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Abstract

At least ten Latin American and Caribbean countries have pledged to achieve carbon neutrality. Has electricity planning in the region evolved towards reaching these goals? We compare power generation capacity in 2023 to announced plans in 2019. We then estimate committed emissions from existing and planned power plants – that is emissions that would result from the normal operations of these plants during their typical lifetime – and compare them to emissions from power generation in published IPCC scenarios. We find that fossil fuel planned capacity has decreased by 47% since 2019, mainly due to the cancellation of 50% of coal and 40% of gas projects, compared to an increase of 24% of renewable energy projects. But existing plants in the region will emit 6.7 $GtCO_2$ during their lifespan, and if all planned plants are built, they will add 4.9 $GtCO_2$, totaling 11.6 $GtCO_2$, exceeding median carbon budgets for 1.5 and 2°C-consistent IPCC pathways (2.3 and 4.3 $GtCO_2$). Natural gas power plants are the largest contributor to existing (62%) and planned (75%) emissions (versus 24% and 23% for coal). We evaluate emissions reduction strategies to achieve carbon budgets. Assuming no new coal plants comes into operation, announced gas and oil projects are canceled at the same rate as in the past four years, all fossil fueled plant lifetimes are reduced by 10 years, and all new natural gas displaces existing coal, committed emissions fall by 67%, meeting the 2°C budget, but still twice as large as the median 1.5°C budget. Our results suggest that while progress is being made, energy planning in the region is not yet consistent with global climate goals as reflected by the IPCC scenario database.

Keywords: Renewable energy transition, decarbonization policy, carbon budget analysis, stranded assets, climate mitigation scenarios, climate policy alignment.

JEL: Q1; Q4; Q5; Q54; Q56; Q58

1. Introduction

Decarbonizing electricity generation is critical to reaching a net-zero emissions economy and stabilizing climate change (Audoly et al., 2018; Azevedo et al., 2021; Bistline and Blanford, 2021; Clarke et al., 2022; DeAngelo et al., 2021). Carbon-free electricity can reduce emissions directly, as power generation is responsible for almost 24% of greenhouse gases (GHG) emissions globally (Dhakal et al., 2022), and indirectly, as the electrification of energy use in transport, buildings, and low heat industry sector would reduce emissions from these sectors that emit 40% of GHG globally (Dhakal et al., 2022)

Despite promising growth in renewables, the power sector is still the largest source of greenhouse gas emissions growth globally (IEA, 2023). Around 1,250 GW of fossil fuel capacity is being built or planned for the next few years globally, exceeding the current installed capacity of Europe and North America (Global Energy Monitor, 2022). Putting this capacity into operation could place climate goals at risk.

Since the seminal paper by Davis & Socolow (2014), many studies have compared *committed emissions* from existing and planned energy infrastructure – that is emissions that would result from the normal operations of these plants during their typical lifetime – against global carbon budget estimates. Most conclude that committed emissions from existing and proposed energy infrastructure globally exceeds the carbon budget consistent with limiting temperature to 1.5°C (Pfeiffer et al., 2018; Tong et al., 2019). To meet the temperature targets of the Paris Agreement, significant reductions in plant use and early retirements of coal and gas plants are thus necessary (Cui et al., 2019; Shearer et al., 2020).

At the same time, countries are making pledges to decarbonize. Between 2019 and July 2023, countries comprising 88% of global emissions and over 92% of global GDP have committed to achieve net-zero GHG emissions (Lang et al., 2023). Have net-zero pledges resulted in changing energy planning?

We ask this question for the case of Latin America and the Caribbean.[1] This developing region has the cleanest electricity mix in the world, as close to 60% percent of its electricity comes from renewable sources (OECD et al., 2022). The region is also increasingly considering investing in natural gas to power economic growth and provide firm energy when droughts threaten the reliability of hydropower (Estrada et al., 2022; Global Energy Monitor, 2022). At the same time, at least ten countries in the region have set net-zero targets, most of them for 2050 (Lang et al., 2023). Are these pledges influencing investment plans in the power sector?

[1] This study was funded by the Inter-American Development, a multi-lateral development bank that focuses on the region.

We start from the Power Plant Tracker database from ENERDATA (2023a), which provides information on installed capacity, fuel type, age, status, and commissioning year of existing and planned power plants. We compare the current planned capacity with 2019 data from the same database, described in González-Mahecha et al. (2019). We also assess committed emissions from operational and planned fossil-fueled power plants. Finally, we compare committed emissions with carbon budgets that limit the global average temperature increase to 1.5°C and 2°C for the Latin America and Caribbean power sector, published in the IPCC Sixth Assessment Report and the IPCC Special Report on Global Warming of 1.5°C (Huppmann, Rogelj, et al., 2018; Riahi et al., 2022).

We find that power planning in the region is shifting towards renewable energy. From 2019 to 2023, nearly 41% of planned fossil fuel capacity was canceled, compared to only 32% of renewable energy capacity. Furthermore, planned fossil fuel capacity declined by 47% between 2019 and 2023, while planned renewable energy capacity increased by 20%.

But our results suggest that power planning in the region might not yet be consistent with Paris goals. In our baseline scenario, we find that, if used for the duration of their typical lifetime, existing coal, natural gas, and oil generators will emit 6.7 GtCO2 between 2023 to 2057, when the final generator ceases operation. Building planned generators would add 4.9 GtCO2 of committed emissions, for a total of 11.6 GtCO2. When compared to the median carbon budgets in the IPCC database (2.3 and 4.3 GtCO2), these findings suggest that if climate goals are to be achieved, 36% to 66% of existing fossil-fueled power plants in the region may need to be closed early, or the utilization rate of existing power plants may need to be reduced to the same effect.

Finally, we explore different emissions reduction strategies and conduct a sensitivity analysis to assess how uncertain factors might affect our results. Just one of the scenarios we simulate reduce emissions enough to meet the median 1.5°C or 2°C carbon budgets in IPCC databases. Our lowest-emission scenario slightly reaches values below meets 2°C median values: it considers a future where no new coal plant is added, gas and oil projects are canceled at the rate seen over the past four years, and the lifetime of existing and future fossil fuel power plants is shortened 10 years below our baseline assumption. In this scenario, emissions reach values below the median 2°C budget by only 0.5 GtCO2eq.

Our results should be interpreted with caution. The Power Plant Tracker database from ENERDATA suffers from inconsistencies and limitations. The scenarios collected by the IPCC are also imperfect. For instance, many pathways assume reforestation from the region will play a large role in meeting global emission targets, at odds with evidence on the feasibility to do so (Dumas et al., 2022).[2] Nonetheless, our results reinforce previous findings about the

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[2] Also, the period we focus on, 2019 to 2023, was marked by the global pandemic. This has probably lead to more power plants being cancelled than would have been otherwise, but it is not clear

importance of aligning energy and climate planning in the region (Bataille et al., 2020) and preparing an orderly transition to a net-zero-consistent energy system, minimizing the social and economic consequences of downsizing fossil fuel power plants (Feng et al., 2023; Quirós-Tortós et al., 2023; Saget et al., 2020; Semieniuk et al., 2022).

The rest of the paper is structured as follows. Section 2 presents the methods and data. Section 3 provides results. Section 4 discusses those results and concludes.

