the lines of the Itaipu Plant. Thus, the four hydroelectric plants planned in the Madeira basin would also serve to compose the great Madeira-Madre de Dios-Beni waterway.

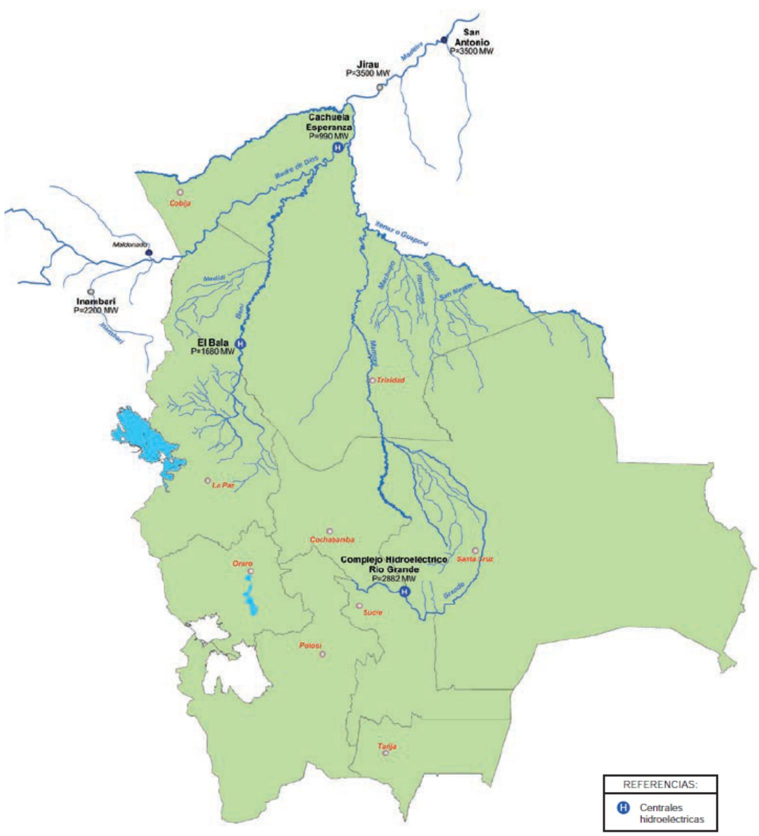
The construction of the El Bala and Cachuela Esperanza dams, besides generating electricity, have the proposal to enable areas for agriculture, create artificial lakes and make the Beni and Madeira rivers navigable to connect with other regions and countries, making possible the transportation and energetic integration. The Cachuela Esperanza hydroelectric, in Beni River in Bolivia, has an estimated generation capacity of 990 MW with a cost of US$ 5 billion and is a national initiative from the 1980s, through the National Electricity Company of Bolivia (Empresa Nacional de Electricidad – ENDE). In the 2000s, the hydroelectric became part of the binational project among Brazil and Bolivia and financed by the IIRSA and Inter-American Development Bank (IDB), the Madeira Complex.

13. Available at: https://www.mhe.gob.bo/2022/10/10/transicion-energetica-bolivia-sustituyo-en-50-el-uso-del-gas-por-energias-renovables/.

14. Available at: http://www.iirsa.org/Page/Detail?menuItemId=45.

Despite the civil society organizations and environmental and cultural impact studies positioning, the Bolivia government did not stop the studies for the hydroelectric project to export energy to Brazil. In this specific case, Brazil is considered an opportunist country, because, although the construction's negative impacts will not be exported to the country, Bolivia will sell the energy for a low cost (Costa et al., 2014). After the Brazilian election in 2023, the third mandate of Lula already had the intention to reopen the conversations with the current Bolivian president, Luiz Arce, to take up various infrastructure projects among the two countries, including this hydroelectric plant, the main project. It is important to note that the firsts conversations occurred in 2007, during Lula's second mandate, and during Dilma's government they were suspended and taken up in 2020, during Bolsonaro's government, but were soon suspended again.

FIGURE 5
Location of mega projects



Source: Bolivia (2014).
Obs.: Figure whose layout and texts could not be formatted and proofread due to the technical characteristics of the original files (Publisher's note).

5.2 Colombia

In Colombia, a large part of electrical energy generation comes from hydroelectric plants, around 70% of total generation. There is, therefore, a high dependence of the country on hydroelectric generation. However, this generation is concentrated in the Andean and Pacific slopes, and not in the Amazon basin in the country. Still, hydroelectric projects and expansion plans for these projects have generated socio-environmental tensions and conflicts in the country.

