AtkinsRéalis

PATH-Aligned Decarbonisation Plan for CELEC EP

European Investment Bank

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CELEC EP DECARBONISATION PLAN

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Executive Summary

Corporacion Electrica del Ecuador (hereafter "CELEC EP") is Ecuador's National Power Company. It is responsible for the generation, transmission, and distribution of electricity across the country. CELEC EP is responsible for up to 90% of the country's power generation and it plays a critical role in ensuring the reliability of the national grid, which supports various sectors including industry, residential, and commercial. CELEC EP are committed to sustainability and reducing their carbon emissions. To support this ambition and to meet the European Investment Bank's (EIB) funding requirements, this document outlines the Decarbonisation Plan for CELEC EP in line with the EIB's Paris Alignment of Counterparties (PATH) framework[1].

Adherence to the EIB's PATH framework is accepted where company decarbonisation plans are aligned to leading independent organisations, such as the Transition Pathway Initiative (TPI) and as such, directly support the objectives of the Paris Agreement. The TPI provides emissions-intensity benchmarks for carbon-intensive sectors including electricity utilities[2], derived from the International Energy Agency (IEA)'s economy-energy model. These benchmarks reflect the range of ambition and economic variances, including target pathways specific to power generation assets that seek to limit global warming at well-below 2°C and 1.5°C, as reflected in the Paris Agreement. CELEC EP's Decarbonisation Plan takes reference from these TPI models in focusing on an emissions intensity pathway, as well as aligning to the PATH requirements through including mid- and long-term targets, driving for carbon neutrality by mid-century.

Current Emissions Baseline

In 2024, CELEC EP's total direct Scope 1 Greenhouse Gas (GHG) emissions amounted to 5,049,210 tCO_2e, with 99.9% attributed to power generation activities, primarily from the combustion of fuel oils in thermal power plants (stationary combustion). Of the total Scope 1 emissions, 4,998 tCO_2e (0.1%) was associated with CELEC EP's use of their vehicle fleet (mobile combustion). The company's operations also involve the use of high-GWP gases such as sulphur hexafluoride (SF_6), however any fugitive emissions from these gases are not currently being captured in the company's emissions inventory.

It is noted that Scope 2 emissions are not relevant as CELEC EP captures all losses from electricity transmission within their Scope 1 emissions; however, reduction in transmission and distribution losses will reduce Scope 1 emissions, therefore these assets are included in the Decarbonisation Plan. Scope 3 (indirect emissions across the value chain) were not in scope for this Decarbonisation Plan, which instead focuses on CELEC EP's core operations.

CELEC EP generated 25,600 GWh of electricity in 2024, with 73.8% coming from hydropower, 25.9% from thermal power plants, and the remaining 0.3% from wind generation. The average GHG intensity for thermal generation during this period was 0.761 tCO_2e/MWh, whilst the company-wide intensity stood at 0.197 tCO_2e/MWh.

A Business-as-Usual (BAU) scenario was modelled to project how baseline emissions are expected to evolve over time based on the company's existing financial commitments. Under the BAU scenario, including CELEC EP's current financial commitments, the company's emissions were projected to rise by 35.3% reaching 6.83 million tCO_2e by 2050.

Increased Generation Scenario

As well as committed projects in the BAU, CELEC EP has plans to increase the generation capacity further, initially through commissioning additional thermal power plants up to 2027, as well as commissioning additional

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[1] European Investment Bank, 2022, The EIB PATH Framework. Available at: https://www.eif.org/news_centre/publications/the-eib-grouppathframework-v1-2-en.pdf

[2] Transition Pathway Initiative, 2021. Available at: TPI Electricity Utilities Reference Pathways

hydropower, geothermal and solar renewable power plants up to 2041. The total increase in generation capacity amounts to a 183% increase on the baseline, reflecting the expectation of higher electrification of many sectors of the economy as Ecuador shifts away from reliance on oil, to meet its climate targets. The increase in generation also responds to recent reliability concerns with the power grid, with major recent droughts impacting the availability of hydroelectric power, causing blackouts in 2024.

This proposed capacity increase is captured in a future generation scenario, whereby CELEC EP's emissions would peak at 8.84 million tCO_2e in 2030 and remain at this level to 2050. In this increased generation scenario, the emissions intensity will peak in 2027 and 2029, with the highest value of 0.257 tCO_2e/MWh; however, the prolonged addition of new renewable generation capacity in the subsequent decade would gradually reduce the emissions intensity to a value of 0.122 tCO_2e/MWh from 2041 onwards.

Decarbonisation Pathway

The Decarbonisation Pathway builds on the BAU and subsequent increased generation scenario, outlining how CELEC EP plans to further decarbonise their operations, illustrated in Figure 0-1. CELEC EP has committed to a phased decarbonisation strategy that outlines a range of short-term (to 2027), medium-term (to 2035), and long-term (to 2050) carbon reduction measures. These interventions are modelled in the Decarbonisation Pathway and projected to significantly reduce the emissions intensity by 2050, falling from the baseline of 0.197 tCO_2e/MWh to 0.077 tCO_2e/MWh by 2050, reflecting a cleaner and more efficient energy mix.

The most impactful measures from the decarbonisation strategy include:

- Conversion of plants from Open Cycle Gas Turbines (OCGT) to Combined Cycle Gas Turbines (CCGT), utilising waste heat from the gas turbine to generate additional electricity through a steam turbine.
- Improve energy efficiency of plants through audits, alignment to ISO50001 and a more effective real-time monitoring with digital controls
- Implement a loss monitoring strategy for the transmission network through pinpointing inefficiencies such as overloaded lines, aging equipment, or inefficient power factors in order to start defining improvement plans.
- Further replacement of emissions-intense fossil-fuel thermal plant with renewable generation.

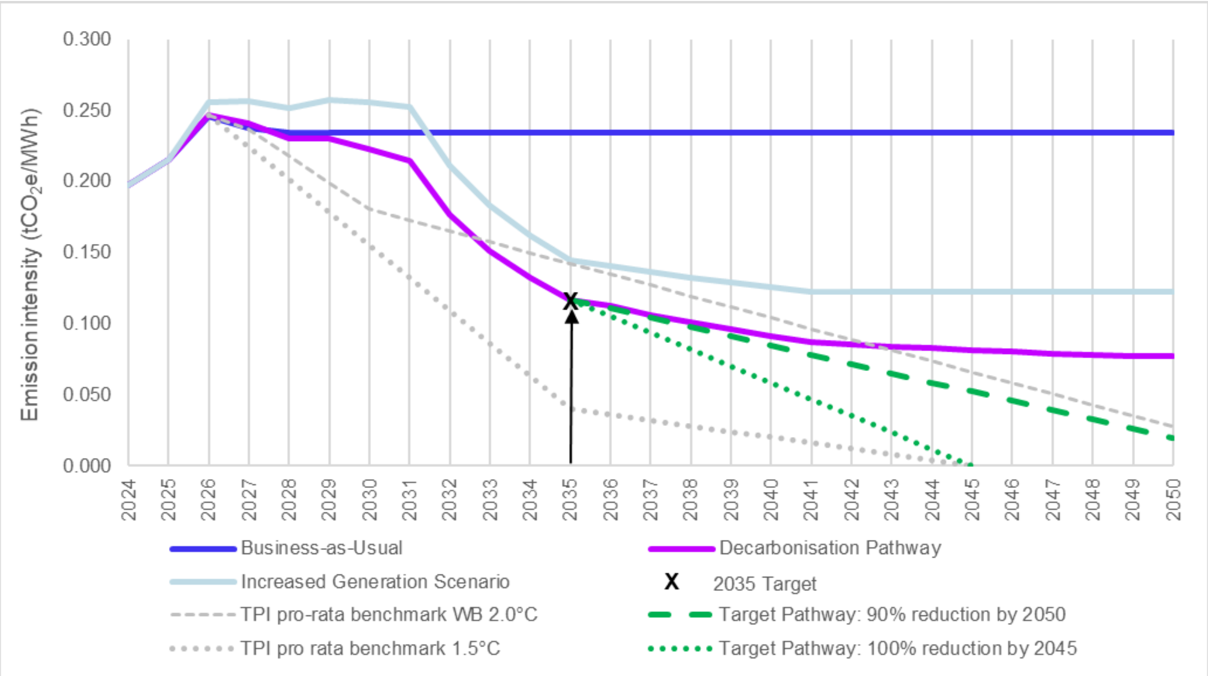

Figure 0-1 - Decarbonisation Pathway of CELEC EP's Emissions Intensity to 2050

To drive alignment with CELEC EP's Decarbonisation Pathway and the EIB PATH framework, a mid-term target and long-term target pathway have been identified (also shown on Figure 0-1), as follows:

- 40% reduction in emissions intensity by 2035, to achieve a target of 0.118 tCO_2e/MWh
- 90% reduction in emissions intensity by 2050, with associated emissions intensity target of 0.020 tCO_2e/MWh

These targets are selected to fall below the TPI well-below 2°C benchmark (based on the maximum BAU energy intensity value, which is less than the non-OECD reference). An alternative more ambitious target pathway is also represented to illustrate the reduction needed to achieve 100% reduction and meet the TPI 1.5°C benchmark.

The medium-term target is realisable through full implementation of the Decarbonisation Plan, which is modelled to reach 0.117 tCO_2e/MWh by 2035. The achievement is considered likely as it is anticipated some of the renewable power capacity will replace fossil-fuel thermal plants, where currently they are modelled to be additional.

To align to the long-term pathway and further, to reach carbon neutrality, CELEC EP will need to go beyond the level of interventions modelled. This is expected to be achieved in future years through a more structured phase-out of fossil-fuel-based thermal plants, as alternative low carbon technologies such as geothermal, PV with battery energy storage, biofuels or hydrogen and small scale modular nuclear reactors become more readability available and feasible for Ecuador's landscape. A regular review of CELEC EP's Decarbonisation Pathway is proposed at least at 5-yearly intervals, where the opportunities for further longer-term carbon reductions can be reviewed.

