Assessment of the policy framework's impact on the renewable energy generation expansion in the Brazilian power grid

ICAT Initiative for Climate Action Transparency

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Initiative for Climate Action Transparency – ICAT

ICAT Brazil Phase 3 Project

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Output 9 – Lessons learned and key achievements

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Content

Forewords

This report is part of the ICAT Brazil Project phase 3, hereafter referred to as ICAT project, which is implemented by Centro Brasil no Clima (Brazil Climate Centre – CBC) in partnership with Centro Clima (PPE/COPPE/UFRJ) with support from the Initiative for Climate Action Transparency (ICAT) and technical support from the UNEP Copenhagen Climate Centre (UNEP CCC).

The previous phases of the ICAT project aimed at the enhancement of the transparency framework in Brazil by developing MRV indicators to assess climate policies and actions at the national (1st phase) and subnational (2nd phase) level. These phases developed mitigation scenarios that provided critical insight for policy development at the national and sub-national levels and proposed MRV indicators to track the implementation of the Brazilian NDC.

The third phase of the ICAT Brazil project, which started in March 2023, builds off insight gained from the first two phases by providing a detailed analysis of the energy sector in Brazil. The project assesses the potential expansion of the power sector in the country through variable renewable energies (wind and solar photovoltaic) and biomass, the sustainable development impacts of sectoral policies by applying the ICAT's Sustainable Development Methodology, and contributes for the Just Energy Transition planning in Brazil.

This report recalls the project objectives and outcomes and presents the approaches and key results found by CBC and Centro Clima while performing phase 3. The report also presents the impacts of the project and Brazil, key lessons learned during the project implementation, as well as recommendations for improvements in the policy development and implementation aiming to maximize the impacts of climate action while considering also the sustainable development impact and just transition aspects.

1 Introduction

During 2023-2024, Centro Brasil no Clima (CBC), in partnership with Centro Clima/COPPE/UFRJ and with technical support from the UNEP Copenhagen Climate Centre (UNEP-CCC), implemented the third phase of a project funded by the Initiative for Climate Action Transparency (ICAT) aiming to conduct an impact assessment of Brazilian policies on the future expansion of electricity production from renewable energy sources up to 2050, in alignment with the NDC targets and contribution to the sustainable development goals.

The specific objectives of the project were:

1. To estimate the potential expansion of variable renewable energy (VRE) and biomass sources and its impacts in the national grid up to 2050;
2. To assess the sustainable development impacts of the VRE and biomass expansion in the Deep Decarbonization Scenario (DDS) in comparison with the expansion under the Current Policy Scenario (CPS) by applying the ICAT Sustainable Development Methodology;
3. To consolidate a partnership network with stakeholders that can contribute to the assessments and to spread the results of the project for the effective use in policies design and implementation.

The project was divided in three axes, in accordance with the set specific objectives:

(A) Potential expansions of variable renewable energy and biomass sources;

(B) Sustainable development impact assessment;

(C) Partnership with stakeholders.

The third phase of the ICAT project comprised nine interconnected outputs:

- Output 1: A detailed work plan for the third phase of the ICAT work in Brazil;
- Output 2: Report on VRE and biomass expansion under current policies;
- Output 3: Report on VRE and bioelectricity expansion impact under Deep Decarbonisation Scenario (DDS) (comparative analysis (CPS x DDS)- costs and emissions);
- Output 4: Report on workshop with stakeholders;
- Output 5: Report ‘Recommendations for policymakers on how to improve the existing legal and regulatory framework’;

- Output 6: Report ‘Defining the objectives, policy framework, impact categories, and indicators for the sustainable development assessment’;
- Output 7: Report on workshop with stakeholders;
- Output 8: Report ‘Results of the sustainable development impacts assessment’;
- Output 9: Report ‘Lessons learned and key achievements’.