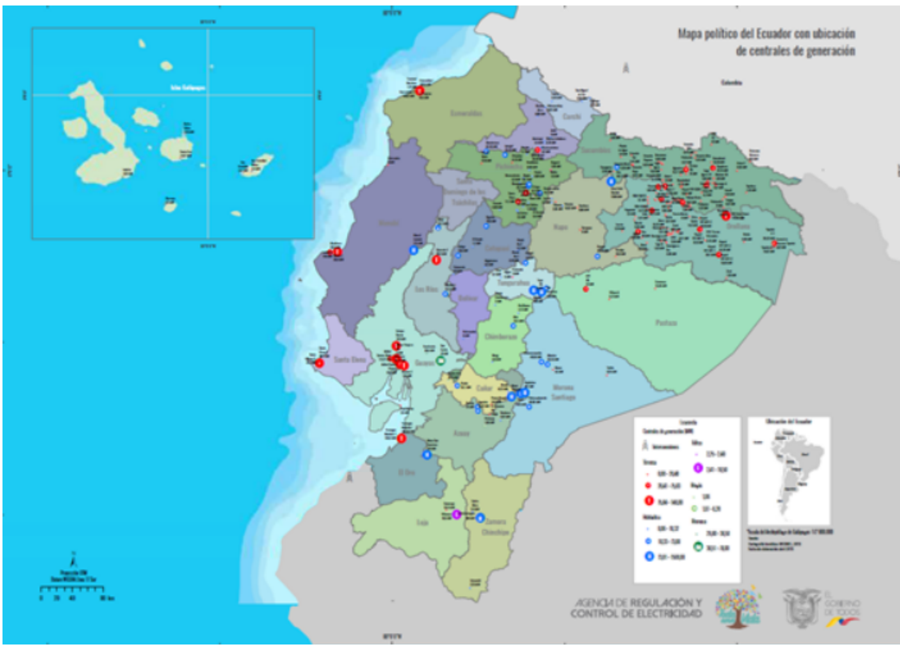
Colombia's Andean region serves as the primary hub for hydroelectric power generation, thanks to its varying rainfall levels ranging from 1500 mm annually in inter-Andean valleys to 4000 mm in high plateaus and forests. The mountainous geography facilitates reservoir construction, forming the foundation of the country's electrical system, predominantly reliant on hydraulic generation. Currently, Colombia boasts an installed capacity of around 14.4 GW, with 69.9% from hydraulic generation, 24.8% from gas thermal, 4.9% from coal thermal, 0.4% from cogenerators, and 0.1% from wind power. The electric generation in the interconnected electrical system is concentrated in the northwest and center of the country, aligning with primary energy resources and demand locations. Hydroelectricity takes the lead with 69.18% of total production, followed by gas thermal at 9.61%. In 2016, hydropower generation slightly decreased due to El Niño, comprising 67.1% compared to 70.39% in 2015. Hydroelectric plants, particularly reservoir-based ones, dominate as the primary means of electricity generation in Colombia. However, climatic conditions like the El Niño Southern Oscillation (El Niño Oscilação Sul – ENOS) cycle have significantly impacted reservoir levels. Additionally, the construction and operation of such infrastructure raise environmental concerns and community impacts, prompting questions about the sustainability of heavily relying on this generation model (Orlando and Toro, 2021; Macías, 2022).

5.3 Ecuador

In Ecuador hydroelectric plants accounted for 19% of the energy balance, and had an installed power generation capacity of 5,107 megawatts, representing 58.47% of the total. Hydroelectric plants correspond to 79.41% of electricity generation with 25,575 GWh (Olade, 2021).

The Coca-Codo Sinclair (CCS) hydroelectric plant was defined by the Ecuadorian government as an emblematic project that would bring several benefits to the country, in particular, to diversify the energy matrix and supply approximately 30-44% of the national energy demand and contribute to reducing emissions of 3.45 tons of CO_2. However, it was a project that caused several socio-environmental impacts and represented an attempt by the government in its Electricity Master Plan (2007-2016) to really generate energy diversification towards an energy transition, contributing to mitigate climate change and ensure safety and energy sovereignty. The Electricity Master Plan for the period 2016-2025 contains 25 hydroelectric projects on the Amazon side as an expansion of the electric matrix.