Overall, CELEC EP's Decarbonisation Pathway represents a technically feasible and operationally pragmatic approach to decarbonisation with a core focus on the mid-term target, leveraging mature technologies and scalable solutions relevant to the current context of CELEC EP's operations. In the long term, further decarbonisation will be required through consideration of wider technologies as they become economically and technologically feasible. In delivering this Decarbonisation Plan, through the provision of increasingly lower carbon electrical power, CELEC EP can play a pivotal role in Ecuador's transition to a low-carbon energy future.

1. Introduction

1.1 Project Summary

CELEC EP, Ecuador's National Power Company, is responsible for electricity generation and transmission nationwide. Operating under the Ministry of Environment and Energy, CELEC EP manages a portfolio of hydropower, wind and thermoelectric plants that according to the country's National Electricity Operator (Centro Nacional de Control de la Energía, CENACE) generate between 80 and 90 percent of all electricity in the country. Their purpose is to ensure a stable and reliable national grid, serving industrial, residential and commercial sectors. Formed in 2010 through the merger of six state-owned entities – five generation companies and one transmission company – CELEC EP also engages in energy trading, project development, research, operation and the maintenance of systems outside the National Interconnected System. These functions are detailed in CELEC EP's official website[3].

CELEC EP's vision is to be recognised as Ecuador's leading energy provider, noted for its technical excellence, transparency, financial strength, skilled workforce and business innovation[4]. Aligned with the country's Electricity Master Plan (2023 - 2032)[5] which is periodically updated, CELEC EP prioritises sustainability and the critical role of the power sector in driving national GHG emissions reduction. It has implemented major infrastructure projects to enhance national electricity supply while expanding the use of renewable energy, particularly hydroelectric power. CELEC EP is also working to better understand its climate impact and to design a target-based Decarbonisation Plan.

AtkinsRéalis have been commissioned by the EIB to develop a Decarbonisation Plan for CELEC EP to drive emissions reductions in line with the Bank's Paris Alignment of Counterparties (PATH) framework[6]. This requires the Decarbonisation Plan to incorporate and publicly disclose the mid-term quantified emission reduction targets and long-term plan to achieve carbon neutrality by mid-century, motivated within the context of CELEC EP's technical, economic and geographic environment.

1.2 Document Purpose

This Decarbonisation Plan provides full context to the pathway modelled for CELEC EP by AtkinsRéalis, including baseline emissions and BAU baseline trajectory, as well as future decarbonisation interventions. The information and content presented within this document can be adapted and used by CELEC EP to communicate and publicly disclose their Decarbonisation Plan and the actions they will take to achieve their carbon reduction targets.

This document incorporates the following key sections:

- CELEC EP organisational context;
- A summary of CELEC EP's GHG emissions baseline for 2024;
- The BAU scenario, showing the projected emission trajectory considering the company's financial commitments as of July 2025;

[3] CELEC EP (n.d.) La Empresa. Available at: https://www.celec.gob.ec/la-empresa

[4] CELEC EP (n.d.) Misión y Visión. Available at: https://www.celec.gob.ec/mision-y-vision/

[5] CELEC EP (2024) Plan Maestro del Electricidad 2023-2032. Available at: https://www.recursosyenergia.gob.ec/plan-maestro-de-electricidad

[6] European Investment Bank, 2022, The EIB PATH Framework. Available at: https://www.eib.org/en/publications/20230343-the-eib-group-path-framework-v1-2

- GHG emission reduction interventions, along with proposed high-level enablers for decarbonisation and associated Decarbonisation Pathway; and
- Mid-term emission reduction target, providing a quantitative benchmark, as well as long-term GHG reduction options, outlining a potential pathway to achieve carbon neutrality by 2050.

1.3 Context

1.3.1 Regulatory Drivers

Paris Agreement

The Paris Agreement, the world's most significant international treaty to combat climate change, is a critical driver for global GHG emissions reductions and commitments. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) on 12 December 2015 and it's overarching goal is to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels".

To meet these targets, the Paris Agreement calls for a "balance between anthropogenic emissions and removals in the second half of the century", introducing the principle of net zero into international climate policy. Following the Paris Agreement, the IPCC's 2018 Special Report on 1.5°C clarified that achieving this temperature goal requires global net zero CO_2 emissions by around 2050. This scientific framing transformed net zero from an abstract concept into a concrete benchmark for climate action.

Ecuador Nationally Determined Contribution

Ecuador's regulatory and policy context regarding GHG emissions is shaped by both international and national commitments. Through the country's second National Determined Contribution (NDC) published in 2025, Ecuador has reaffirmed its commitment to contribute to the achievement of the objectives set by the Paris Agreement (2015) and the United Nations Framework Convention on Climate Change (UNFCCC).

Ecuador's NDC covers the country's plans from 2026 to 2035 in the energy, industry, agriculture, land use, and waste sectors. Ecuador's unconditional commitments are to reduce its GHG emissions by 7% from their BAU scenario created in 2010. Additionally, the country has a conditional commitment for a further 8% reduction subject to international cooperation and support[7].

Ecuador Climate Policy

The 2024 National Climate Change Mitigation Plan of Ecuador (PLANMICC) was developed by the Ministry of Environment, Water and Ecological Transition (Ministerio de Ambiente, Agua y Transición Ecológica, MAATE) and defined a long-term strategy for decarbonisation to 2070. This strategy considers emissions from energy, agriculture, LULUCF, residues and industrial processes and includes projections to 2070 for each sector and its constituent parts including increased electricity generation, improvement in energy efficiency and the development of a hydrogen industry.

On 14 August 2025, Executive Decree No. 94 ordered the merger by absorption of the Ministry of Environment, Water, and Ecological Transition (MAATE) into the Ministry of Energy and Mines (MEM), creating the new Ministry of Environment and Energy, integrating MAATE as a vice ministry. The MAATE is additionally developing NDC

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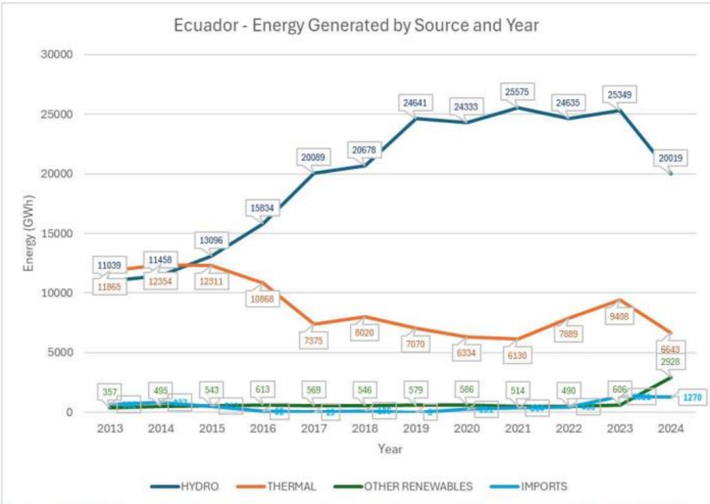
[7] República del Ecuador (2025) Segunda Contribución Determinada a Nivel Nacional. Available at: https://unfccc.int/sites/default/files/2025-02/Segunda%20NDC%20de%20Ecuador.pdf

targets for 2030 and 2035 and has published a National Plan for Adaptation to Climate Change (2023), with goals identified to 2027.

In 2024, the Ministry of Energy and Mines launched an updated Electricity Master Plan (2023 – 2032) [8], setting out a strategy for investment in generation, transmission and distribution. This plan sets out 1,290MW investment to 2029 to replace and repower old power stations at the end of their life. From 2030, electricity expansion is achieved by hydropower from mega projects in the Southern Amazon basin.

1.3.2 Economic and Environmental Context

Ecuador has a population of approximately 18 million and whilst it has experienced significant growth of 10% over the last decade, the growth rate is slowing, estimated at 0.85% in 2025[9]. The population growth historically drove a rise in total energy demand, with energy emissions increasing by approximately 10% from 2012 to 2022. and electricity capacity increasing by 62% over the same period[10], albeit stabilising from 2019, as illustrated in Figure 1-1 below.



Source: Ministerio de Energía y Minas. Balance Energético Nacional 2023 (2024); CENACE. Informe Anual 2024 (2025); own calculations

Figure 1-1 – Ecuador's Historical Electrical Generation Breakdown

Ecuador's economy has a high reliance on oil for revenue. Oil exports, accounted for 7.5% of GDP in 2023, or 25% of total exports[11]. This dependence on oil results in high economic instability due to the impact of variation in global oil pricing, as well as wider future challenges to this income stream, due to the global energy transition and shift to lower carbon economies.

Ecuador's power generation has a relatively high percentage of renewable sources (mainly hydropower), which accounted for 73.8% of generation for CELEC EP in 2024 (as illustrated in Section 2.2). Future climate commitments, as outlined in the PLANMICC, include reducing Ecuador's reliance on oil, and will require significant increase in electrical capacity to meet future energy needs. This is estimated to represent an electrical capacity increase of ~50% by 2030 and ~150% by 2050, as reflected in CELEC EP's increased generation plan, outlined in Section 3.1.

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[8] CELEC EP (2024) Plan Maestro del Electricidad 2023-2032. Available at: https://www.recursosyenergia.gob.ec/plan-maestro-de-electricidad

[9] Country Statistics from Worldometer. Available at: Ecuador Population (2025) - Worldometer

[10] NDC Aspects Country Report: Transition Pathways for Ecuador (EU Horizon funded) 2024. Available at D5.2 - Ecuador country fiche.pdf

[11] International Monetary Fund (MF Library) 2024. Available at: IMF Reducing Vulnerabilities to Global Energy Transition in Ecuador

In parallel to the increase in electrical demand, Ecuador is highly vulnerable to impacts of climate change, with increasing critical weather events causing extreme drought and impacting availability of hydropower, evidenced by the nationwide power outages of 2024[12]. It is noted therefore that a minimum firm reserve capacity will be required to cover years of low water potential and retain flexibility and reliability of the power system. In the short term this is likely to comprise fossil fuel power plants. This need for reliable and independent power supply is exasperated by the variety and remoteness of much of the Ecuadorian landscape and the distances between the generation centres and where the energy is required, which spans the Amazon jungle, the Andean highlands and extends to remote islands including the Galapagos.