2 Approaches and key results

1.1 Axis (A) Potential expansion of variable renewable energy (VRE) and biomass sources

The first axis of ICAT 3, led by Centro Clima, had the objective to evaluate the prospects of expanding electricity generation with renewable sources in Brazil by 2050 employing MATRIZ[1] modelling tool to identify public policies that maximize the production and use of intermittent renewable energy in Brazil. Four policies scenarios were constructed: two current policies scenarios (CPS1 and CPS2) and two deep decarbonization scenarios (DDS1 and DDS2). CPS1 and CPS2 were developed to follow the trend of ongoing mitigation actions, while DDS1 and DDS2 were developed to follow a GHG emissions trajectory compatible with the global objective of 1.5ºC, achieving net-zero emissions in 2050. Scenarios 1 and 2 differ in terms of the inventoried potential with or without interference in protected areas is available for the model. Scenario 1 (CPS1 and DDS1) considers all inventoried potential is available with total HPP potential, while Scenario 2 (CPS2 and DDS2) only considers the inventoried potential without interference with protected areas (conservation units and indigenous and quilombola lands) is available (CPS2 and DDS 2).

In terms of installed capacity, analysis of the four scenarios – CPS1, CPS2, DDS1, and DDS2 – reveals notable differences and trends. By 2060, all scenarios anticipate Brazil's power mix shifting significantly towards renewables, ranging from 90% in CPS2 to 99% in DDS1. Aging thermopower plants are expected to be phased out and replaced, mostly by cost-effective renewable alternatives across all scenarios. While CPS 1 and 2 emphasize gas-fired power plants, DDS 1 and 2 prioritize renewable sources with increased integration of variable renewables and a focus on storage systems for grid stability.

[1] The MATRIZ model (projection of the Brazilian energy mix) (LISBOA, M. L. V.; *et al.*, 2012) represents the Brazilian energy system, with minimization of the total cost of investment and operation, choosing the best configuration in terms of capacity expansion and energy supply in the evaluated horizon. The MATRIZ model has been continuously developed by the Electric Energy Research Center (CEPEL).

In all scenarios - CPS1, CPS2, DDS1, and DDS2 - Brazil's electricity generation will continue to heavily rely on renewables, particularly wind and solar, by 2060. CPS2, constrained by hydro power plant construction and needing natural gas to supplement variable renewables, achieves the lowest renewable share at 89%. DDS1 and DDS2 lead with nearly 98% renewable generation by 2060, reflecting their emphasis on renewable integration and grid stability. Emissions from the electricity sector are projected to decrease across all scenarios compared to 2020 levels, with reductions observed until 2040. CPS1 and CPS2 anticipate a rise in emissions post-2040 due to increased natural gas usage, while DDS1 and DDS2 continue lowering emissions towards near-zero levels by 2060.

Cost considerations show minimal divergence among scenarios until 2030, influenced by electricity auction inputs. Contrasting CPS1 and DDS2 highlights their distinct strategies: CPS1 relying on hydro and gas, and DDS2 prioritizing renewables and conservation of protected areas. Although DDS2 initially incurs higher costs, it becomes more cost-effective post-2040 compared to CPS1 due to reduced reliance on natural gas. Brazil's future in transitioning to a secure, decarbonized electrical grid hinges on diversification. Embracing a variety of electricity sources and technologies will bolster power security and bolster the nation's climate change mitigation efforts. By fostering a balanced and resilient power portfolio, Brazil can navigate the complexities of the evolving global energy landscape while ensuring sustainable development and a resilient future.

1.2 Axis (B) Sustainable development impacts and just transition

The specific objective of this axis was to assess the sustainable development impacts of the VRE and biomass[2] expansion in the DDS in comparison with the expansion under the CPS. The assessment was done by applying the ICAT Sustainable Development Methodology and included stakeholder consultation processes. In addition, the project included the challenge to further the understanding of the just transitions in Brazil through the lens of sustainable development, aiming to uncover gaps surrounding the topic.