2. Methods and data

2.1. Carbon emissions per generator from ENERDATA

We define committed emissions as those that will occur over the remaining lifespan of a fossil-fuel-burning electric generator. We focus on generators, defined as devices that generate electrical power for use in an external circuit. A plant consists of one or more generators. We estimate annual emissions per generator by decomposing CO_2 emissions *F* (tCO_2/yr) as the product of capacity *C* (GW), utilization rate *E/C* where E is electricity output (GWh/yr), and carbon intensity of electricity generated F/E (tCO2/GWh). We assume utilization rates and carbon intensities to be constant over time. To make the most of the data available, each quantity is computed per country *i*, fuel *f,* and status *s.*

$$F_{i,f,s} = C_{i,f,s} \times \left(\frac{E_{i,f}}{C_{i,f}}\right)_s \times \frac{F_{i,f}}{E_{i,f}}$$

We take net capacity from the Power Plant Tracker database from ENERDATA (ENERDATA, 2023a) in February 2023. The database includes details for each generator: country, type of fuel, commissioning year, status, net capacity, energy production, decommissioning year, type of technology (for different fuels) and load factors. The statuses include *announced, authorized, bidding process, under construction, cancelled, frozen, mothballed, operational, stopped, submitted, suspended construction,* and *synchronized.* We group under the label "planned" generators with statuses of announced, authorized, submitted, bidding process, and under construction. Those labeled "planned" do not currently emit carbon dioxide but will do so starting at their commission date. We group operational and synchronized units already emitting carbon dioxide under the label "existing". We group under the "canceled" label plants with statuses of canceled, frozen, mothballed, stopped, and suspended construction.

The database reports 5,203 fossil-fuel-based generators for Latin America and the Caribbean (coal, natural gas, or oil), of which 4,369 are existing generators and 287 are planned in February 2023. The Power Plant Tracker does not provide a commissioning year for all

whether this has affected relatively more renewable power plants or fossil fuel power plants on average.

generators. To fill this gap, we use the average year at the country, fuel type, and unit status levels.

We track 6 different fossil power plant types: coal, oil, and 4 technologies of natural gas power plants: Combined Cycle Gas Turbine, Combustion Engine, Gas Turbine, and Steam (Table 1). We add detail in gas power plant types because gas plays a predominant role in both existing and planned power plants, but new technologies have significantly lower carbon intensities than the ones represented in the stock of existing plants. Each technology is characterized by a carbon intensity of electricity and a typical utilization rate. We calibrate utilization rates of existing power plants per country and technology based to match 2019 rates. For planned power plants, we calibrate the utilization rate using regional averages by technology (Table 1).

We compute the carbon intensity of electricity produced using each fuel and technology using the heat rate (thermal energy per unit of electricity generated) of the plant and the emission factor of the fuel, derived from the U.S. Energy Information Administration (see Table 1 and appendix A).

The Power Plant Tracker does not report the electricity output production for all generators. It reports 184 TWh, only 27% of the 688TWh output in 2019 reported in national statistics (ENERDATA, 2023b) – see Appendix B. We complete electricity output for each generator using average generation per country and fuel, then scale up production from all plants to match what is reported in national statistics, assuming no bias in reporting. In two countries, the generation obtained from summing the data in the Power Plant Tracker is greater than the data reported in the national statistics. For those cases, we scale down electricity output linearly to match the production.

The Power Plant Tracker covers 18 Latin America and the Caribbean countries in the region,[3] which accounted for 93% of emissions from power generation in 2019 (ENERDATA, 2023b). We create an aggregate “rest of Latin America and the Caribbean,” to which we assign, for each fuel, the difference between the total reported for Latin America and the Caribbean and the sum of emissions from all countries reported.

We then project emissions for the remaining lifetime of each generator. For our central estimate we assume the lifetime of power generators to be 37, 35, and 32 years for coal, natural gas, and oil following Davis and& Socolow (2014). For the 294 generators currently operating beyond these lifetime (appendix I), we assume an extended useful life of 5 more

[3] Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

years, following Davis & Socolow (2014). The Power Plan Tracker also reports the age of decommissioned plants (table 1), which we use in a sensitivity analysis.

Table 2 Global and Regional lifetimes, utilization rates and average carbon intensity of electricity generation by fuel

Fuel Type	Technology	Average lifetime	Average age of decommissioned plants	Utilization rate	Carbon Intensity (gCO2 /kWh)
Natural Gas	Combined Cycle Gas Turbine	35	22	59%	402
	Combustion Engine			19%	471
	Steam			31%	548
	Gas Turbine			25%	582
Oil		32	21	13%	759
Coal		37	29	47%	961

2.1. Transition of planned energy matrix in the short term

We compare the status of energy capacity in our February 2023 data to a snapshot of the Power Plant Tracker in January 2019 from Gonzáles-Mahecha et al. (2019), by country and fuel type. based on the unit's name, plant and country in the databases and achieve a match above 97% capacity for all statuses. We estimate cancellation rates as the proportion of the total planned capacity in January 2019 that had been canceled by February 2023. We compute of sensitivity committed emissions are to cancellation rates.

2.1. IPCC carbon budgets for Latin America and the Caribbean

The carbon budget represents the total amount of CO_2 that can be emitted in the future while limiting global warming to a given temperature target (IPCC, 2018). We estimate carbon budgets from the AR6 Scenario database (Byers, Edward, et al., 2022). In these scenarios, we look at carbon emissions from power generation in Latin America and the Caribbean (R5LAM region in the database).

The AR6 uses eight scenario categories grouped by their likelihood of meeting different temperature targets (Shukla et al., 2022). We consider all the pathways that limit temperatures to 1.5°C to 2°C. To compute gross carbon budgets, we use two variables from the IPCC database: CO_2 emissions from electricity supply, which represents net emissions from energy supply emissions, and the separate carbon sequestration in the electricity supply from bioenergy with carbon capture and storage (BECCS), which is the negative component of net emissions. We evaluate gross CO_2 emissions as the sum of net CO_2 emissions from electricity supply and carbon sequestration from BECCS. We exclude the simulations that do not report CO2 sequestration potential from BECCS. We compute gross carbon budgets as cumulated CO2 emissions for the period 2023 to 2064 and compare with committed emissions.

The AR6 also categorizes scenarios into levels of concern considering feasibility dimensions. Indeed, many pathways assume deep levels of carbon dioxide removal such as CCS on fossil fuel power plants, BECCS, or afforestation (Pathak et al., 2022). But it has been argued that the potential of these solutions is much lower than most scenarios assume, as most models misrepresent constraints on land use and practical and economic limitations to retrofitting fossil fuel power plants with CCS (Creutzig et al., 2021; Hanssen et al., 2022). The IPCC thus defined thresholds on the use of these solutions by 2050 (Table 2). We label “feasible” the scenarios that do not exceed these medium level of concern thresholds, and “consistent” those who do.

Table 3 IPCC feasible dimensions (Guivarch et al., 2022)

Indicator	Computation	2050 threshold
Fossil CCS scale-up	Amount of CO2 captured in a given year	3.8 Gt CO2/year
BECCS scale-up	Amount of CO2 captured in a given year	3 Gt CO2/year
Afforestation and reforestation	Decadal percentage increase in forest cover	3.6 Gt CO2/year

In a sensitivity analysis, we compare carbon budgets from the AR6 with those from the IPCC’s Special Report of Global Warming of 1.5°C (Huppmann et al., 2018).

3. Results

3.1. Transition of Planned Capacity between 2019 and 2023

We compare planned capacity in January 2019 to operational capacity in February 2023 to assess the direction in which the electricity mix is shifting in Latin America and the Caribbean (appendix C shows regional transition results). In 2019, total planned capacity was 364 GW, comprising 102 GW of fossil-fueled plants (28%) and 261 GW (72%) of renewable energy plants. By 2023, 35% of total capacity was canceled (126 GW), 13% came into operation (46 GW,) and 49% remained under planned status (177 GW). The remaining 4% have been removed from the database or lack updated status information. Figure 1 shows planned net capacity in 2019 by 2023, by status and energy type.