This economic and geographic backdrop is reflected in the forward projection of CELEC EP's GHG emissions through the proposed Decarbonisation Pathway. This context is furthermore referenced to establish motivation for the decarbonisation targets and alignment to the EIB's PATH framework.

1.3.3 EIB Drivers

As the EU climate bank and a public institution, the EIB Group is committed to support its clients to transition towards a low-carbon and climate-resilient future: in other words, to align their operations over time with the goals and principles of the Paris Agreement.

As set out in the EIB's Climate Bank Roadmap (CBR)[13], the principal way in which the EIB Group can advance this transition is through the provision of finance and advisory services to invest in Paris-aligned projects and operations. The CBR, approved in November 2020, provides a clear interpretation of alignment in the context of EIB Group projects and products. The EIB Group wishes to support specific investments after gaining a clear understanding of the counterparty's plan to transition to a low-carbon and climate-resilient future.

The EIB energy lending policy[14], describes how focusing on long-term energy investment represents an ambitious challenge, and thus the Bank will phase out support to energy projects reliant on unabated fossil fuels. This implies that the Bank will phase out support to (i) the production of oil and natural gas; (ii) traditional gas infrastructure (networks, storage, refining facilities); (iii) power generation technologies resulting in GHG emissions above 250 gCO2 per kWh of electricity generated, averaged over the lifetime for gas-fired power plants seeking to integrate low carbon fuels and (iv) large-scale heat production infrastructure based on unabated oil, natural gas, coal or peat.

The Paris Alignment of counterparties (PATH) framework[15] aims to encourage financial intermediaries to be more transparent about their climate risk management. In addition, the EIB Group needs to be able to address legitimate concerns from stakeholders around the risk of "greenwashing'', that is, providing financial support to a company that continues to engage in activities that are difficult to reconcile with the long-term goals of the Paris Agreement. The PATH framework is developed around the public disclosure of two crucial elements to a Decarbonisation Plan:

1. A mid-term, rolling (meaning that the targets need to be updated periodically, for example recommended every 5 years), quantitative emission reduction target; and
2. Options over a longer time horizon to achieve carbon neutrality towards mid-century.

The choice of a particular target should be motivated in the specific context of the corporate and the geography in which it operates.

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[12] Centro Internacional de Energía (IESEA) 2024. Available at: Ecuadors-2024-Power-Failures-V0_compressed.pdf

[13] European Investment Bank, 2020, EIB Climate Bank Roadmap 2021-2025. Available at: https://www.eib.org/files/publications/thematic/eib_group_climate_bank_roadmap_en.pdf

[14] European Investment Bank, 2019, EIB energy lending policy. Available at: https://www.eib.org/en/publications/eib-energy-lending-policy

[15] European Investment Bank, 2022, The EIB PATH Framework. Available at: https://www.eib.org/en/publications/20230343-the-eib-group-path-framework-v1-2

1.3.4 Net Zero Standards

Science Based Targets Initiative (SBTi)

SBTi was established to provide companies with a framework and validation service to set and commit to science-based absolute emissions reduction targets aligned with the Paris Agreement's goals. According to the SBTi Net Zero Standard, drawing on scenarios from the Integrated Assessment Modelling Consortium (IAMC)[16], an annual linear reduction in absolute emissions of at least 4.2% from 2020 levels, and reaching a minimum 90% reduction by 2050, with the remainder balanced by carbon removals, would be consistent with limiting the rise in global average temperature to 1.5°C.

The SBTi focuses on absolute emissions reduction, with intensity targets accepted where absolute emissions are also reduced in line with climate science or are modelled using sector-specific decarbonisation pathways. The SBTi is highly prescriptive, with targets to be set within specific timescales and to include all material Scope 1,2 and 3 emissions to be included.

Transition Pathway Initiative (TPI)

The TPI [17] was developed to support asset owners transition to a low carbon economy across different economic sectors, using the Sectoral Decarbonisation Approach (SDA), based on the economy-energy models developed by the International Energy Agency (IEA).

The TPI focuses on emissions-intensity pathways for electricity utilities, with the carbon performance methodology[18] considering tCO_2e/MWh for generation-based Scope 1 emissions only for consistent comparison across the industry. TPI also provides reference pathways that vary by economic groupings, with the example electricity utility pathways for non-OECD countries shown below for reference by this Decarbonisation Plan.

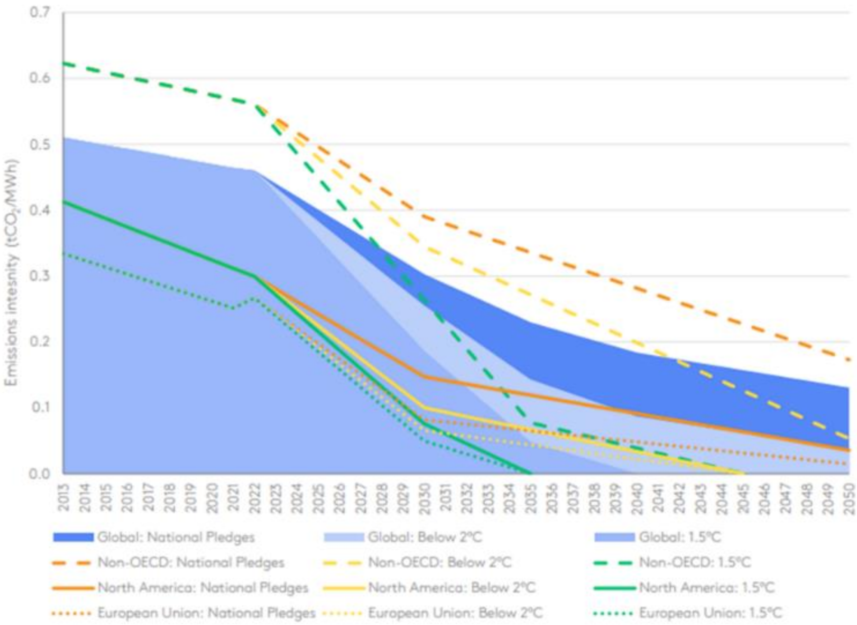

Figure 1-2 - Global and Regional Emissions Intensity Benchmark Pathway by Warming Scenario for the Electricity Utilities Sector

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[16] Foundations of Science-based Target Setting, Version 1.0, 2019. Available at: foundations-of-SBT-setting.pdf

[17] Transition pathway initiative. Available at: Electricity Utilities - Transition Pathway Initiative

[18] Transition pathway initiative methodology. 2024-carbon-performance-assessment-of-electricity-utilities-note-on-methodology.pdf

2. Emissions Baseline

An emissions baseline was established for CELEC EP's GHG emissions for the financial and calendar year 2024. At the time of data collection this was the latest complete dataset available. This baseline serves as a starting point from which the organisation's performance can be measured and also provides the basis for generating the modelled scenarios and a reference point for the Decarbonisation Plan.

2.1 Emissions Boundaries

The emissions boundary includes the organisational boundary, capturing CELEC EP's activities for which carbon data is collected; and, the operational boundary, which specifies the scope of emissions data to be included.

Organisational and Operational Boundary

The operational control approach, as defined by the GHG Protocol[19], was identified with CELEC EP as the most relevant approach to define the organisational boundary, whereby 100% of emissions are considered for all activities where CELEC EP can impose its own operating policies. A detailed list of all operations included within CELEC EP's organisational boundary is provided in Appendix A.

CELEC EP's operational boundary is categorised into two internationally recognised scopes, as defined by the GHG Protocol:

Scope 1: includes direct GHG emissions from sources that are owned or controlled by CELEC EP (e.g. emissions from fuel combustion in power generation and mobile combustion from the operations of diesel and petrol vehicles).

Scope 2: includes indirect GHG emissions from the generation of electricity purchased from third parties, and consumed by CELEC EP.

It should be noted that Scope 3 emissions, which capture all other indirect emissions across an organisation's value chain, are excluded from CELEC EP's Decarbonisation Plan.

Under the GHG Protocol, GHG emissions are measured in carbon dioxide equivalent (CO_2e), which accounts for the global warming potential of different gases over a specific period. The Kyoto Protocol identifies seven GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). This study quantifies the impact of these gases through converting the emissions into the relative Global Warming Potential (GWP) ($kgCO_2e$), in line with GHG Protocol guidelines.

Exclusions

For Scope 1, some direct emissions from leaks of GHGs, used for insulation of electric equipment or as refrigerant, are not included in the Scope 1 baseline, as this data is not currently considered in CELEC EP's emissions inventory. It is recommended to include these emissions in future reporting.

For Scope 2, since CELEC EP generates 100% of the electricity it consumes, and owns and operates its own transmission infrastructure, the Scope 2 emissions are reported as zero. This is because the emissions associated with electricity generation are fully accounted under Scope 1. Similarly, transmission & distribution

[19] GHG Protocol. Available at : Corporate Standard | GHG Protocol

losses (Scope 2 emissions from transmission activities) were also excluded as the majority of the electricity being transmitted by CELEC EP is generated by themselves. However, any efficiency gains or reductions in electricity consumption or transmission losses remain important and are factored into the decarbonisation roadmap, as lower electricity demand will directly reduce Scope 1 emissions by decreasing the amount of energy CELEC EP needs to generate.

The company's plans include a 500 kV interconnection system between Ecuador and Peru designed to enhance regional energy exchange. During Ecuador's dry season (six months per year), when hydroelectric output is reduced, the system will enable the import of approximately 400 GWh per month from Peru. Conversely, in the remaining six months, when Ecuador experiences surplus hydroelectric generation, it will export around 450 GWh per month to Peru. This net-export of 50GWh of electricity is assumed to already be covered by the company's increase in generation capacity. Any impact of the difference in emissions factors for exported and imported energy between the countries are not calculated due to uncertainty in the future generation mix.

Additionally, CELEC EP's current plans include the replacement of two blocks of thermal equipment (Reposición Parque Termoeléctrico), scheduled for 2028 and 2029. These upgrades were not incorporated into the model due to the absence of sufficiently detailed technical and operational data.