As mentioned, one of the key findings of the project is the verification that Brazilian energy policies seem to enable deep decarbonization in the energy sector, if only they were more ambitious in terms of going beyond the NDC target and focusing on achieving a net-zero emissions in 2050. One of the main references in this context is the enactment of Law n. 14,300/2022 and the establishment of the Regulatory Framework of Distributed Power Generation in the country. Due to the relevance of Solar Photovoltaic Distributed Generation (PVDG) in the scenarios elaborated on axis (A) and the growing expansion of PVDG in Brazil after, PVDG was the focus of the sustainable development impacts and just transition assessment performed.

[2] Particularly, bioelectricity, given the scope of work of Axis A.

The assessment indicated that promoting distributed generation (DG) implies lower GHG emissions from the electricity sector, given that part of this expansion in DG will substitute fossil fuel sources in the power sector. It also contributes to a positive impact on cities' air quality, due to a reduced coal power generation. Another indicator assessed on the environmental dimension was land use, for which analysis pointed out that the expansion of territorially dispersed distributed photovoltaic systems on the rooftops of Brazilian residences reduces the need for land use in contrast to centralized PV energy generation.

On the other hand, the assessment of the environmental dimension highlighted that the disposal of PV panels is an issue that the country needs to address, as the production of photovoltaic waste will skyrocket in the next few years. The disposal of PV panels is complex and requires legal and technological considerations, such as better understanding of shared obligations between manufacturer and distributors to provide final consumers with the collection and disposal of their PV Waste. Unlike other countries, there is still no specific legislation for solar panel recycling in Brazil, and the Solid Waste Policy in the country works on a different governance level, as cities are responsible for the integrated management of their solid waste. In this sense, considering growing expansion of PV waste expected to soar from 2030 onwards, it would be important that Brazil establishes mechanisms, including regulatory framework for managing photovoltaic waste while significant losses are not yet occurring.

Regarding the economic dimension, the analysis emphasized that the national production of photovoltaic energy technology in Brazil is still very incipient, considering that decentralized generation has only been regulated in the country for eleven years. However, the increased capacity of PVDG projected in future years will promote the national industry, as there will be a high demand for materials, especially aluminum, for the construction of wiring and metal structures necessary for the installation of photovoltaic systems for distributed generation. On the other hand, currently almost all photovoltaic modules used in Brazil are imported, despite the country being one of the main global producers of silicon, a basic raw material needed to produce photovoltaic cells. The assessment indicated that promoting DG would likely increase technology importation, given the incipient state of the domestic industry.

Furthermore, the assessment highlighted the growing demand for PVGD that has been occurring in recent years. This increase has promoted economic gains and a considerable decrease in the final price of photovoltaic kits installation. Also, the growing demand has generated a significant increase in the number of integrating companies in the photovoltaic energy sector, with more suppliers of photovoltaic kits and providers of installation and maintenance services. The analysis pointed out that, even though it is not possible to project future trends in terms of the PVGD costs and the expansion of

the market as a whole, as both indicators depend on other variables, such as inflation, market dynamics, exchange rates, input prices, and other factors that directly influence the Brazilian and global economy, positive outcomes can be foreseen. It is expected that the incentive of public policy in the sector will contribute to maintaining price reduction, even if it is at a slower rate, and that the solar energy market will continue to grow in the coming years.

Lastly, the social dimension assessment indicated that the likelihood of solar systems becoming more affordable for families in the C/D/E classes is highly optimistic. Also, the analysis pointed out that there will be a risein job opportunities in future years. However, as professionals become more qualified, it is expected that employability growth will decrease. There were no datasets available to assess gender equality in the sector, despite the importance of integrating women on the workforce. This indicates the need of addressing gender and other traditionally marginalized segments equality in the future potential growth of PVDG market in Brazil.

Another indicator assessed concerned new socioeconomic arrangements, through which it was discussed that the DG regulatory framework allows consumer groups such as consortiums, cooperatives, voluntary civil condominiums or buildings, and any other form of civil association to share PV credits. The analysis demonstrated that the number of PV cooperatives has grown in recent years and is expected to continue rising, although quantitative projections cannot be assessed, as it is not possible to infer the linearity of the data given its social and political dimensions.