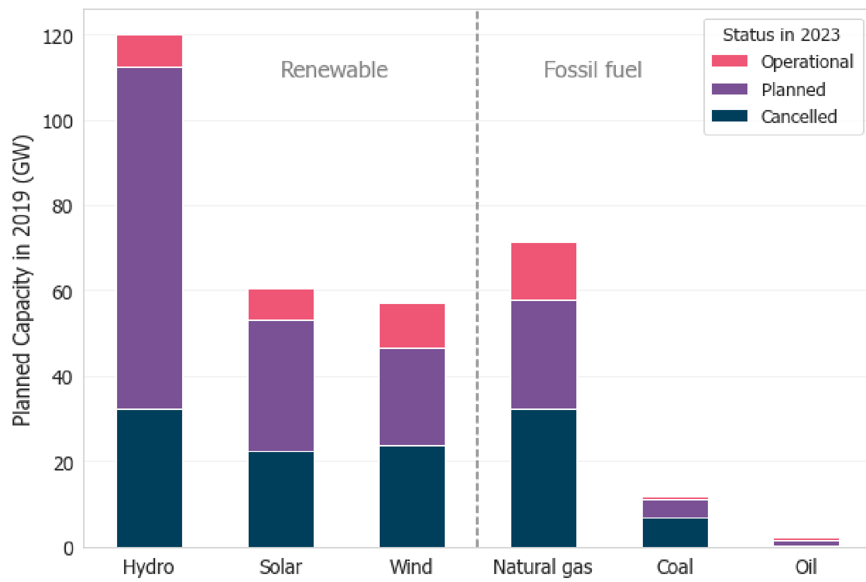

Figure 1 Planned capacity in 2019 by status in 2023, per fuel.

Of planned fossil fuel capacity in 2019 (102GW), 41% had been canceled (42 GW) by 2023. Over 80% of the canceled capacity, 34 GW, comes from Brazil, mostly natural gas. Only 17% (17 GW) of planned fossil fuel capacity in 2019 came into operation by 2023, mainly natural gas (15 GW). In the case of planned coal, more than 50% (7 GW) was canceled, mostly from Brazil and Chile, with 4.5 GW and 2.2 GW, respectively. This trend is consistent with the global tendency for coal, with proposed capacity declining by over 60% worldwide between 2016 and 2021 (Edwards et al., 2022). Still, Dominican Republic, Brazil, and Chile turned into operation 1.5 GW of coal in the last four years.

The planned renewable energy capacity in Latin America and the Caribbean in 2019 was 261 GW, comprising hydropower (123 GW), solar power (72 GW) and wind power (66 GW). Of total planned capacity, 32% had been canceled by 2023 (84 GW); 11% came into operation (29 GW); and 54% remains planned. Of total canceled planned capacity for renewable energy, 39% corresponds to hydropower. Brazil contributes 82% of total canceled planned capacity for renewable energy.

At the same time, Brazil leads the entry into operation of renewable energy, adding 14.6 GW, followed by Mexico with 7.3 GW and Chile and Argentina with 2.6 GW each. Together, these countries contribute 93% of the renewable energy capacity that has come into operation in the region.

Planned fossil-fuel capacity has declined 47% over the past four years, from 102 GW in 2019 to 54 GW in 2023 in the region. Meanwhile, planned renewable energy capacity has increased by 24%, from 261 GW in 2019 to 324 GW in 2023. Planned wind and solar power has increased 73% since 2019, however, planned hydroelectric capacity has decreased by 30% since 2019, from 123 GW to 86 GW.

Almost all countries are reducing planned fossil fueled capacity and increasing renewables (appendix D shows changes in planned capacity by country). Few countries increased their planned fossil fuel capacity relative to 2019 levels. Four countries (El Salvador, Jamaica, Panama, and Venezuela) still have more than half of their planned capacity based on fossil fuel; they account for only 4% of the total planned capacity for the region. Mexico has the most planned fossil fuel capacity, with 25% of the fossil fuel planned capacity for Latin America and the Caribbean; but even there, planned fossil fuel capacity has decreased over the last four years, by 37%.

3.2. Committed emissions of existing and planned generators.

In Latin America and the Caribbean, existing fossil-fueled generators comprise 186 GW of installed capacity. Most existing power plants are natural gas plants (134 GW), followed by oil (18 GW) and coal (9.6 GW). Mexico and Argentina lead in existing natural gas capacity, with 53 GW and 25 GW, respectively. For oil, Brazil and Mexico lead with an operating capacity of 9.8 GW and 6.7 GW, respectively. And Mexico and Chile have the highest coal operating capacity with 5.9 GW and 4.4 GW.

Natural gas represents 85% of planned fossil-fueled capacity, followed by coal (12%) and oil (3%). Mexico and Chile lead planned capacity for natural gas with 13.4 GW and 6.8 GW, respectively. For coal, Colombia and Chile have the most planned capacity with 4.2 GW and 0.8 GW; and for oil, Chile, and Brazil lead with 0.8 GW and 0.5 GW, respectively.

We find that continued operation of existing generators would result in 6.7 $GtCO_2$ emissions over their remaining lifetime. (The last existing power plants in our simulation closes in 2057.) Figure 2 shows committed emissions by country and fuel type for existing power plants (appendix E shows this data in a table). Most committed emissions from existing generators come from natural gas (62%), followed by coal (24%) and oil (13%). Mexico, Brazil, and Argentina account for 60% of committed emissions from existing power plants.

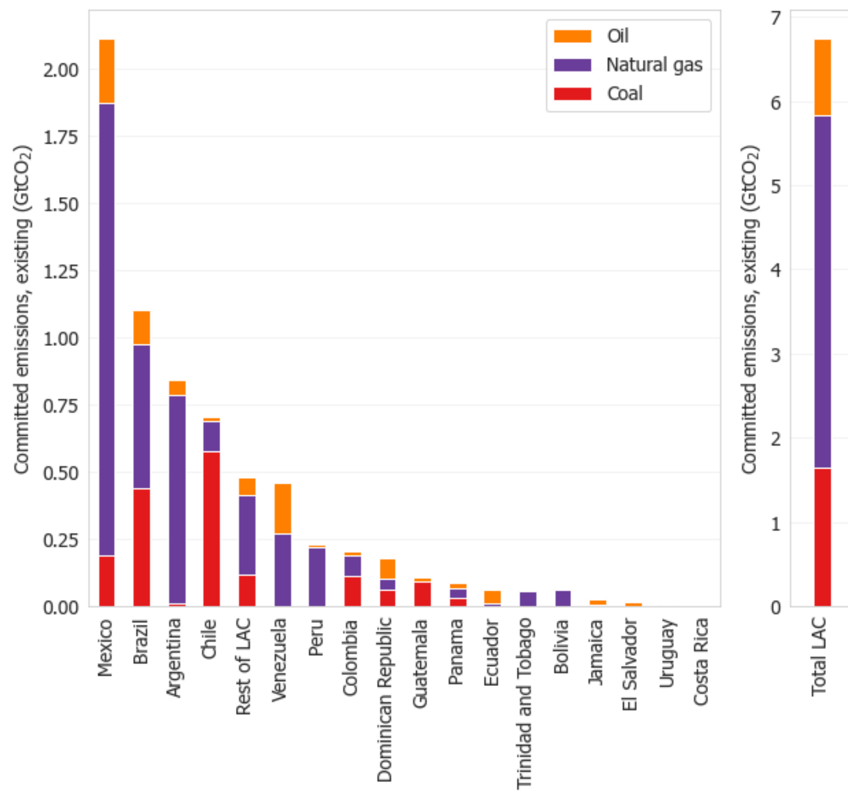

Figure 2 Committed emissions from existing power plants by country and fuel (2023-2057).