2.2 2024 Baseline

Baseline GHG Emissions

Table 2-1 presents CELEC EP's total direct GHG emissions for the 2024 calendar and financial year, amounting to 5.05 million tCO_2e. As illustrated in Figure 2-1, emissions are overwhelmingly attributed to power generation activities, which account for 99.9% of the total. Emissions from diesel and petrol vehicle operations are minimal, contributing just 0.1%. To this end, it is assumed that the emissions intensity across all captured CELEC EP operations represents an effective model for Scope 1 generation emissions intensity, for comparison with benchmarks outlined by the TPI.

Over 95% of CELEC EP's emissions result from the combustion of various fuel oils used in thermal power plants. These include diesel, Fuel Oil No. 4, Fuel Oil No. 6, and residual oils, described in Appendix B, each with distinct physical properties and combustion characteristics that influence operational efficiency and environmental impact.

Table 2-1 - Total GHG Emissions (tCO_2e), FY 2024

Asset	Emission Source	GHG Emissions (tCO_2e)	% of total
Power Plants	Diesel	1,319,708	26.1%
	Fuel oil No 4	1,809,531	35.8%
	Fuel oil No 6	893,740	17.7%
	Residue	709,938	14.1%
	Natural gas	311,294	6.2%
Vehicles	Diesel	3,393	0.1%
	Petrol	1,271	~0.0%
	Total Power Plants	**5,044,212**	**99.9%**
	Total Vehicles	**4,998**	**0.1%**
	Total	**5,049,210**	**100.0%**

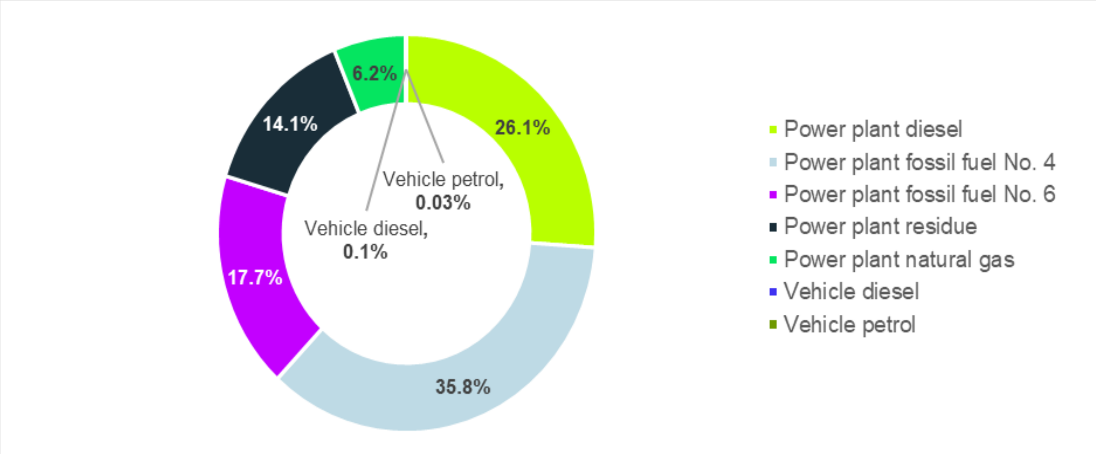

Figure 2-1 - Total GHG Emissions in 2024, with Breakdown Per Emission Source

In addition to combustion-related emissions, CELEC EP's operations involve the use of sulphur hexafluoride (SF_6) in circuit breakers, a gas with a GWP 23,500 times greater than CO_2. The company currently operates 872 SF_6-containing breakers, holding a total of 26.9 tonnes of the gas; however, leaks from these systems due to maintenance, operational incidents, or replacements are not currently tracked. It is recommended that such fugitive emissions from SF6, as well as other GHGs such as HFCs used for refrigerants are captured in the future.

Baseline Generation Capacity

Table 2-2 presents the total generation per production type and per business unit. CELEC EP's total electricity generation in 2024 was 25.6 million MWh, with 25.9% from thermal sources, 73.8% from hydropower and the remaining 0.3% from wind. The average GHG intensity for thermal generation was 0.761 tCO_2e/MWh, while the overall company-wide intensity was 0.197 tCO_2e/MWh. The assumptions used to define the baseline are detailed in Appendix E.1.

Table 2-2 - Total Generation (MWh), GHG Emissions (tCO_2e) and Emission Intensity Factors (tCO_2e/MWh) per Business Unit, FY 2024

Type	Business Unit	Plant Generation Gross Energy (MWh)	GHG Emissions (tCO_2e)	Emission Intensity Factor (tCO_2e/MWh)	% of Total Gross Energy Generation	% of Generation GHG Emissions
Thermal power	Electroguayas	2,621,717	2,621,717	0.793	10.2%	41.2%
	Termoesmeraldas	899,632	899,623	0.735	3.5%	13.1%
	Termomanabi	808,367	808,367	0.701	3.2%	11.2%
	Termogas Machala	608,378	608,378	0.732	2.4%	8.8%
	Termopichincha	1,689,412	1,689,412	0.766	6.6%	25.6%
Hydro power	Celec Sur	7,001,092	-	-	27.3%	0.0%
	Coca Codo Sinclair	7,586,740	-	-	29.6%	0.0%
	Gensur	902,598	-	-	3.5%	0.0%
	Hidroagoyán	2,120,115	-	-	8.3%	0.0%
	Hidroazogues	24,712	-	-	0.1%	0.0%
	Hidronación	1,155,414	-	-	4.5%	0.0%
	Hidrotoapi	181,909	-	-	0.7%	0.0%

Type	Business Unit	Plant Generation Gross Energy (MWh)	GHG Emissions (tCO_2e)	Emission Intensity Factor (tCO_2e/MWh)	% of Total Gross Energy Generation	% of Generation GHG Emissions
Total thermal power		6,627,506	5,044,212	0.761	25.9%	100.0%
Total hydropower		18,901,606	-	-	73.8%	-
Total wind power		70,974	-	-	0.3%	-
	Total	25,600,086	5,044,212	0.197	100.0%	100.0%

2.3 Business-As-Usual (BAU) Scenario

The BAU scenario illustrates CELEC EP's projected GHG emissions from the 2024 baseline, assuming no further action will be taken beyond current financial commitments. Based on this trajectory, total Scope 1 and 2 emissions are expected to increase from 5.05 million tCO_2e in 2024 to 6.83 million tCO_2e by 2050, representing a 35.3% increase, as illustrated in Figure 2-2.

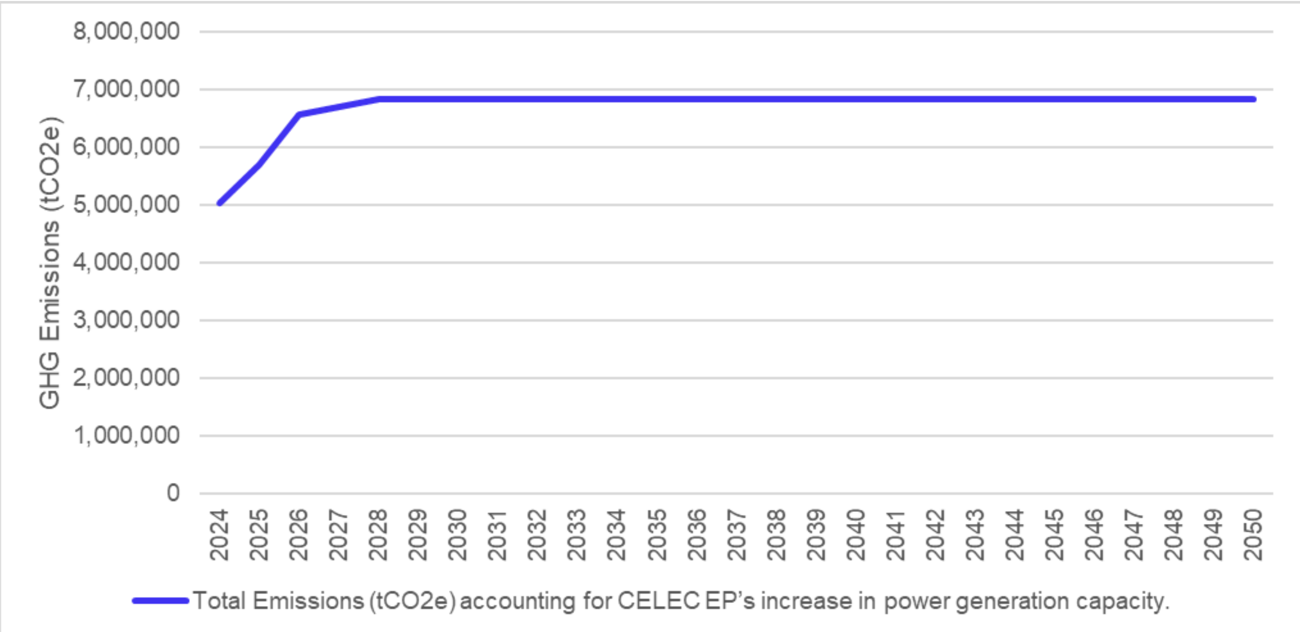

Figure 2-2 - BAU Projected GHG Emissions (tCO_2e) for CELEC EP's Operations, from the 2024 Baseline Year to 2050

The BAU scenario incorporates the commissioning of four thermal power plants, which will add 501 MW of capacity, projected to increase generation by 10.0%. These thermal assets will operate on heavy fuel oils (HFO) No. 4 and No. 6, with associated emissions included from 2025 onwards. Additionally, two hydropower plants are scheduled to commence operations in 2025, adding 205.4 MW of capacity and contributing an estimated 3.8% to annual generation.

As a result of these developments, CELEC EP's generation intensity in this scenario is expected to increase from 0.197 tCO_2e/MWh in 2024, peaking at 0.246 tCO_2e/MWh in 2026, before stabilising at 0.235 tCO_2e/MWh from 2028 onwards. The BAU pathway serves as a reference point for future emissions comparisons, acknowledging that actual trajectories will vary due to future investments not yet financially committed, asset retirements, or policy changes not reflected in current projections.

The assumptions used to define the BAU are detailed in Appendix E.2.