The assessment was performed for both Current Policies Scenario (CPS) and Deep Decarbonization Scenario (DDS) scenario. The results found were similar for both cases, as it is expected that PVDG will rise in the two scenarios. However, as DDS has a higher PVDG install capacity, impacts are greatest in this scenario, which is positive regarding the environmental, economic, and social benefits of PVDG, but highlights the need of addressing potential trade-offs.

1.3 Axis (C) Partnership with stakeholders

The specific objective of this axis was to consolidate a partnership network with stakeholders that could contribute to the assessments and to spread the results of the project regarding sustainable development impacts for the effective use in policies' design and implementation. Also, considering that, as already indicated, current energy policies in Brazil are already highly effective in terms of fostering renewable energy production, the engagement with stakeholders was more effective regarding the just transition dimension. Furthermore, this topic is gaining more evidence and relevance in the Brazilian climate agenda given its social unequal roots, which contributed to the interest of public and private stakeholders.

Including the just transitions perspective in this project has favored the engagement with key government stakeholders, such as the Ministry of Environment and Climate Change, the Ministry of Mines and Energy, and the Ministry of Foreign Affairs, whose interest in developing just transitions perspectives for Brazil were manifested throughout the project|. This engagement with key stakeholders culminated in the workshop “Diálogos para uma transição justa no Brasil” (Dialogues for a just transition in Brazil), which included the participation of the three ministries.

Not only did the workshop consolidate the engagement with the government and public sector, but it also provided a remarkable moment to establish a partnership network with other relevant stakeholders from different governance spheres, namely, the academy, private sector, civil society, and traditional communities, including Indigenous Peoples, Quilombolas, and others. All sectors participated in the workshop, totalizing 55 participants.

The workshop shed light on some of the participants' perceptions of the just transition in Brazil. Several insights stand out, including: the disbelief that a just transition is possible; the perception that just transition must ensure that existing inequalities are not exacerbated; the use of several terms to refer to "just transition"; the use of the term "energy poverty" as one of the existing consequences of an unjust transition; and the recognition that the concept of just transition in Brazil is different from international perspectives.

Three rounds of dialogues were conducted, providing an opportunity to discuss the subject deeper. In the first round, focused on the energy sector, questions were raised regarding relevant aspects of just energy transitions in the country, ways which sectors are impacted by or impact the just energy transition, and which policies and plans should be monitored to guarantee Brazilian energy transition to be just. The relevant aspects identified were grouped into five themes: i) justice and rights; ii) participation and governance; iii) sustainability; iv) jobs; and v) energy access/exclusion. Regarding the policies and plans to be monitored, responses were grouped into: i) decarbonization; ii) energy access/exclusion; iii) security; iv) participation; and v) rights of traditional peoples.

In the second round of dialogue, also focused on the energy sector but with representatives from different sectors mixed in groups, questions were posed regarding priority agendas, key challenges, and principles for a just energy transition. The identified priority agendas can be grouped into the following themes: i) energy access and/or exclusion; ii) renewable energies; iii) education; iv) participation and governance; v) impacts of the energy transition; vi) national autonomy; vii) alternatives for promoting a just energy transition; and viii) intersection of energy agendas with other sectors.

Contributions regarding challenges for the transition were organized into seven themes: i) energy access and/or exclusion; ii) equity; iii) economy; iv) energy security; v) corporatism; vi) participation and governance; and vii) job provision. Lastly, the fundamental principles for a just transition pointed out by the participants encompass a wide range of topics, from universal access to clean energy to national sovereignty, including issues of decentralization of generation, distribution of benefits, gender equity, popular participation, and technology transfer.

The third round of dialogue shifted the discussion focus to other sectors of the economy: agriculture; forests; industry; urban planning; waste management; and others. Once again, questions were posed regarding relevant aspects, challenges, and which policies and plans should be monitored. Overall, it can be observed that there are indeed sector-specific characteristics that must be taken into account in the transition to a low-carbon economy.