Committed emissions from planned power plants add 4.9 GtCO2 by 2064, when the last planned plant would be decommissioned (Figure 3). Most committed emissions from planned generators come from natural gas (75%), followed by coal (23%). Over 58% of committed emissions for planned power-plants would come from Mexico, Colombia, and Chile with 1.09, 1.02, and 0.7 GtCO2, respectively.

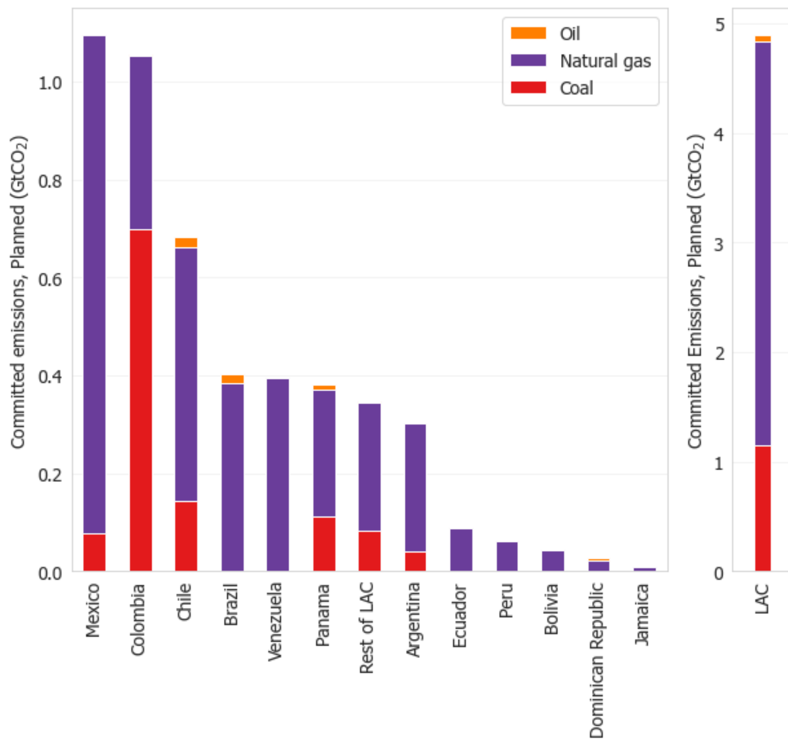

Figure 3 Committed emissions from planned power plants by country and product (2023-2064).

The project pipeline in Panama and Colombia are particularly carbon-intensive compared to their existing stock. If Colombia builds all the planned fossil-fueled power plants listed in the Power Plant Tracker database from ENERDATA (2023a), it will increase committed emissions in 521%, relative to emissions from existing plants. In Panama, committed emissions would increase 433%. Emissions would more than double in Ecuador (138%). In the rest of the region, planned power plants would increase emissions 49% compared to existing plants.

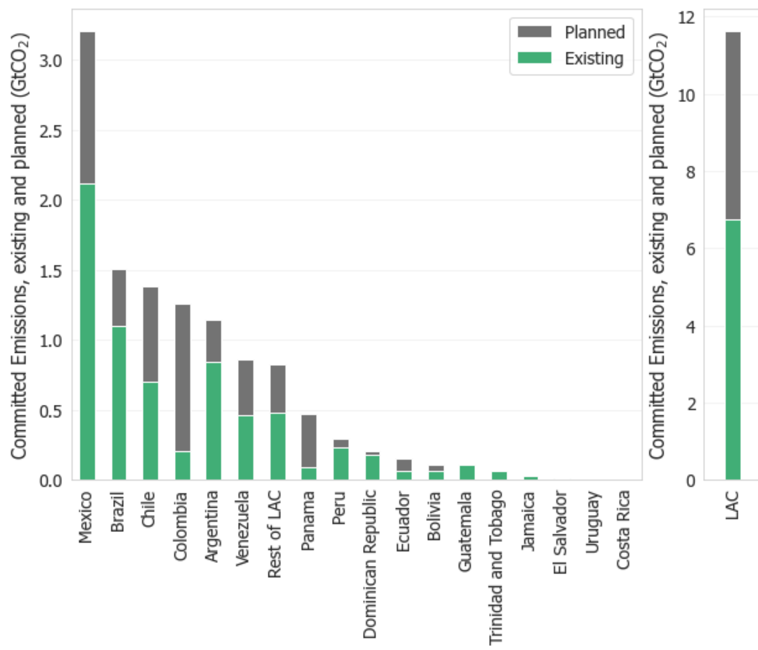

Figure 4 Committed emissions from existing and planned power plants by country (2023-2063).

If existing power plants continue to operate and planned plants come into operation for the duration of their expected lifespans, committed emissions would rise to 11.6 GtCO2 (Figure 4). Committed emissions come mainly from natural gas (7.9 GtCO2) followed by coal (2.8 GtCO2). In absolute terms, the countries with the highest committed emissions would be Mexico (3.2 GtCO2), Brazil (1.5 GtCO2), and Chile (1.4 GtCO2).

3.3. Compatibility of committed emissions with remaining IPCC carbon budgets

Figure 5 shows gross carbon budgets for Latin America and the Caribbean power sector, in "feasible" and "consistent" 1.5°C and 2°C pathways from the AR6 database. Estimated carbon budgets consider emissions between 2023 and 2064, at which point existing and planned plants are expected to cease operation. In the scenarios compatible with 1.5°C, gross carbon budgets range from -2 to 12.2 GtCO2, with a median value of 2.3 GtCO2. In the scenarios compatible with 2°C, gross carbon budgets range between 0.8 to 18.1 GtCO2, with a median value of 4.3 GtCO2. Some carbon budgets resulted in negative emissions, although we considered gross emissions by removing BECCS emission captures from the net emissions of energy supply, some models consider other CCS technologies captures.