CELEC EP have a pipeline of expansion projects, subject to financial and commercial approval. These were not included in the BAU, as this scenario only includes projects with the company's current financial commitment. These projects have been included in the subsequent "increased generation scenario" and the decarbonisation pathway to reflect the future change in generation output, emissions, emission intensity, and how the proposed interventions interact with these new conditions.

2.4 Increased Generation Scenario

CELEC EP's future expansion plans are captured in an "increased generation scenario", in a similar manner to the modelling of the Announced Pledges scenarios modelled by the International Energy Agency[20], where it is assumed government and industry commitments are met. For CELEC EP, this scenario involves the commissioning of 30 additional generation plants detailed in Appendix C.

In this scenario, the company is projected to increase its installed power capacity by 10,106 MW, meaning an additional 46,852 GWh of electricity generation, a substantial 183% increase reaching 72,452 GWh by 2050. Under this scenario, the company's renewables in 2050 are forecasted to total 60,117 GWh of electricity, including 52,100 GWh of hydro, 1,891 GWh of wind, 3,390 GWh of solar, and 2,736 GWh of geothermal generation, as illustrated in Figure 2-3. In the scenario model, new generation projects defined by CELEC EP as undergoing pre-feasibility studies are considered to start generating electricity in 2032 at 10% of their expected capacity, and increase by 10% each year thereafter, reaching their full potential in 2041. This modelling approach was followed due to the unknown nature surrounding which plants will begin operations first and whether a phased startup will occur.

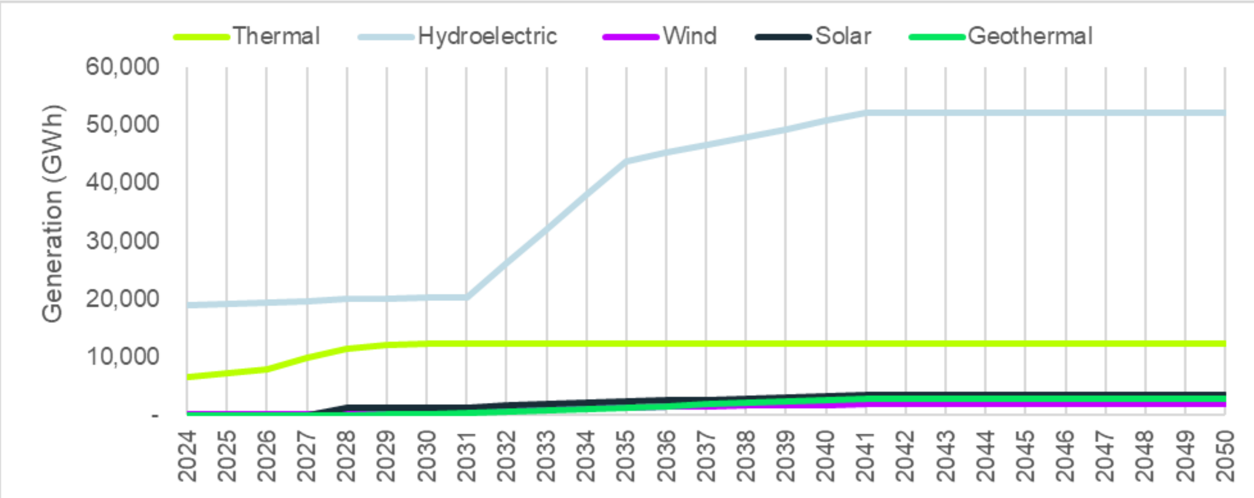

Figure 2-3 - Annual Future Forecasted Electricity Generation by Source.

In the short term, the additional generation capacity includes an increase in thermal generation, scheduled for 2025, 2026, and 2027 when the thermal output is forecasted to increase by 86% from 6,628 GWh to 12,335 GWh. The percent of thermal capacity within the generation mix is set to peak at 35.7% in 2029, as illustrated in Figure 2-4. This investment is assumed to be additional to the baseline thermal capacity; however, it is anticipated that the work will also include update of older power plants to improve reliability subsequent to the power outages in 2024.

[20] International Energy Agency Scenarios. Available at: Understanding Global Energy and Climate Model Scenarios - IEA

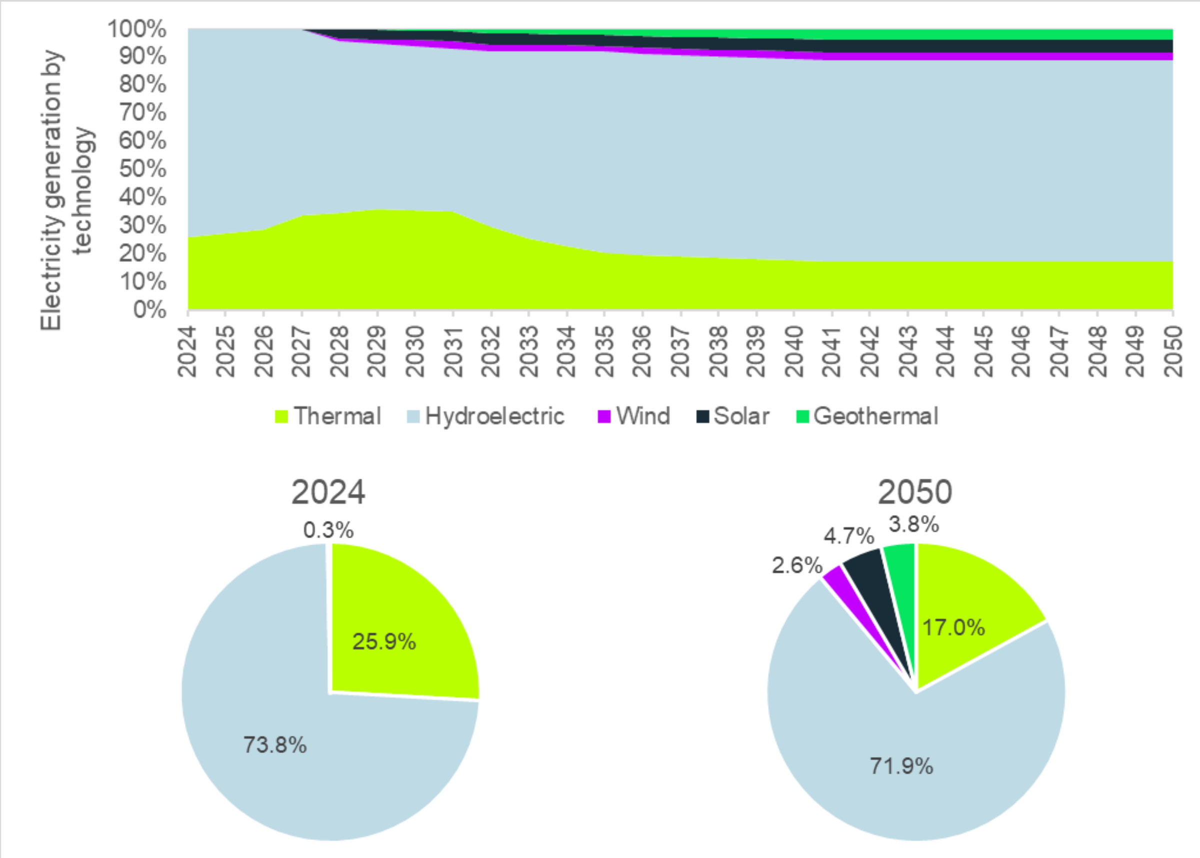

Figure 2-4 - Proportion of Annual Future Forecasted Electricity Generation by Technology

Despite the increase in electricity generation using thermal plants in the short-term, the proportion of CELEC EP's thermal-power production in their energy mix is projected to reduce from the baseline of 25.9% in 2024 to 17.0% in 2050. This change reflects the company's significant increase in hydropower forecasted for 2032, alongside the development of solar, wind, and geothermal sources, as well as the increase in demand.

The company's carbon emission intensity factor is projected to increase by from the 2024 figure of 0.197 tCO_2e/MWh, to a peak of 0.257 tCO_2e/MWh between 2026 and 2029, as shown in Figure 2-5. From 2031, the emissions intensity is projected to drop gradually over the next decade, when hydroelectric, wind, solar, and geothermal projects currently being explored in the pre-feasibility stage of planning are projected to come into operation. From 2041 onwards, the emission intensity factor reaches 0.122 tCO_2e/MWh which remains stable up to 2050, as no investments later than this date are identified within this future generation scenario.

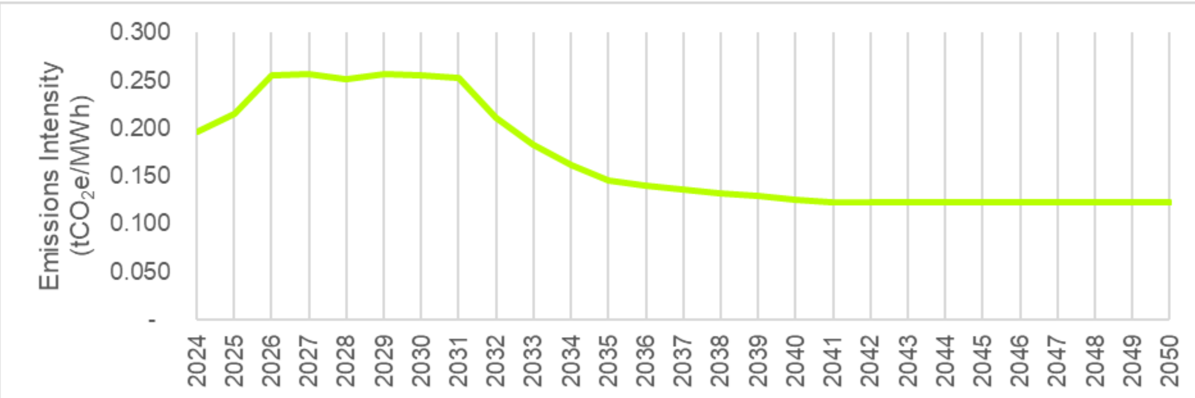

Figure 2-5 - Forecasted Annual Average Intensity Factor for CELEC EP's Increased Generation Scenario

3. Decarbonisation Pathways

3.1 Decarbonisation Pathway Development

To support CELEC EP in further reducing their emissions, a decarbonisation pathway has been developed in which a range of carbon reduction interventions are applied to the increased generation scenario. The decarbonisation interventions proposed in this pathway were derived through a series of workshops with CELEC EP, run by AtkinsRéalis, whereby an initial long list of interventions was reviewed and refined to produce a short-list of targeted interventions, subsequently modelled within this roadmap. The workshop attendees consisted of representatives from teams across operations, technical experts and the CELEC EP leadership team and were carefully selected to ensure they can provide the required technical insight as well as senior-level buy-in.