The Workshop “Diálogos para uma transição justa no Brasil” (Dialogues for a just transition in Brazil) is highlighted in this section given its impact on the project and the opportunities that arose since its implementation, which will be furthered explained in the next section.

3 Impacts of the project in the country

As explained, the project was structured into three axes that were intended to assess the potential expansion of variable renewable energy and biomass and the sustainable development impacts of this expansion, and to promote a stakeholder engagement to discuss those aspects. In addition, the project provided initial steps for the just transition planning in Brazil.

Regarding the assessment of the renewable electricity expansion, the analysis provided by the project shows that the country already has a policy framework and economic conditions that enable an expansion in line with a net zero target by 2050. The project’s deep decarbonization scenarios, DDS1 and DDS2, illustrated Brazil's potential path towards greater adoption of renewable electricity and reductions in power supply emissions. These results highlight the transition to variable renewable energy sources like wind and solar, alongside advancements in bioelectricity, grid flexibility, and storage technologies. These factors were identified as critical drivers in diversifying the electricity mix and decreasing reliance on fossil fuels. By comparing CPS and DDS scenarios, the project outlined potential routes to decarbonization, with DDS2 demonstrating a more aggressive shift towards renewables and substantial emissions reductions over time. This transition is underpinned by carbon pricing mechanisms, advances in renewable technologies, and strategic electricity infrastructure planning.

While Brazil's abundant renewable resources position the country likely to progress towards an even more sustainable electricity matrix, the project calls for a cohesive energy transition plan aligned

with comprehensive policy frameworks, infrastructure development, international cooperation, and financial support to achieve a resilient and sustainable power sector in Brazil.

Regarding the sustainable development impacts assessment, the project was the first attempt to make a structured assessment of SD impacts of renewable energy policies in Brazil. The results of the SD assessment of the regulatory framework for PVDG could put light on relevant aspects that need to be considered to maximize positive impacts and minimize the negative. Also, the assessment provided a valuable contribution to the just transition monitoring through the identification of main indicators.

One very relevant impact of the project in the country was the outcomes of the workshop "Diálogos para uma transição justa no Brasil" (Dialogues for a just transition in Brazil), which led to the proposal of an extension of the project, focused in addressing this issue and contribute to the just transition component of Plano Clima (Climate Plan) that is being coordinated by the Ministry of the Environment and Climate Change. The stakeholder workshop highlighted the growing interest in the topic of just transition in Brazil, not only from civil society but also from the government. This perception indicates the need for deeper discussions and the fact that there is room and a proper timing to align government climate planning with other policies focused in addressing urgent social issues.

The event gave room for discussion among different sectors and stakeholders that seem to be aligned with the perception that the energy transition in Brazil is far from being just and that this needs to be addressed, a position also advocated by the government. This alignment is considered to be positive given that such planning requires significant coordination efforts among various stakeholders. The stakeholders that participated in the workshop indicated a common understanding that Brazil's development needs to transition to a low-carbon economy, addressing social issues and mitigating the harm of these transitions. However, the workshop demonstrated that there is still no consensus on the paths, mechanisms, and tools that should be employed to ensure a just transition in the country. Thus, the topic needs to be further developed in the country, promoting a greater understanding of what constitutes a just transition and what needs to be done to achieve it.

The workshop presented itself as a starting point to discuss and plan just transitions in Brazil, with contributions of different sectors. It led to further conversations between CBC and the Ministry of Environment and Climate Change regarding the topic and the government effort to update its National Plan on Climate Change – Plano Clima. Plano Clima will be the main instrument to achieve national climate change objectives and Brazil's Nationally Determined Contributions (NDCs), to be updated by November 2024. It will cover the period between 2024 and 2035. The mitigation part will have national and sectoral targets for the years 2030 and 2035, and an outlook towards 2050.