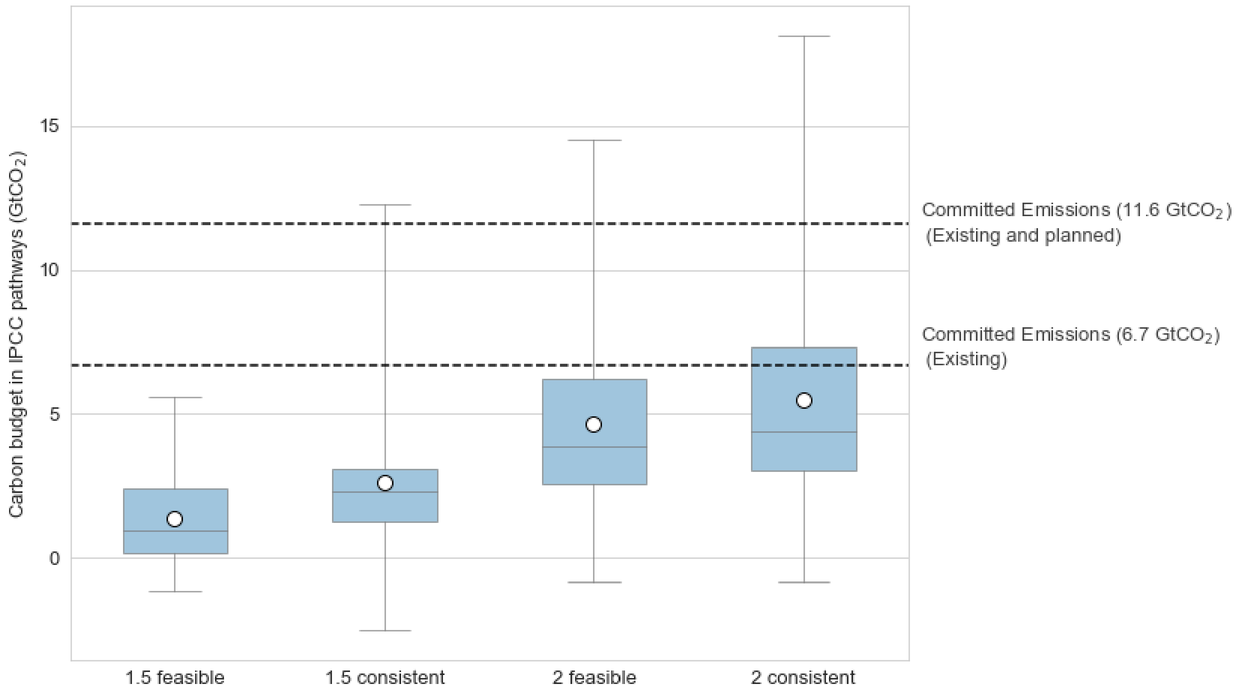

Figure 5 Carbon budget ranges from IPCC AR6 WGIII 1.5°C and 2°C pathways (2023-2064). "Consistent" contains all scenarios. "Feasible" contains only the scenarios that make a moderate use of carbon dioxide removal (section 2.1). Dashed lines show committed emissions for existing and planned power plants. The central line in the boxplot shows the median budget; white circles show mean values; the rectangle shows the interquartile range; whiskers show full range.

Table 3 summarizes gross carbon budget ranges and median values for climate stabilization categories. Committed emissions from existing fossil-fueled power plants (6.7 GtCO2) are thus within the interquartile range of carbon budgets consistent with 2°C target, within the top 25% budget for 2°C pathways that considers medium levels of concern in the use of CCS, BECCS and afforestation ("2 feasible") and the top 4% for 1.5°C but falls outside range of any 1.5°C feasible pathways in the IPCC database.

Conversely, if all planned power plants were built, total committed emissions (11.6 GtCO2) would fall outside ranges for the 1.5°C feasible subsets, and 99% of the 1.5°C consistent, 97% of 2°C feasible and 93% of 2°C consistent subsets of gross carbon budgets, surpassing median values.

Table 3 IPCC AR6 Carbon Budgets statics for 1.5°C and 2°C scenarios.

Category	**Number of scenarios**	**Carbon Budgets Range (GtCO2)**	**Median Value for 2023-2064 Gross Carbon Budget (GtCO2)**	**Committed Emissions from existing and planned plants) (GtCO2)**
1.5°C feasible threshold	37	[-1.1 – 5.6]	**1.05**	11.6
1.5°C consistent	165	[-2 – 12.2]	**2.3**	

2°C feasible threshold	133	[-0.8 – 14.5]	**3.9**
2°C consistent	351	[-0.8 – 18.1]	**4.3**

One way to align with the 1.5°C and 2°C climate goals is to avoid the construction of new fossil-fueled power plants and to retire existing plants early. We find that roughly 36% to 66% of existing generators in Latin America and the Caribbean would need to be closed prematurely or will need to reduce the utilization rate to the same effect for temperature targets to be met. This risk will increase as more fossil-fueled power plants come into operation, jeopardizing the achievement of climate goals.

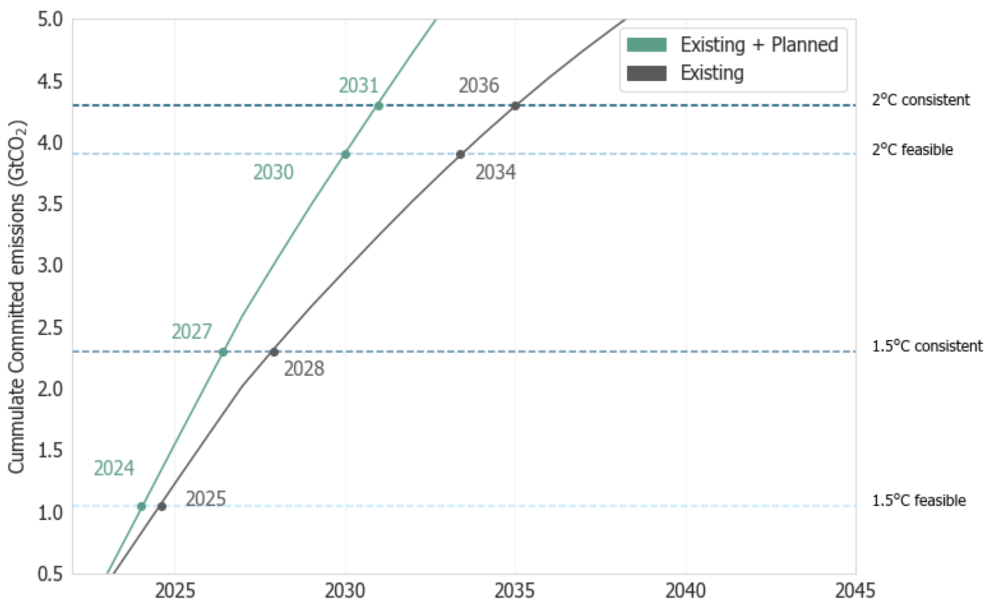

Figure 6 Cumulative committed CO_2 emissions in Latin America and the Caribbean power sector with the median values of carbon budgets from the emissions pathways reported in AR6 IPCC report (dashed lines).

Figure 6 shows the year when committed emissions would hit median carbon budget values for scenarios compatible with 1.5°C and 2°C. If no additional power plants come into operation, existing fossil-fueled plants should cease operation before 2028 to meet the 1.5°C carbon budget.

We assess how estimates of carbon budgets have changed since the publication of the IPCC Special Report of Global Warming of 1.5°C (SR1.5) emissions database. Median values are higher in SR1.5, for both 1.5°C and 2°C consistent subsets (see appendix F). While 66% of existing fossil-fueled power plants would need to reduce utilization rates or close prematurely to meet the median 1.5C budget from AR6, only 13% of existing plants would need to close prematurely meet the SR1.5 budget. For 2°C consistent pathways, 36% of existing fossil-fueled power plants would be at risk of being retired early to comply with the carbon budget we compute from AR6, compared to 13% for the SR1.5 carbon budget.

3.4. Sensitivity analysis and options to reduce future committed emissions.

We conduct a sensitivity analysis and evaluate emissions reduction strategies to achieve climate goals (Figure 7). Scenario (a) presents our baseline results. In scenario (b), we apply the same cancellation rates to planned capacity as the one implicit when comparing the proportion of total capacity planned in 2019 that was cancelled by 2023 (from section 3.1, details by country in appendix G). Scenario (c) additionally cancels all new coal plants, which seems realistic in the region.[4] In Scenario (d), we additionally use lifetimes estimated from the age of decommissioned power plants, which are about 10 years lower than our central assumption (Table 1). Finally, in scenario (e) we also assume that all new gas plants displace the same amount of existing coal power generation.