FIGURE 6
Location of power generation plants



Source: Ecuador, 2016. Available at: https://www.recursosyenergia.gob.ec/plan-maestro-de-electricidad.
Obs.: Figure whose layout and texts could not be formatted and proofread due to the technical characteristics of the original files (Publisher's note).

The CCS is situated in Ecuador's Napo and Sucumbios provinces, around 100 km east of the capital city, Quito. It occupies an area where the River Coca is formed by the convergence of the Quijos and Salado Rivers. Initial investigations for the project commenced in the 1970s. A pre-feasibility study was conducted in 1976, followed by a feasibility study in 1992, which relied on recorded flow data spanning from 1972 to 1990. In 2007, the 1992 plan underwent an update, envisioning a potential capacity of up to 1500 MW and utilizing a maximum discharge of 222 m^3/s from the estimated average annual flow of 287 m^3/s. However, the subsequent feasibility studies were critiqued for relying on historical hydrological data with questionable validity. Consequently, these studies resulted in overestimations regarding water availability (Teräväinen, 2019).

5.4 Peru

Peru has 35.64% of installed capacity generated by hydroelectric plants corresponding to 15.2 GW (Peru, 2020). Energy production through hydroelectric plants accounted for 43% of the total in 2019, and in the energy balance hydroelectric plants accounted for 16% (Olade, 2021). Peru has an installed power generation capacity from hydroelectric plants of 5,514 megawatts, representing 35.94% of the total and regarding electricity generation by source hydroelectricity corresponds to 31,926 GWh, 55.62% (Olade, 2021).

In 2010, Brazil and Peru also signed an energy integration agreement aimed at supplying electricity to Peru and exporting surpluses to Brazil, through electrical interconnection. This agreement provides for the construction of five large hydroelectric plants in the Peruvian Amazon, close to the border with Brazil. The export of 6,000 MW was agreed, for a fixed contract period of 30 years from the beginning of operations of each hydroelectric plant. The first project to be carried out is the Inambari hydroelectric plant, which will be installed on the border between the departments of Madre de Dios, Cuzco and Puno, 300 km from the border of Acre, in Brazil. This plant will have an installed capacity of 2,200 MW (DAR, SER and CARE, 2011, p. 9). The project foresees the flooding of part of the recently inaugurated Interoceanic Highway, one of IIRSA's projects. This agreement has not yet been implemented due to opposition from part of Peruvian society and, mainly, due to the resistance of environmentalists to the construction of the Inambari plant, located in an area close to ecological reserves in the Peruvian Amazon. The project was suspended in 2011.

TABLE 1
Hydroelectric plants evaluated according to order of certainty of implementation in the Amazon and central jungle, according to SEIN

Hydroelectric power station	Power (MW)	Area	Grant	Environmental position	Year
Veracruz	639	North	Final	Medium opposition	2022-2024
Chadín II	650	North	Final	Medium opposition	
Rio Grande I	600	North	Temporary	Medium opposition	2028 onwards
Rio Grande II	150	North	Temporary	Medium opposition	
Lorena	304	North	Temporary	Medium opposition	
Tambo 40	1,286	East	No concession	Greatest opposition	
Tambo 60	580	East	No concession	Greatest opposition	
Mainique 1	607	East	No concession	Greatest opposition	
Pakitzapango	1,379	East	No concession	Greatest opposition	
Inambari	2,200	East	No concession	Greatest opposition	

Source: Sistema Elétrico Interligado Nacional (SEIN) 2019-2028; DAR ,2019.

TABLE 2
Main hydroelectric projects of the Peru-Brazil energy agreement

No.	Name	Location	Power (MW)	Current status
1	Inambari	Madre de Dios, Cusco and Puno	2,000	No concession, but under review
2	Pakitzapango	Junín	2,200	No concession
3	Mainique I	Cusco	607	No concession
4	Tambo 40	Junín	1,287	No concession
5	Tambo 60	Junín	597	No concession
	Total		**6,730**	

Source: DAR, SER and CARE (2011).

FIGURE 7
Location of the hydroelectric plants of the Brazil-Peru agreement

Source: DAR, SER and CARE (2011).
Obs.: Figure whose layout and texts could not be formatted and proofread due to the technical characteristics of the original files (Publisher's note).