All interventions within this study are modelled to have achieved their full carbon reduction potential by 2050, aligning with the long-term horizon outlined in the PATH framework and reflecting broader alignment to the timelines associated with the Paris Agreement.

3.1.1 Decarbonisation Interventions

The defined and agreed decarbonisation interventions to be included in the model are implemented over different timescales, spanning from short to medium and long-term from now (2025) until 2050. Short-term interventions are modelled up to 2027, medium-term interventions extend until 2035, and long-term interventions are planned from 2035 onwards. The sections below present a comprehensive list of interventions, along with their relative contributions to cumulative GHG emissions reductions.

Further detail in the decarbonisation interventions is provided in Appendix D, and assumptions for the decarbonisation modelling are detailed in Appendix E. The three first interventions are captured in the increased generation scenario.

Table 3-1 - Interventions Aimed at Decarbonising CELEC EP's Operations

Int No.	Intervention	Change in t CO_2e
1	Expansion of CELEC EP thermal plant, increasing capacity through Esmeraldas IV, Duran, Santa Elena IV and La Concordia plant.	32,546,736
2	Expansion of renewables and thermal plant to reflect CELEC EP's Generation Expansion Plan (2023-2032).	14,415,341
3	Expansion of renewables to reflect CELEC EP's Generation Expansion Plan beyond 2032, including the pre-feasibility plant.	Increase in generation capacity through renewable sources.
4	Procure more energy from Peru, which has a cleaner electricity grid (powered through natural gas).	This intervention was not considered in the model.
5	Transition fleet of vehicles to be electric, switch to hybrid vehicles where full electric conversion is not feasible.	- 75,406
6	Conversion of plants from OCGT to CCGT. CCGT utilises waste heat from the gas turbine to generate additional electricity through a steam turbine. This dual-stage energy conversion process makes better use of the fuel's energy content and therefore reducing the fuel consumption per unit of electricity produced.	- 9,331,818
7	Perform an efficient HFO6 and diesel fuel blending process to improve fuel quality to decrease unscheduled MCI unavailability and improve the efficiency of pre-fuel-injection boosters.	Variable impact depends on extent of intervention.

Int No.	Intervention	Change in t CO_2e
8	Improve combustion efficiency by pre-heating the fuel prior to combustion, this ensures that fuels burn more completely, leading to improved thermal efficiency and power output.	Variable impact depends on extent of intervention.
9	Improve monitoring of system processes through metering and energy audits. Consider aligning processes with ISO 50001 (Energy Management). The standard provides a framework for assessing energy management and increase efficiencies in operations. A further stage could involve getting certified to the standard, which could show the commitment of the company with energy management. Produce a digital twin of the plant systems to optimise the throughput of all systems and processes within plant. This would allow operators to run simulations and predict potential failures before they occur. By analysing data from sensors and equipment, the digital twin can help make informed decisions and to sine-tune processes for better energy use.	- 8,566,842
10	Assess the operation and design efficiency of transmission infrastructure. Consider design efficiency by shortening transmission distances, building grid interconnectivity, and right-sizing infrastructure.	Enabling action.
11	Currently, CENACE's decision making is cost-based; CELEC EP will work with CENACE to seek to incorporate information regarding which plants are carbon-intensive (less efficient) into decision-making, and opt to reduce the use of thermal plants when sufficient hydroelectric power is available.	Enabling action.
12	Implement a fuel hierarchy which includes commitments / targets to move away from carbon-intensive fuels. For example, reduce the amount of residue oil used for combustion, transition operations to Fuel Oil 6 and eventually Fuel Oil 4. For plants that are compatible, convert engines to use natural gas instead (for example: Miraflores plant). Subject to availability of fuels at each plant.	- 2,587,699
13	Install Waste Heat Recovery systems to maximise energy conversion within steam generations processes (e.g. coolant loops). These systems capture and reuse heat that would otherwise be lost during the energy conversion process. The recovered heat can be used to produce additional electricity or to power other processes within the plant, reducing the need for extra fuel and lowering the overall energy consumption.	- 309,280
14	Use of oxygen-enriched flue gases in combustion chamber. By increasing the concentration of oxygen in the combustion air, fuels burn more completely, leading to improved thermal efficiency.	- 3,081,764
15	Where it is not possible to provide oxygen enrichment to the combustion chamber, install turbochargers to increase the amount of airflow to the combustion chamber, leading to improved fuel combustion.	This intervention is already present within the relevant Business Units for CELEC EP.
16	Install carbon scrubbers on exhaust chimneys, especially in the larger, less efficient plant. This captures carbon and will reduce combustion emissions.	- 3,223,957
17	Opportunities to install pilot projects, e.g. floating solar arrays that can be used to increase the proportion of energy that is delivered by renewables in Ecuador. Increasing the capacity of renewables could allow the older, less efficient thermal plants to be shut down / reduce operations.	Projects under consideration. It is the Ministry's responsibility to decide if these are implemented or not.
18	Replace aging, inefficient models with new high efficiency furnaces to maximise plant lifespan, reduce energy losses, and enhance combustion performance. Older furnaces often suffer from wear, corrosion, and outdated designs that limit heat transfer and increase fuel combustion. Modern furnace technologies offer better insulation, advanced burners, and improved control systems that ensure more complete fuel combustion and optimal heat distribution.	Variable impact depends on extent of intervention.
19	Upgrade network transformers. Modern transformers are designed with advanced materials and improved core designs that minimise resistive and magnetic losses. These upgrades can lead to more efficient voltage regulation, lower heat generation, and enhanced load-handling capabilities.	This intervention is already being applied at relevant sites / facilities as part of CELEC EP's

Int No.	Intervention	Change in t CO_2e
		maintenance regime and pipeline of projects.
20	Opportunity to install turbines in spillway channels for downstream dams that need to maintain ecological flow.	Increase in generation capacity through renewable sources increased generation output but did not impact overall emissions.
21	Implement a loss monitoring strategy on Transmission Network. By continuously tracking losses, CELEC EP could pinpoint inefficiencies such as overloaded lines, aging equipment, or poor power factors. This data-driven approach could enable targeted upgrade.	- 10,133,300
22	Proposed additional intervention subject to budget availability: decommission/ upgrade higher polluting plants (i): Replace emissions-intense thermal plant with an intensity of >0.75 tCO2e/MWh with renewable generation.	- 7,058,232
23	Proposed additional intervention subject to budget availability: decommission/ upgrade higher polluting plants (ii): Replace emissions-intense thermal plant with an intensity of >0.70 tCO2e/MWh with renewable generation.	- 6,403,358

Figure 3-1 displays the cumulative emissions savings from start of implementation up to 2050, for each of the modelled interventions (as presented in Table 3-1 above), relative to the cumulative 2024 emissions BAU baseline. Following the implementation of the interventions agreed, due to CELEC EP's increase in thermal generation, cumulative emissions savings from 2025 to 2050 are projected to total 3,809,580 tCO_2e, only 2.1% of the cumulative baseline emissions. Should the decarbonisation interventions be instead compared to a revised baseline in 2027, subsequent to the thermal plant capacity increase, the total impact of the interventions would represent a 24% reduction of the cumulative baseline. The interventions delivering the most significant savings are:

- Conversion of plants from OCGT to CCGT. CCGT utilises waste heat from the gas turbine to generate additional electricity through a steam turbine. This dual-stage energy conversion process makes better use of the fuel's energy content therefore reducing the fuel consumption per unit of electricity produced.
- Implementing a loss monitoring strategy. By continuously tracking losses, CELEC EP could pinpoint inefficiencies such as overloaded lines, aging equipment, or inefficient power factors. This data-driven approach could enable targeted upgrade.
- Longer-term replacement of emissions-intense thermal plant with renewable generation. As well as reducing CELEC EP's emissions, this could lower fuel and operating costs, reduced exposure to carbon pricing, as well as support innovation and grid flexibility while aligning with national decarbonisation goals.