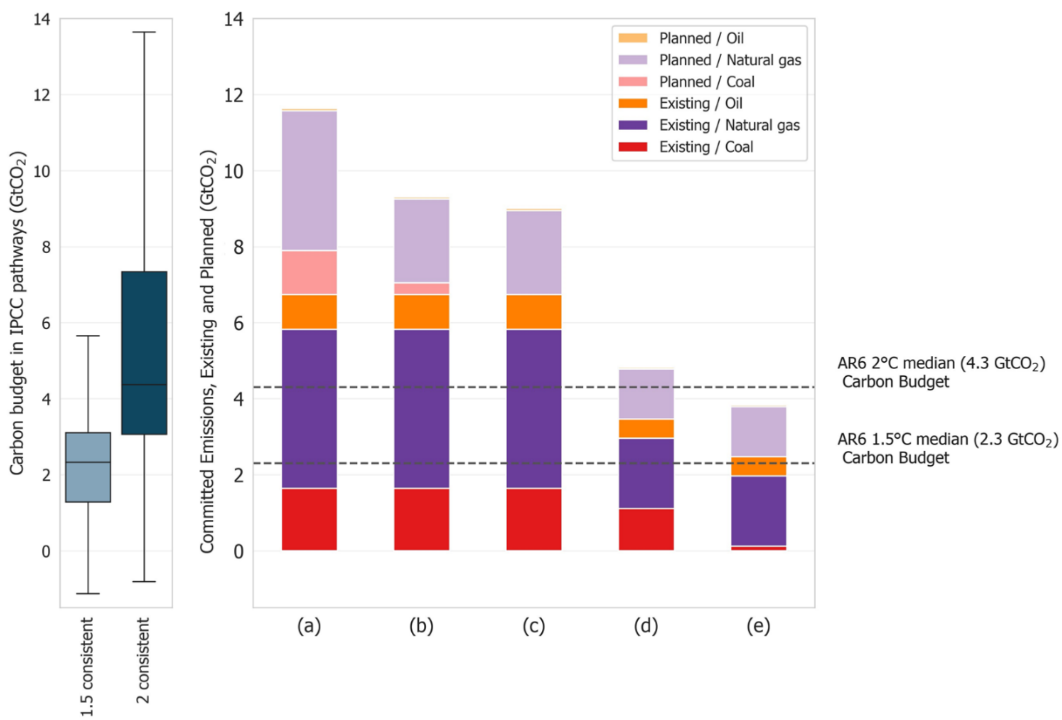

Figure 7 Sensitivity analysis of committed CO_2 emissions from existing and planned power plants in 5 scenarios (2023-2064) and median values for carbon budgets in IPCC pathways. Scenario (a) Committed emissions baseline assumptions, Scenario (b) Committed emissions considering cancellation rates, Scenario (c) Committed emissions considering (b) assumptions and excluding planned coal plants, Scenario (d) Committed emissions considering (c) assumptions and regional lifespan, Scenario (e) Committed emissions considering (d) assumptions, and closing old coal power plants, as natural gas power plants come into operation. Dashed lines stand for median gross carbon budgets values for 1.5°C

[4] While the Power Plant Tracker lists planned coal plants in the region, we manually reviewed each unit and found evidence that they are likely to be cancelled (appendix H).

and 2°C of Latin America and the Caribbean power generation computed from the emission pathways reported in AR6 IPCC report.

If planned capacity is cancelled as in the last four years (scenario b), committed emissions from existing and planned plants drop to 9.3 $GtCO_2$, 20% lower than our baseline estimates. Banning new coal (c) would reduce committed emissions to 9 $GtCO_2$, 23% below our baseline estimate. Assuming shorter lifetimes (d) effectively reduces them to 4.8 $GtCO_2$, 59% below our baseline estimate, and below our baseline estimate of committed emissions from existing power plants alone (6.7 $GtCO_2$). This may not be easy to do, a significant fraction of fossil-fueled plants currently in operation exceed these lifespans (appendix I). Finally, phasing out coal early as new gas is built reduces committed emissions to 3.8 $GtCO_2$, 67% below our baseline estimate.

If all planned power plants are built (scenario a), 63% and 88% would need to be stranded to meet the average allowable carbon budgets for 2°C and 1.5°C respectively. Even in the most ambitious scenario (e 47% of power plants need to be closed to meet 1.5°C. In 2019, Gonzáles-Mahecha found that 52%-55% of planned and existing power plants would need to be stranded to meet median carbon budgets from the Special Report on 1.5 °C. Since then, the IPCC issued the AR6 report, with much smaller carbon budget estimates (appendix F). This is the main reason we find the higher risk of 63% to 88%, despite progress in transitioning to renewable electricity.

4. Discussion and conclusion

Latin America and the Caribbean are making progress in transitioning towards a carbon free power system. In 2023, fossil fuels comprised only 14% of planned capacity, down from 28% in 2019.

Our simulations find that committed emissions from existing and planned power plants are still larger than median carbon budgets from the IPCC scenario database. To reduce emissions faster, energy planners in Latin America and the Caribbean may shorten the operational lifetime of natural gas and coal power plants and avoid adding new ones. Even if new natural gas power plants are built to replace older and dirtier coal power plants, we find that doing so would add more committed emissions than what the median carbon budgets for 1.5°C and would reach slightly lower values for the 2°C carbon budgets of in IPCC scenarios suggest would be consistent with meeting the temperature targets of the Paris Agreement.

One interpretation of our results is that they confirm previous findings that adding fossil fuel power plants puts climate goals at risk (Achakulwisut et al., 2021). That conclusion would be consistent, in particular, with the repeated findings summarized in IPCC and UNFCCC reports that the global temperature targets are extremely challenging to meet. We have already passed 1.1°C and limiting warming to 1.5°C would require unprecedented changes to energy and food systems globally. Some readers will also find our paper to be reminiscent of literature that points that the climate impact of natural gas is underestimated. Previous papers have found that methane emissions from leaks in the energy system have been strongly underestimated in the last years (MacKay et al., 2021; Weller et al., 2020; Zavala-Araiza et al., 2021). Considering methane leaks, replacing old coal with new gas plants may not achieve much for climate change (Shearer et al., 2020).

Another takeaway from our results, not necessarily contradictory with the previous one, is that IPCC scenarios can only imperfectly inform policymakers about what a reasonable carbon budget is. Indeed, doing so is complex, for at least two reasons. One is that any way of splitting a global carbon budget by region will inevitably look like a burden-sharing exercise, inherently contingent on subjective valuations and political considerations. This is even while there is a growing corpus of evidence forming that suggests emission reductions can be beneficial to countries that undertake them – counterbalancing the burden sharing view (Fazekas et al., 2022; World Bank, 2023).

The second reason is that IPCC carbon budgets for the power sector depend crucially on assumptions made about the feasibility of large-scale carbon removals based on reforestation. While IPCC scenarios, that energy models from the global north play an important role in shaping, tend to assume that doing so at scale in Latin America is a low-hanging fruit, studies focused on modeling tradeoff between different land uses tend to have sobering results in this regard (Dumas et al., 2022; Searchinger et al., 2023).

Either way, without proper planning, the transition towards decarbonization can put energy security at risk and vice versa (Afonso et al., 2021; Ramirez et al., 2020; Slameršak et al., 2022). Our results reinforce previous findings on the importance of aligning energy and climate planning and preparing for the social and economic consequences of downsizing fossil fuel power plants (Bataille et al., 2020; Feng et al., 2023; Quirós-Tortós et al., 2023; Saget et al., 2020; Semieniuk et al., 2022).

5. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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7. Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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9. Appendices

A. Heat Rate and Emission Factor of fuels

Table A.1 Heat Rate and emissions factor of fuels ()

	Heat rate	*Emission Factor of Fuels*	*Heat rate*	*Carbon intensity*
	Btu/KWh	Kilograms CO2/Mbtu	MBtu/KWh	gCO2/kWh
CCGT	7600	52.91	0.0076	402
Combustion Engine	8900	52.91	0.0089	471
GT	11000	52.91	0.011	582
Steam	10350	52.91	0.01035	548
Oil	10236	74.14	0.010236	759
Coal	10002	96.1	0.010002	961

B. Fossil-fuel-based generation in 2019 (TWh)

Table B.1 Fossil-fuel-based generation in 2019 (TWh)

COUNTRY	PRODUCT	COUNTRY DASHBOARD	POWER PLANT TRACKER	MISMATCH BETWEEN PPT AND COUNTRY DASHBOARD
ARGENTINA	Coal	1.26	0.36959	71%
Argentina	Natural gas	91.004	76.11017	16%
Argentina	Oil	3.447	1.696119	51%
Bolivia	Natural gas	6.334	5.25375	17%
Bolivia	Oil	0.087	0.087366	0%
Brazil	Coal	21.309	11.04505	48%
Brazil	Natural gas	60.448	23.6825	61%
Brazil	Oil	10.224	4.33116	58%
Chile	Coal	28.134	12.53922	55%
Chile	Natural gas	15.865	1.992521	87%
Chile	Oil	1.17	0.130502	89%
Colombia	Coal	8.162	7.22258	12%
Colombia	Natural gas	13.165	7.31066	44%
Colombia	Oil	2.725	0.31153	89%
Costa Rica	Oil	0.096	0	100%
Dominican Republic	Coal	2.515	0	100%
Dominican Republic	Natural gas	5.077	0	100%
Dominican Republic	Oil	10.325	0	100%
Ecuador	Natural gas	1.39	0.80163	42%
Ecuador	Oil	5.662	1.86061	67%
El Salvador	Oil	1.756	1.711609	3%
Guatemala	Coal	4.063	3.072402	24%
Guatemala	Oil	1.628	0.395531	76%
Jamaica	Natural gas	0.936	0	100%
Jamaica	Oil	3.001	0	100%
Mexico	Coal	25.976	0	100%
Mexico	Natural gas	193.178	0	100%

Mexico	Oil	45.349	0	100%
Panama	Coal	1.069	0	100%
Panama	Natural gas	2.812	2.716307	3%
Panama	Oil	1.625	0.707781	56%
Paraguay	Oil	0.002	0	100%
Peru	Coal	0.156	0.036149	77%
Peru	Natural gas	21.771	17.78534	18%
Peru	Oil	0.697	0.253361	64%
Trinidad and Tobago	Natural gas	9.148	0	100%
Trinidad and Tobago	Oil	0.035	0	100%
Uruguay	Natural gas	0.123	0.250293	-103%
Uruguay	Oil	0.163	0.023625	86%
Venezuela	Natural gas	21.298	0	100%
Venezuela	Oil	14.135	0	100%

C. Transition Matrix for Unit status from 2019 to 2023

Table C.1 Transition matrix for unit status from 2019 to 2023

		FOSSIL FUELED	Renewable	Total
Capacity in 2019	Planned	102.4	261.2	363.6
Status in 2023	Planned	36.6	140.1	176.7
	Operational	17.2	29.1	46.3
	Cancelled	41.9	83.6	125.5

D. Changes in planned capacity in electricity mix by country between 2019 and 2023

Table D.1 Changes in planned capacity in electricity mix by country between 2019 and 2023

	Changes in Planned Fossil-fuel Capacity (GW)		Planned Renewable Energy Capacity (GW)	
Countries	Δ2023-2019	Δ%	Δ2023-2019	Δ%
Argentina	-2.0	-35%	-0.1	-1%
Bolivia	-1.0	-56%	-1.0	-8%
Brazil	-38.3	-87%	34.9	36%
Chile	-2.3	-21%	25.6	86%
Colombia	5.3	150%	14.0	87%
Costa Rica	0.0	0%	0.0	0%
Dominican Republic	-0.8	-64%	0.4	166%
Ecuador	1.0	1299%	0.3	2%
El Salvador	0.0	0%	-0.2	-29%
Guatemala	0.0	0%	-0.1	-14%
Jamaica	-0.6	-85%	0.0	-61%
Mexico	-8.4	-38%	-12.4	-42%
Panama	-1.6	-25%	-0.2	-4%
Paraguay	0.0	0%	0.7	35%
Peru	0.0	2%	3.8	11%

Trinidad and Tobago	0.0	0%	0.1	0%
Uruguay	0.0	0%	0.1	16%
Venezuela	0.0	0%	-2.2	-73%

Table C.2 Changes in operational capacity in electricity mix by country between 2019 and 2023

	Operational Fossil-fuel Capacity (GW)		Operational Renewable Energy Capacity (GW)	
	Δ2023-2019	Δ%	Δ2023-2019	Δ%
Argentina	2.4	9%	10.8	43%
Bolivia	1.0	57%	0.8	39%
Brazil	3.3	12%	121.7	14%
Chile	0.0	0%	10.8	46%
Colombia	0.9	18%	12.2	11%
Costa Rica	0.0	0%	2.8	0%
Dominican Republic	0.4	11%	0.9	43%
Ecuador	0.1	2%	5.3	-2%
El Salvador	0.0	0%	0.7	35%
Guatemala	-0.2	-13%	1.6	10%
Jamaica	0.2	19%	0.2	19%
Mexico	9.3	16%	20.7	51%
Panama	-0.1	-6%	2.2	16%
Paraguay	0.0	-6%	8.8	0%
Peru	-0.4	-5%	5.6	7%
Trinidad and Tobago	0.0	1%	0.0	0%
Uruguay	0.0	0%	3.3	0%
Venezuela	0.0	0%	15.5	0%

E. Committed emissions of the operational and planned power plants by country.

Table E.1 Committed emissions of the operational and planned power plants by country.

Country	*Plant / Fuel*	*Committed Emissions (MtCO2eq)*
Argentina	Planned / Oil	0.522708
Argentina	Existing / Coal	9.688817
Argentina	Planned / Coal	39.89303
Argentina	Existing / Oil	57.09077
Argentina	Planned / Natural gas	262.1914
Argentina	Existing / Natural gas	776.3205
Bolivia	Existing / Oil	1.099286
Bolivia	Planned / Natural gas	42.54021
Bolivia	Existing / Natural gas	62.50635
Brazil	Planned / Oil	17.10692
Brazil	Existing / Oil	129.0672
Brazil	Planned / Natural gas	384.516
Brazil	Existing / Coal	441.4193

Brazil	Existing / Natural gas	533.0842
Chile	Existing / Oil	15.46695
Chile	Planned / Oil	22.07983
Chile	Existing / Natural gas	111.6985
Chile	Planned / Coal	142.95
Chile	Planned / Natural gas	517.8541
Chile	Existing / Coal	576.7757
Colombia	Planned / Oil	2.786686
Colombia	Existing / Oil	11.07239
Colombia	Existing / Natural gas	79.03656
Colombia	Existing / Coal	112.7843
Colombia	Planned / Natural gas	355.5628
Colombia	Planned / Coal	698.1114
Costa Rica	Existing / Oil	0.872387
Dominican Republic	Planned / Oil	4.900386
Dominican Republic	Planned / Natural gas	21.77131
Dominican Republic	Existing / Natural gas	41.54346
Dominican Republic	Existing / Coal	61.21211
Dominican Republic	Existing / Oil	77.55372
Ecuador	Existing / Natural gas	12.25373
Ecuador	Existing / Oil	52.1891
Ecuador	Planned / Natural gas	89.15478
El Salvador	Existing / Oil	13.75369
Guatemala	Existing / Oil	11.19395
Guatemala	Existing / Coal	94.68601
Jamaica	Existing / Natural gas	7.600137
Jamaica	Planned / Natural gas	7.781383
Jamaica	Existing / Oil	17.0248
Mexico	Planned / Oil	0.032669
Mexico	Planned / Coal	76.54476
Mexico	Existing / Coal	191.4543
Mexico	Existing / Oil	237.6758
Mexico	Planned / Natural gas	1018.78
Mexico	Existing / Natural gas	1684.348
Panama	Planned / Oil	8.986329
Panama	Existing / Oil	21.15933
Panama	Existing / Coal	32.88046
Panama	Existing / Natural gas	33.92251
Panama	Planned / Coal	113.0303
Panama	Planned / Natural gas	258.9065
Peru	Existing / Coal	1.799352
Peru	Existing / Oil	10.82037
Peru	Planned / Natural gas	60.87252
Peru	Existing / Natural gas	216.6469
Rest of LAC	Planned / Oil	4.323559
Rest of LAC	Existing / Oil	65.2593