6 HYDROELECTRIC PLANTS IN THE AMAZON: SOCIO-ENVIRONMENTAL IMPACTS

As presented above, Amazonian countries have included several hydroelectric projects in their national planning, driven by regional initiatives of energy integration. There are different narratives in relation to these hydroelectric projects in the Amazon basin, which corroborates the view of the social construction of nature and, therefore, of rivers. The relationship between development plans for the Brazilian Amazon region and the country's energy policy goes back decades. Thus, as the vision of water resources management policy subordinated to energy policy (Bermann, 2007), which is reflected in the great predominance of hydroelectricity in the electrical energy matrix in Brazil. Not only in Brazil, but in other Amazonian countries, hydroelectric projects play a significant role in their energy matrices and especially in the expansion of renewable energy and energy transition plans. Even energy security discourses, based on narratives about the energy crisis, drive plans to expand the construction of hydroelectric plants in the Amazon, based on the predominant view of the need for increasing the energy supply. The energy and water security discourses are intertwined with the countries' developmental policy discourses, and with the vision of the Amazon region as the provider of natural resources for the other more populous and "economically developed" regions (Batista and Miranda, 2019).

The energy sector's focus on competitiveness has led to a lack of scrutiny in methods of energy generation. Large corporations are consolidating global water and energy supply, often with projects framed as being in the national or continental interest. Research reveals a link between big hydraulic projects and narratives of national development, resulting in authoritarian measures that neglect public input. Concerns arise about genuine social participation and democratic processes. In the energy and water sector, the prevailing knowledge framework favors large dam projects based on modern positivist perspectives, using depoliticized technical-scientific knowledge to justify hydraulic modernization efforts like large hydroelectric dams (Atkins, 2019; Bermann, 2012; Boelens, Shah and Bruins, 2019).

The relationship between water and energy emerged amid concerns about the energy and food price crisis in 2007-2008, as well as apprehensions about growing demand and shortages in scenarios of environmental degradation. The "nexus" concept was introduced by the World Economic Forum during global crises, driven by private actors who see business opportunities in the green economy. The alarmist narrative securitizes crises, reducing them to financial calculations. Energy and water governance are securitized by global financial networks, linking the nexus to development projects. This approach politicizes the nexus, highlighting technological innovation, market efficiency, and ecological modernization, but neglects issues of inequality and justice. A critical approach suggests evaluating whether proposed technologies reduce or exacerbate poverty, decentralize or centralize control and decision-making, and affect income inequality and the "three securities" – water, food and energy (Allouche, Middleton and Gyawali, 2015; Schmidt and Matthews, 2018).

Thus, the observed narratives demonstrate that the Amazon basin remains an arena contested by different narratives. At the domestic level the narratives of national governments emphasize modernization and economic development. Other narratives challenge the economic benefits and highlight the social injustices and socio-environmental impacts of the hydropower projects.

The Amazon's significance extends beyond its ecological and social aspects to climate regulation and water availability. The forest's degradation, coupled with climate change, poses a threat. Over 54.2 million hectares were deforested in the Amazon between 2001 and 2020, impacting Brazil, Bolivia, Peru, and Colombia the most. Protected areas and indigenous territories have played a crucial role in curbing deforestation. According to MapBiomas data from 1985 to 2022, Brazil burned 1,857,025 km², equivalent to 21.8% of its territory.[15] The Amazon Biome accounted for 68,077 km²/year of burned area, with 809,505 km² accumulated over 38 years. Notably, 68.9% of fires occurred in native vegetation. The Amazon's vulnerability to fire is linked to anthropic activities like agriculture, deforestation, and forest fires. The Amazon's climate and water dynamics, including flying rivers and ecosystem services, connect it to regional and global climate patterns. However, environmental degradation, deforestation, and land-use changes contribute to Brazil's substantial greenhouse gas emissions, exacerbating climate change.

Addressing climate change involves not only curbing deforestation but also transitioning to renewable energy sources. However, studies reveal that large hydroelectric plants in the Amazon may emit greenhouse gasses, challenging their classification as "clean" or "green" energy. Research carried out by Fearnside (2019) showed that large hydroelectric plants in the Amazon basin emit greenhouse gases, mainly due to the decomposition of organic matter and, in some cases, to the design and operation of the plant itself. Tropical hydroelectric dams, especially those with large reservoirs, emit methane (CH_4) due to the stratification of water into layers separated by temperature. This results in a lack of oxygen in the deeper water, leading to the decomposition of organic matter that does not form CO_2, but rather CH_4. Methane can be released into the atmosphere through bubbles or diffusion at the surface of the reservoir. Additionally, emissions can occur when water is removed from the bottom of the reservoir to pass through turbines or spillways. Another source of emissions is carbon dioxide released by the

15. Available at: https://mapbiomas-br-site.s3.amazonaws.com/Fact-Sheet-Fogo.pdf.

decomposition of dead trees when the reservoir is full, either because they were thrown out of the water or removed to another location. Emissions from large reservoirs exceed those from run-of-the-river plants, contradicting the hydropower industry's claims of zero or negligible emissions from these plants. A notable example is the Santo Antônio dam,[16] which blocked the Madeira River in Brazil in 2011. Furthermore, environmental impacts, such as human displacement, loss of forest and biodiversity, are more significant in large reservoirs.