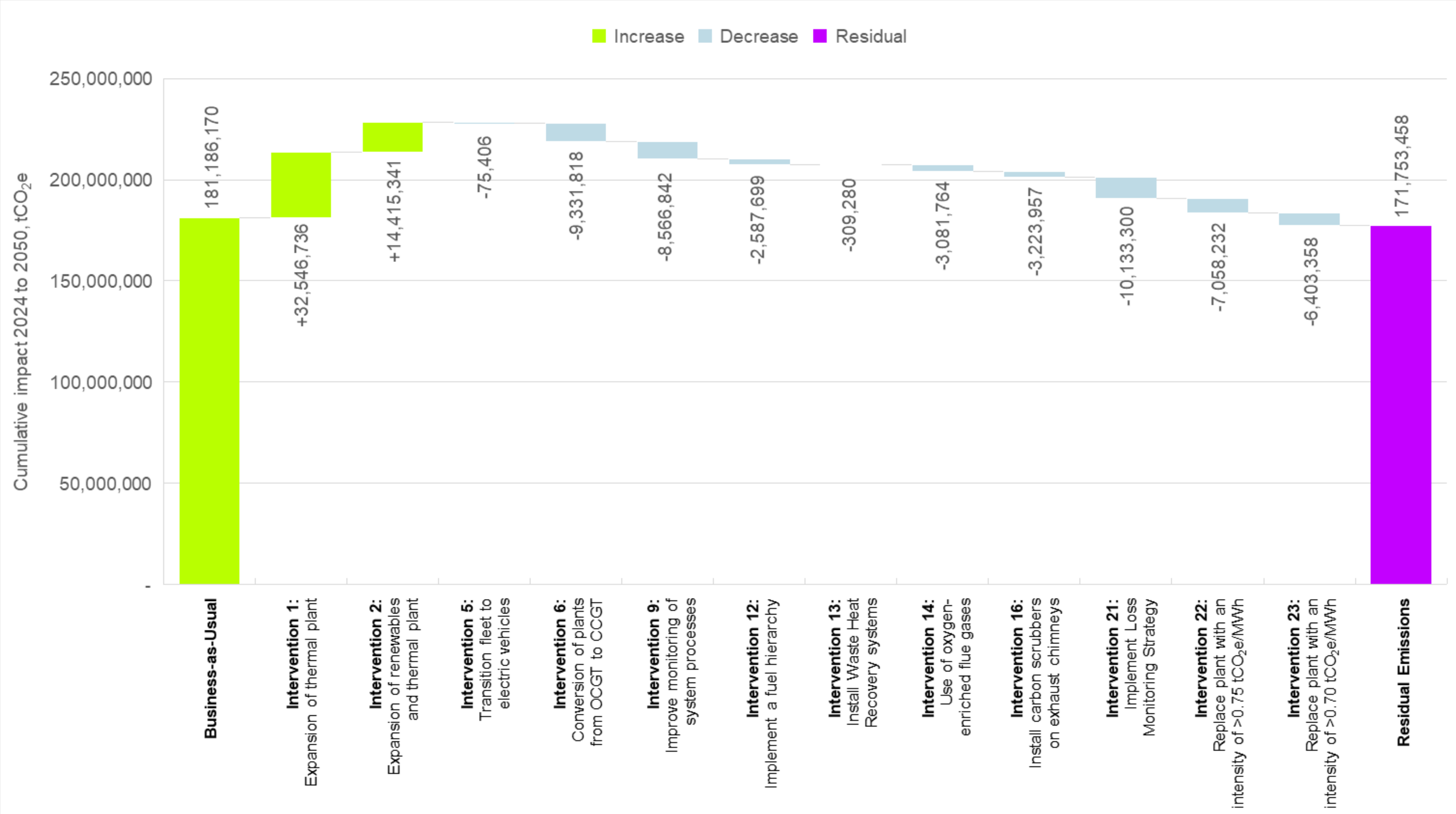

Figure 3-1 - Cumulative Emissions Savings per Intervention (2024 to 2050)

3.1.2 Decarbonisation Scenario Results

Emissions Intensity Decarbonisation Pathway

CELEC EP's emissions intensity progress up to 2050 under the different modelled scenarios is shown in Figure 3-2. The purple line illustrates the Decarbonisation Pathway, which is derived from the BAU scenario (dark blue line), the increased generation scenario (light blue line) and the application of additional decarbonisation interventions as described in Section 3.1.1.

Decarbonisation Pathway (purple line)

In the modelled Decarbonisation Pathway, from 2024 to 2050, CELEC EP's emissions intensity is projected to reduce from the current 0.197 tCO_2e/MWh to 0.077 tCO_2e/MWh, once the decarbonisation interventions outlined in this Decarbonisation Plan are implemented. This represents a 61% reduction in emissions intensity over the 26-year period.

Within this Decarbonisation Pathway, the emissions intensity is projected to peak at 0.247 tCO_2e/MWh in 2026. The peak corresponds to the committed addition of new thermal power plants required in the short term to increased reliability of the grid, after which additional forecasted capacity is to be achieved through renewable generation sources. The Decarbonisation Pathway shows the emissions intensity of CELEC EP's operations reducing significantly in the early 2030s, reaching an intensity of 0.117 tCO_2e/MWh in 2035, with a lessening pace of reduction from this point, corresponding to the timeline for when the generation capacity levels out.

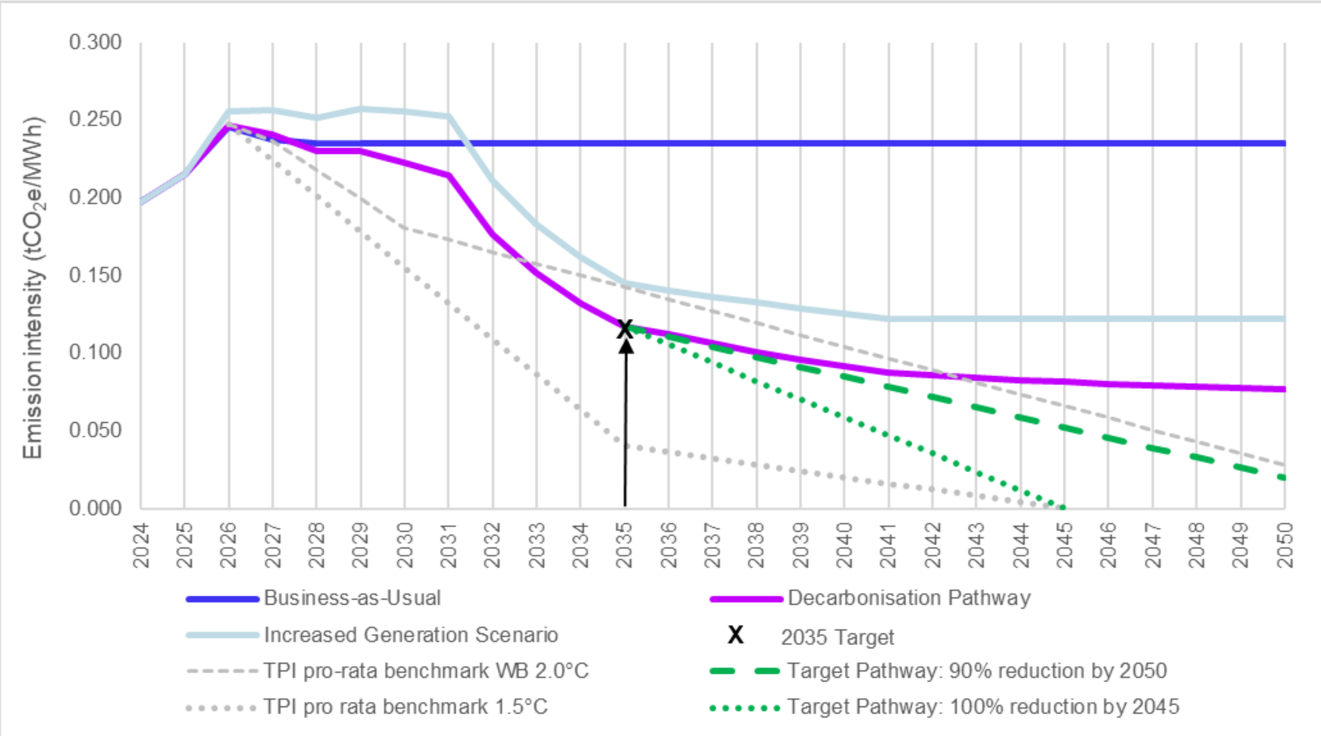

Figure 3-2 - Decarbonisation Roadmap of CELEC EP's Emissions Intensity to 2050

Transition Pathway Initiative (TPI) Benchmark and Paris Alignment (grey lines)

The grey lines on the graph show how much electricity emissions would need to drop to meet the goals of the Paris Agreement. These lines seek to represent two climate scenarios as modelled by the TPI: keeping global warming well below 2°C and aiming for 1.5°C. The benchmarks are based on emissions data for non-OECD countries but adjusted (prorated) to match CELEC EP's peak BAU emissions intensity, so they show the same percentage emissions intensity reductions starting from 2026.

It is noted that the Decarbonisation Pathway closely falls within the TPI “well-below 2°C” benchmark from the early 2030s. The slowing pace of reductions in emissions intensity of the Decarbonisation Pathway from 2041 however are not sufficient however to maintain this alignment towards 2050.

Target Pathways to close the gap to Paris Alignment (green lines)

To identify the additional carbon reductions that would be required to close the gap between the current Decarbonisation Pathway and Paris aligned pathways, two target pathways are modelled:

1. 90% reduction in emissions intensity by 2050. This is modelled from 2035 with a 90% reduction of the 2024 baseline. This target pathway falls within the well below 2°C benchmark and achieves an emissions intensity of 0.020 tCO2e/MWh.
2. 100% reduction in emissions intensity by 2045. This is also modelled from 2035 and would require the pace of emissions reduction from 2030 to 2035 to be maintained for the subsequent decade.

If CELEC EP was to align to the target pathways, additional decarbonisation measures would be required. Should the measures consist solely of increased replacement of fossil-fuel thermal generation with renewable sources, for the 90% reduction by 2050 pathway in line with the well below 2°C benchmark, an average replacement rate of around 690 GWh thermal power capacity per year would be required from 2035 to 2050. To reach the TPI benchmark for 1.5°C alignment, would require full replacement of the ~12,000 GWh fossil-fuel thermal capacity by 2045. The rate of replacement from 2035 to 2045 equates to an average of 1,120 GWh per year.

These target pathways are used to consider appropriate mid- and long-term targets for CELEC EP, as described in Section 4.4.

Absolute Emissions Decarbonisation Pathway

As detailed in Section 2.4, CELEC EP could be increasing its 2024 generation output by 183.5% to 2050, including installing new thermal power plants, as well as hydro, wind, solar, and geothermal plants. Despite implementation of the decarbonisation interventions, this additional thermal plant capacity results in a total increase in absolute annual emissions of 10.5% by 2050. Overall, absolute emissions increase from 5.05 million tCO_2e in 2024 to 5.58 million tCO_2e in 2050 after peaking at 7.87 million tCO_2e in 2029, as shown in Figure 3-3.