Rest of LAC	Planned / Coal	82.04297
Rest of LAC	Existing / Coal	116.6963
Rest of LAC	Planned / Natural gas	261.7414
Rest of LAC	Existing / Natural gas	298.0365
Trinidad and Tobago	Existing / Natural gas	59.24806
Uruguay	Existing / Natural gas	1.645541
Uruguay	Existing / Oil	2.221846
Venezuela	Existing / Oil	193.268
Venezuela	Existing / Natural gas	269.0453
Venezuela	Planned / Natural gas	395.3762

F. Carbon budgets in different IPCC scenarios and databases

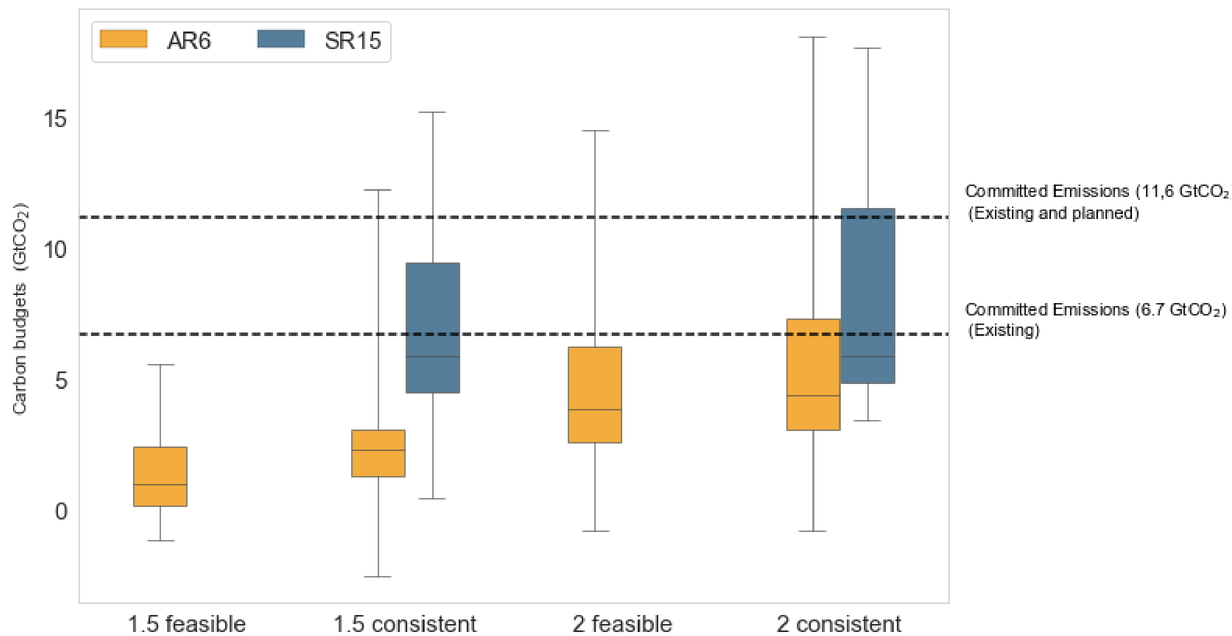

Figure F.1 Carbon Budgets in different IPCC scenarios and databases

G. Cancellation rates of planned capacity (between 2019 and 2023)

Table G.1 Cancellation rates of planned capacity (between 2019 and 2023)

Product	Status	Country	% of 2019 planned capacity canceled
Coal	Announced	Chile	100%
Coal	Authorized	Brazil	100%
Coal	Authorized	Chile	60%
Coal	Authorized	Panama	55%
Coal	Bidding process	Brazil	100%
Natural gas	Announced	Brazil	100%
Natural gas	Announced	Mexico	36%

Natural gas	Authorized	Brazil	3%
Natural gas	Authorized	Jamaica	100%
Natural gas	Authorized	Mexico	12%
Natural gas	Bidding process	Brazil	89%
Natural gas	Under construction	Mexico	7%
Oil	Authorized	Brazil	1%
Oil	Authorized	Panama	25%
Oil	Bidding process	Brazil	100%
Oil	Under construction	Brazil	6%

H. Countries with Planned coal listed on the Power Plant Tracker.

Chile: Member of Powering Past Coal Alliance (PPCA, 2023), and has issued a government back plan to close down all existing power plants (Feng et al., 2023) .

Colombia: The 2021-2034 expansion plan does not consider coal-fired power plants (Unidad de planeación Minera Energética, 2020a). The government committed to reach net-zero emissions by 2050, and the energy ministry found that this requires closing all thermoelectric plants by 2035 (Unidad de planeación Minera Energética, 2020b)

El Salvador: Member of Powering Past Coal Alliance (PPCA, 2023)

México: Member of Powering Past Coal Alliance (PPCA, 2023)

Panamá: A study indicates that in the alternative scenario (which it aspires to achieve), an installed coal capacity of 200MW is expected, and it currently has 420MW, so it should decrease (Secretaría Nacional de Energía, 2015). In the expansion plan, Central Carbonera is mentioned as a possible installation of the plant after 2033.

I. Fraction of existence at a certain age of existing power plants by fuel type from Power Plant Tracker

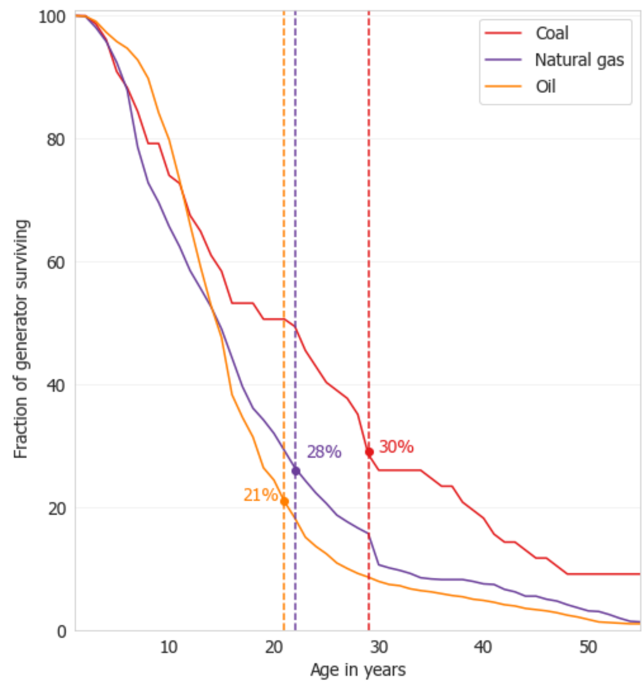

Figure H.1 Fraction of existence at a certain age of existing power plants by fuel type from Power Plant Tracker. Dashed lines indicate mean lifespan for the region from retired plants. Dots indicate the percentage of plants above estimated regional lifespan.