The decrease in precipitation is one of the effects of climate change that is affecting the Amazon basin. These effects show significant negative impacts that require attention from public policies, mainly when dealing with energy policy and energy transition and, in particular, when focusing on hydroelectric plants. Extreme events, such as periods of floods and periods of drought, also negatively impact the infrastructure of hydroelectric plants, in addition to their own operation and energy supply (Soito and Freitas, 2011). This change in the pattern of rainfall with more severe droughts is one of the main reasons for the policies of Amazonian countries to diversify renewable energy sources.

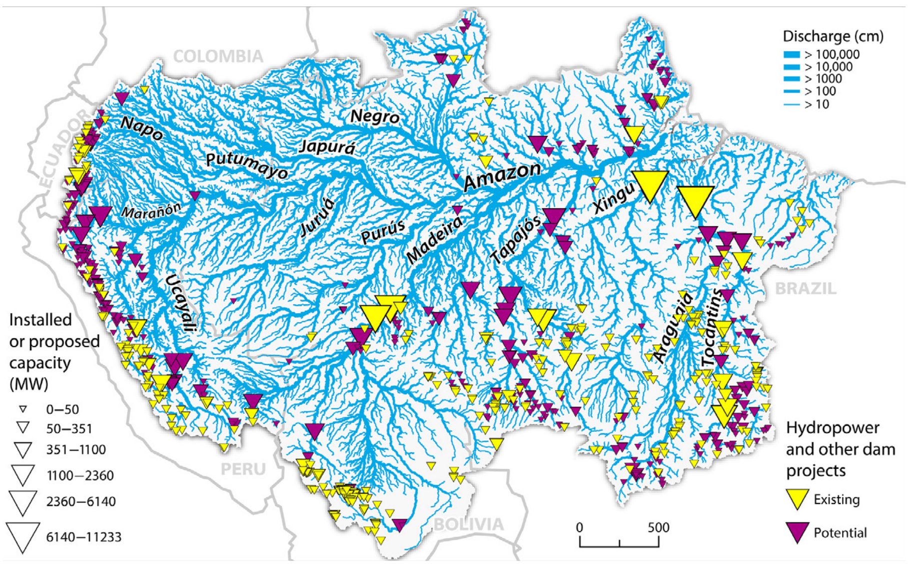
Hydropower often gets labeled as a "clean" or "green" energy source, but its impacts on river ecosystems are a subject of debate. The scientific community and civil society challenge this classification due to observed effects and interactions with other stressors. Various campaigns and initiatives, involving both scientific research and civil society, actively monitor the consequences of dams and power plants on river ecosystems. Globally, there's a growing consensus that hydroelectricity can significantly transform river systems, leading to a reconsideration of its "green" status to a more cautionary "red" designation. Negative repercussions include fish mortality, loss of aquatic biodiversity, and ecological harm related to the fragmentation of once freely flowing rivers (free-flowing rivers) (Geist, 2021; Sant'Anna, Honorato and Bortoletto, 2020).

Fish mortality and its impact on fishing are relevant aspects in the Amazon basin caused by the fragmentation of rivers that negatively impact the food security of the Amazon population. The impact on fisheries of dam and hydroelectric plant infrastructure is due to effects on riverine geomorphology, thermal regime, flow regime and other physical-chemical and biological characteristics that shape the local habitat and drive fish diversity, composition, distribution and abundance. The implementation of dams in the Amazon basin affects the livelihoods and well-being of fishermen, as there are "330,000 artisanal fishermen (MAPA 2016), whose livelihoods and well-being are closely linked to fishing systems, biodiversity

16. At the time of finalizing the article, a large part of the Amazon region is suffering a serious drought, including the Hydroelectric Power Plant of Santo Antônio in Rondônia suspended its operation from October 1, 2023. Available at: https://oglobo.globo.com/economia/noticia/2023/10/02/usina-de-santo-antonio-suspende-operacao-due-a-dry-na-amazonia.ghtml. Accessed on: Oct. 10, 2023.

and to the environmental services provided by the Amazonian ecosystems" (Doria et al., 2018, p. 453, our translation). In the Amazon basin alone, 20% of the world's freshwater fish diversity is found, totaling more than 13,000 species (Doria et al., 2018).The new "boom" in the expansion of hydroelectric dams in the tropics threatens a third of the world's freshwater fish species, due to projected diversity losses only in the megadiverse basins of the Amazon, Congo and Mekong.