This project has enabled the CBC to be recognized as a reference for just transition in Brazil, which has sparked the interest of ministries in having the CBC develop the cross-cutting axis of just transition for the Plano Clima. This culminated in the extension of this project to assess socio-economic impacts of Brazil's mitigation plans and develop the basis for a just transition roadmap. The ICAT Just Transition Project for Brazil will aim to support Brazil, under the guidance of its Ministry of Environment and Climate Change (MMA), to:

1. Assess the sustainable development and macroeconomic impacts of the proposed sectoral climate target and policies. This assessment will use the ICAT Sustainable Development Methodology and an existing modelling framework; and
2. Develop elements of a just transition strategy that can help address some of the potentially negative impacts identified. The strategy will have as a core an M&E framework with indicators to define the just transition and enable its monitoring.

The work plan of this project will be expanded to cover all relevant sectors, including: energy, transport, agriculture, land-use change, industry, and waste.

4 Lessons learned

Regarding axis (A), Output 5 has delivered important policy recommendations for unlocking the DDS scenario in Brazil. These recommendations, systematized, include strengthening political, legal, and regulatory frameworks; enhancing financial mechanisms; promoting new renewable electricity projects; investing in grid infrastructure; funding for research and development; balancing development with environmental and social impact; and global leadership. One key lesson to be considered in the next steps is that, while Brazil is already on the right path to achieve a net-zero scenario, balancing development with environmental and social impacts remains a crucial aspect.

Promoting a just transition that considers environmental protection and social impacts is essential. This includes stimulating local economies, creating jobs, and ensuring equitable distribution of clean electricity benefits. Leveraging Brazil's leadership roles in global forums like the G20 and hosting COP30 can position the country as a key player in the global energy transition. By advancing and expanding its renewable power mix, aiming to become a global energy hub, and setting an example in the energy transition, Brazil can move from a comparative advantage to a competitive edge in the global market.

Regarding axis (B) Sustainable development impacts of this expansion and first steps for just transitions, a remarkable lesson learned was the applicability of the ICAT Sustainable Development Methodology to assess the impacts of public policies of the Brazilian energy sector on just transition.

Even though some insights from ICAT's Methodology on Managing Transparency of Just Transitions, which is currently under development, were considered during the assessment, the study of the ICAT Sustainable Development Methodology enabled the technical team to expand the methodology to understand just transition impacts on Brazil. In fact, some of the insights from the Workshop "Diálogos para uma transição justa no Brasil" (Dialogues for a just transition in Brazil) were used as a reference in the ICAT's Methodology on Managing Transparency of Just Transitions, indicating the usefulness of the SD methodology to address just transitions' issues. This lesson was of great value, since the methodology will be used in the project extension.

Regarding axis (C) Partnership with stakeholders, a notable lesson learned is related to the approach to stakeholder engagement. It was identified that stakeholders do not typically respond well to surveys, especially extensive ones that require a significant time investment. This challenge was recognized early in the project, during the preparation of Output 6 "Report 'Defining the objectives, policy framework, impact categories, and indicators for the sustainable development assessment'." To overcome this obstacle, bilateral meetings with key stakeholders were conducted to validate the selected impact categories and indicators for assessment, as well as to identify other important stakeholders for the project.

Another relevant lesson learned was the engagement with the government and ministries. The third phase of the project began in 2023, a transition year for the government in Brazil. The new government elected in 2022 was committed to restructuring ministries and resuming projects, leading to a busy agenda and difficulty in meeting with representatives. This obstacle was overcome by finding common ground on the topic of just transition, which was of great relevance to the ministries. This allowed CBC to engage with the federal government and even have the participation of three ministries in the workshop conducted.

Finally, the team has gained experienced with ICAT Sustainable Development Methodology and has developed assessment skills while implementing the project. This lesson learned is of great importance as the ICAT Sustainable Development Methodology will be used in the extension of the project and the experienced gained will be foundational to the success of the next phase of ICAT project.

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