FIGURE 8
Hydropower and other dam projects in the Amazon river basin



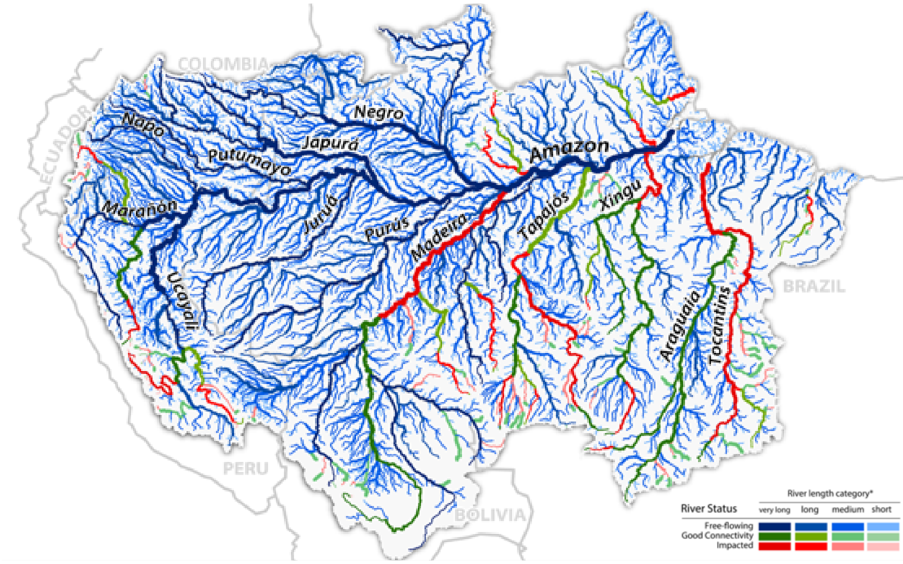
Source: Caldas et al. (2023).

Healthy and connected rivers in the Amazon basin provide a set of essential ecosystem services for the population, such as fishing, floodplain agriculture, river transport and carbon sequestration. Dams not only prevent the migration of species, but also affect hydrological dynamics and water quality, harming various aquatic organisms. Thus, the Amazonian population, which heavily depends on fishery resources for its food security, is negatively impacted by the effect of dams on fisheries. As migratory fish account for about 93% (range 77% to 99%) of what is caught in the basin, they contribute a total of US$ 436 million annually to the region (Caldas et al., 2023). The reduction in fishing therefore, in addition to affecting food security, also has a significant economic impact for this population (Lima et al., 2020).

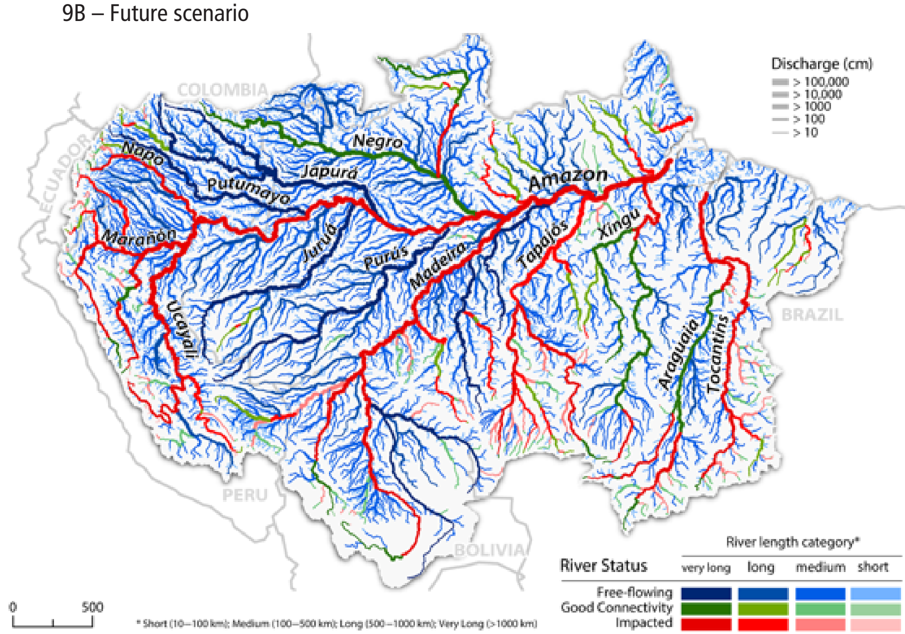
FIGURE 9

Current and future scenarios of free-flowing river status

9A – Current scenario



9B – Future scenario



Source: Caldas et al. (2022).

The location and characteristics of dams play an important role in impacts, as even small dams can cause significant effects. Recent studies have emphasized the potential loss of biodiversity, fisheries, water flows and sediments, and the fragmentation of river connectivity due to dam development (Anderson et al., 2018; Flecker et al., 2022). These assessments show that existing dams are concentrated in tributary networks and headwater systems, leaving many major rivers particularly vulnerable to fragmentation by future large dam development (Caldas et al., 2023).

The Amazon basin still has many free-flowing rivers, with the Amazon River being the longest in the world in this category. An initiative from the Chico Mendes Institute for Biodiversity Conservation (Instituto Chico Mendes de Conservação da Biodiversidade – ICMBIO), in Brazil, was launched in 2022, the Plan for Reducing the Impacts of Hydroelectric Power Plants on Biodiversity in the Amazon (ICMBIO, 2022). Despite acknowledging the significant repercussions of hydroelectric power plants on Amazonian biodiversity, the plan aims to harmonize conservation efforts with the expansion of hydroelectric projects – a conundrum highlighted by Geist (2021). Essentially, it proposes minimizing the impact of hydroelectric plants without impeding the establishment and operation of new ventures.

To navigate this complex scenario, the plan overlays the map of impact exposure with a biodiversity sensitivity map, creating a compatibility map between biodiversity conservation and hydroelectric endeavors. While offering recommendations and a guide for assessing the cost-benefit of dam construction in the basin, the plan concedes that future projects will inevitably bring about environmental impacts. It presents a perspective that lacks a thorough exploration of alternatives to hydroelectric expansion, positioning itself as a response to the mounting calls from the scientific community and civil society. This response is driven by the accumulation of scientific evidence highlighting the adverse effects of hydroelectric activities.

Although the greatest repercussion of negative socio-environmental impacts comes from large hydroelectric plants in Amazonia, a significant number of small hydroelectric plants (SHP) have a major impact on river systems due to the fragmentation of watercourses. In Brazil, for example, 85% of the 1,517 operating hydropower plants are SHP, which contributes to 7% of the total generation capacity (Couto, Messager and Olden, 2021). Currently, social groups that depend on fishing for their food security, such as indigenous peoples in the Amazon, have been strongly impacted by the expansion of SHP. The fishing practice of the Enawene Nawes, for example, faces serious threats due to small hydroelectric plants that have caused the loss of river connectivity in the Juruena basin, which puts both the food security and the sovereignty of the Enawenes at risk, also impacting their relationships cultural aspects linked to fishing (Couto, 2023).

The number of SHP in the Tapajós River basin is a concern since the licensing of SHP is decentralized, disregarding the cumulative environmental impact of the fragmentation of several watercourses in the basin. As is the case of the Juruena river basin, despite there being no PCH in the indigenous territory, it is still affected by the cumulative effect throughout the basin. Therefore, it is essential to develop a strategic planning based on trade-off analysis, taking into account this cumulative effect (Couto, Messager and Olden, 2021).

The Amazon basin witnessed vehement opposition to various projects and the establishment of hydroelectric plants, scrutinized for their feasibility and environmental impacts. This criticism extended to both older plants like Balbina (Uatumã, Amazonas) and more recent ventures like Belo Monte (Altamira, Pará). This backdrop prompted numerous studies and debates addressing the problems surrounding project impacts and viability. It also spurred discussions on alternatives to hydroelectric projects in the Amazon. A notable example is the publication during Rio+20 of *The brazilian electric sector and sustainability in the 21st century: opportunities and challenges*. This work concludes that dispelling misconceptions about hydroelectric plants as clean, cheap, and renewable energy sources is essential. It emphasizes the urgency of upholding socio-environmental safeguards, complying with Brazilian legislation and international human rights and environmental protection standards, and eliminating perverse incentives for dam construction, such as the allocation of carbon credits under the Clean Development Mechanism (CDM) (Millikan and Moreira, 2012, p. 10).

Among the proposed initiatives is the optimization of resources for energy efficiency, which can lead to economic efficiency (Kishinami, 2012). Additionally, addressing the substantial energy losses in Brazil's transmission system, among the highest globally (Rey, 2012), is highlighted. The overarching challenge for Global South countries, including Brazil, marked by significant social inequality, lies in investing in modern renewable energy technologies and electro-intensive sectors. Simultaneously, the emphasis is on distributing and democratizing access to energy across the entire population. In this context, the imperative is to navigate the energy transition without resorting to large dams, prioritizing human security and sustainable development.

In addition to the problem presented regarding the socio-environmental impacts of hydroelectric plants, it is important to highlight that all renewable energies cause environmental impacts. In this sense, research aimed at improving technologies thinking about the complete product cycle is essential, since at the end of the useful life of photovoltaic modules it is still necessary to improve the recycling process (Chaves, 2023). Demand management policies are necessary to reduce consumption, such as energy efficiency, with the use of more efficient equipment, reducing losses in transmission lines.

In Brazil, the National Policy for Conservation and Rational Use of Energy and other measures (Law No. 10.295/2001), a key energy efficiency framework, emerged in response to the national electricity crisis of the same year. The nation successfully navigated energy rationing through demand management strategies. The law emphasizes the need for strategic energy planning by public authorities to ensure consistent energy generation, supply, and consumption. The National Energy Plan 2030 sets energy efficiency targets, with potential measures ranging from 2.9% to 7.3% by 2020 and 4.4% to 10.9% by 2030 compared to 2010. This potential varies based on economic development (Altoé et al., 2017).

The National Energy Efficiency Plan outlines actions across sectors like agriculture, commerce, public services, residential, transport, industry, public lighting, sanitation, and education. Effective coordination and partnerships between public authorities, ministries, and departments are crucial for widespread adoption of energy efficiency measures. To meet the goals of the National Energy Plan 2030, exploring measures beyond the National Energy Efficiency Plan is essential. One alternative is implementing a robust incentive system for decentralized energy generation, like the Feed-in Tariff, where consumers generating electricity from renewables can sell surplus at a higher price. The Net Metering system in Brazil is a positive step, and future developments, possibly adopting models like feed tariffs, could further enhance participation and investment in renewable energy sources (Altoé et al., 2017).

7 CONCLUSION

The energy transition needs to meet energy justice, as social inequalities and environmental impacts need to be equalized to guarantee a future in the Anthropocene. A just energy transition will require countries to have policies that aim not only at technological development, but also at seeking equity, access to energy for vulnerable populations, as well as sustainability in alternative forms of renewable energy generation. Even renewable energies have negative socio-environmental impacts that need to be considered in public policies, requiring a holistic approach that includes life cycle assessments, the strengthening of environmental regulations and the implementation of compensatory mechanisms for the most affected communities. Furthermore, it is crucial to encourage society's participation in the decision-making process and invest in education to ensure that everyone is prepared for new opportunities in the energy sector, promoting a more equal and inclusive transition.

Even renewable energies have negative socio-environmental impacts that need to be addressed, such as the need for large areas to install infrastructure that affect natural habitats and local communities. Hydroelectricity, for example, which has been promoted as an alternative to combat climate change, has caused a large expansion of hydroelectric plants in natural reserves, causing adverse effects on river systems, affecting terrestrial and aquatic biodiversity, altering water flow regimes and sedimentation, impacting local communities and their traditional ways of life.

The just energy transition still faces many complex challenges for the Amazon region. The policy of bringing energy to those who do not have access, as well as renewable and increasingly sustainable sources, is a significant part of this transition. Combating climate change by increasing the number of hydroelectric plants also means increasing the fragmentation of river systems in the Amazon basin, with significant negative impacts on biodiversity and food security for the Amazonian population. Furthermore, the need to ensure the participation of local communities in the planning and implementation of energy projects, ensuring that their rights and ways of life are respected, becomes paramount. This challenge involves adapting local specificities to coexist harmoniously with the unique ecosystem of the Amazon, promoting sustainable development without compromising the region's natural wealth.

If Amazonian countries accept the challenge of a fair energy policy, it will be necessary to address both distribution and access for the population without energy, as well as mitigating the negative impacts of hydroelectricity and planning so that the cumulative effects of plants of different sizes can be analyzed in river basins. And planning takes into account not only energy security, but also water and food security, that is, the ecosystem connections that are the basis for understanding climate change.

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