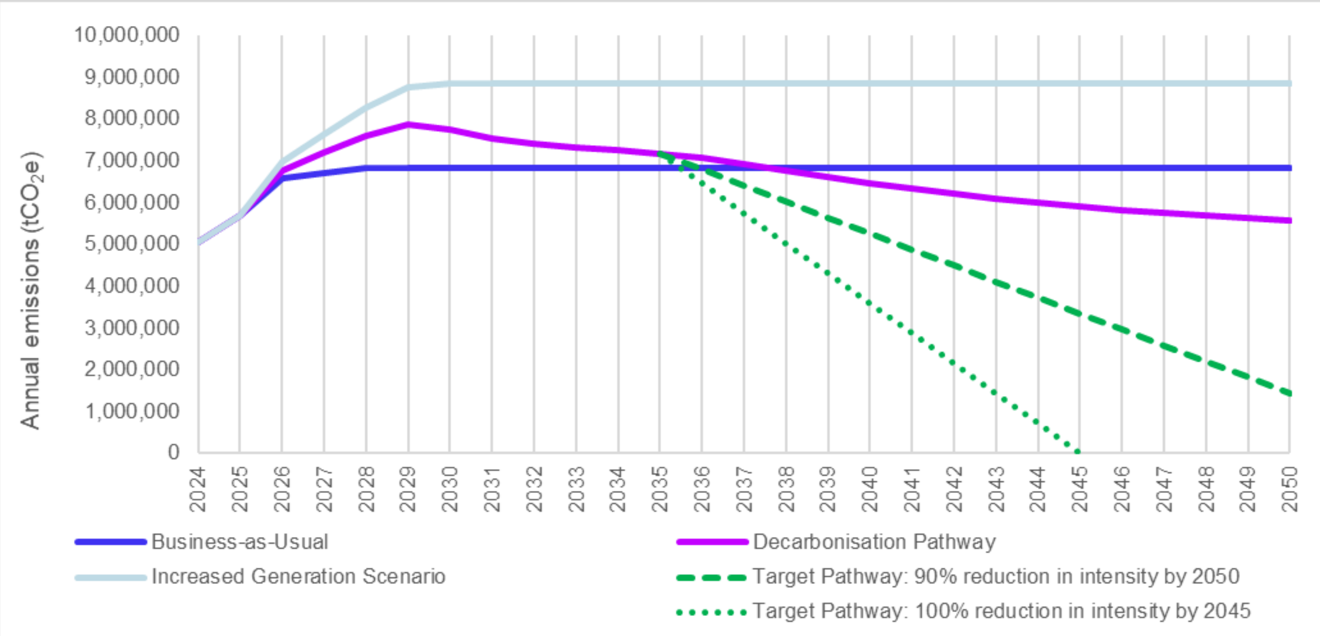

Figure 3-3 - Modelled Pathways of CELEC EP's Absolute Emissions to 2050

It should be noted that this emissions model assumes that when renewable generation is added, it is additional to the existing capacity (unless otherwise specified as per interventions list), rather than as replacement for existing thermal generation. Should this assumption change, the absolute emissions would reduce.

The target pathways (in green – corresponding to those developed for the emissions intensity pathway), demonstrate the gap between achieving Paris Alignment (on an intensity basis) and the absolute emissions decarbonisation pathway. It is noted that the 90% reduction target pathway for emissions intensity, does not reach 90% reduction in absolute emissions.

4. Alignment to PATH Framework

4.1 Paris Agreement

As described in Section 1.3, the Paris Agreement requires the pursuit of reduction of GHG emissions to limit global warming to well below 2°C and pursue efforts for a maximum mean global temperature increase of 1.5°C. After an initial period of grid expansion, the Decarbonisation Pathway modelled falls within the TPI electricity utilities benchmark for well below 2°C from the early 2030s to the early 2040s; however, further work in the longer term is required to drive emissions in line with the Paris Agreement, with phasing out of fossil-fuel based thermal power plants being critical for this to be realised.

It is noted however that the EIB's PATH framework establishes that targets should be motivated in the specific context of the corporate and the geography in which it operates. Considering the context of Ecuador's wider economy, with electricity anticipated to replace higher carbon fossil fuels as part of the national decarbonisation plans, if CELEC EP were to follow the identified Decarbonisation Pathway, this will provide further carbon reductions in other sectors of the economy, as Ecuador seeks to reduce reliance on oil as an energy source across the country.

Additionally, the reliability of the grid in Ecuador has been recently impacted by climate change, with significant blackouts in 2024. The focus of investment is therefore to quickly increase both the capacity and the reliability of the grid, making decisions to roll out newer, low carbon technologies less likely to occur in the short term. The need for reliability is further exasperated by the need for the power generation to operate reliably often in remote parts of Ecuador including the Andes, Amazon and Pacific Islands, unsuited to testing of new technologies or reliant on availability of wider supply chains.

CELEC EP's operations are defined as 'high emitting' by the EIB, and the bank no longer supports energy projects reliant on fossil fuels, including power generation with an intensity above 0.250 $kgCO_2e/MWh$. In 2024, CELEC EP's thermal power generation had an intensity of 0.761 $kgCO_2e/MWh$ while when including renewables, the overall intensity for the company was 0.197$kgCO_2e/MWh$. Whilst CELEC EP's generation emissions intensity is projected to increase under the Increased Generation scenario to 0.247 $kgCO_2e/MWh$ in 2026, it soon falls to significantly within the EIB investment limit.

4.2 Stakeholder Engagement

In order to fulfil its duties and responsibilities, CELEC EP maintains relationships with various stakeholders, both internal and external, with whom it constantly interacts through the provision and receipt of information, services, goods, and products. These stakeholders include NGOs, international organizations, academia, banks, investors, suppliers, allies, consumers, collaborators, clients, government agencies, and the media, among others.

CELEC EP recognises the importance of maintaining an open and continuous dialogue with all stakeholders and in its 2021 Sustainability Report (Memoria de Sostenibilidad)[21] they establish that they periodically review, identify, and list the main responsibilities and expectations of its stakeholders. These actions ensure that all relevant stakeholders are considered to guide strategic decisions, foster trust, and gain buy-in to commitments such as the PATH alignment plan, to help facilitate a just transition to a low carbon future.

All interventions proposed in the Decarbonisation Plan are subject to regulatory approval. CELEC EP's approval process integrates stakeholder engagement and socio-environmental management into their decision-making.

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[21] CELEC EP, 2021, Memoria de Sostenibilidad. Available at: https://celecloud.celec.gob.ec/s/yC9ebz8gHpT5JXd

This process operates within the company's framework of compliance with its legal obligations, respect and protection of ecosystems, pollution prevention, and harmonious integration into the territory where it builds and operates its projects, contributing to the sustainable development of the environment and the long-term sustainability of the company.

4.3 Additional Decarbonisation Measures

To meet Paris-aligned emission targets, as noted above, CELEC EP will need to go beyond the level of interventions modelled in the Decarbonisation Pathway. The Pathway based on the agreed interventions, represents a pragmatic Decarbonisation Pathway, based on widespread applicability across operations, and reliance on mature, commercially available technologies.

Due to the forecasted increase in demand in Ecuador, the increase of renewable generation in the model was considered as additional to the company's thermal generation rather than as a replacement of older carbon intensive thermal power plants. Should Ecuador's electricity demand be met earlier through other national expansion plans, there is further opportunity to reduce emissions by switching off the carbon-intensive plant and move closer to the desired rate of decarbonisation by 2050. Further opportunities to accelerate and increase the company's emissions reductions beyond the modelled Decarbonisation Pathway as identified below:

- Ensure senior leadership endorsement of this Decarbonisation Plan and its associated targets to support future decision making and prevent the commitment of investment in the long term in new fossil-fuel based thermal power plants. These facilities will increase the company's carbon emissions, providing further challenges in meeting climate goals.

- Assess if it would be possible to bring forward the commissioning of renewable generation sites already under consideration, as this enables earlier displacement of fossil fuel-based electricity generation, thereby reducing cumulative carbon emissions over time. This may include renewable projects with shorter turnaround times, to provide an immediate boost to renewable supply.

- Increase the number and / or size of future renewable generation sites to replace existing thermal power generation beyond the current horizon, to ensure continued and long-term transition to a resilient, low-carbon power system.

- Identify and prioritise decommissioning of sites using high-emitting fuels or those with the highest emissions intensity, as these facilities disproportionately contribute to the company's carbon emissions. Prioritising their closure / replacement with renewable energy supply could provide immediate and substantial emission reductions.

- Engage with Ecuador's National Electricity Operator, CENACE, to establish a fuel hierarchy that considers carbon emissions in its decision making. Considering the fuel's carbon emissions when deciding which plants to start or stop producing electricity could have a considerable impact in the company's emissions by being able to favour the use of lower-carbon intensive sources.

- Engage technical and commercial experts to investigate the potential integration of alternative energy sources such as hydrogen, biomass, increased geothermal, PV with battery energy storage systems and nuclear such as small-modular reactors in the country's energy-mix, considering emissions reductions, increasing resilience to climate impacts and balancing the grid to optimise supply and demand cycles.

4.4 Carbon Reduction Targets

The PATH framework requires the Decarbonisation Pathway to incorporate both a mid-term target and the identification of longer-term actions to drive towards net zero. These targets should be realistic and relevant, aligned to CELEC EP business strategy and climate goals.

The identified Decarbonisation Pathway, which captures both planned generation increases and agreed actions in the short-medium term to decarbonise existing operations, falls within the TPI well-below 2°C benchmark from around 2032 and continues a significant decline to 2035. This point is therefore considered a reasonable mid-term target.

To this end, it is proposed that the mid-term target is as follows:

- **40.0% reduction in the 2024 emissions intensity by 2035** - achieving a generation emissions intensity of 0.117 tCO2e/MWh. This target is illustrated in Figure 4-1.

Further acceleration of actions identified in this Decarbonisation Plan, including the roll out of renewables and decommissioning of fossil fuel power plants, will serve to enable CELEC EP to exceed this target, reflecting an effort to drive towards a 1.5°C pathway. This target should be updated every 5 years at least, to ensure continued relevancy based on changes such as shift in business operations, updates to policy, or improved data through realisation of interventions. This rolling update to the mid-term target is a requirement of the PATH framework.

In the longer term, it is proposed a **minimum target pathway of 90% reduction in emissions intensity by 2050** is pursued, further aligning to the TPI well-below 2°C benchmark. This target pathway corresponds to that illustrated as the longer-dashed green line on Figure 3-2 and Figure 3-3.

This long-term target pathway would allow wider alignment with the concept of reducing emissions to at most a residual of 10%, with an option for carbon removals to achieve effective carbon neutrality (Scope 1 and 2 emissions) by the mid-century. As such this longer-term ambition is in line with the PATH framework as well as support CELEC EP and Ecuador's wider climate ambitions. The long-term emissions intensity target is a value of 0.020 tCO_2e/MWh.

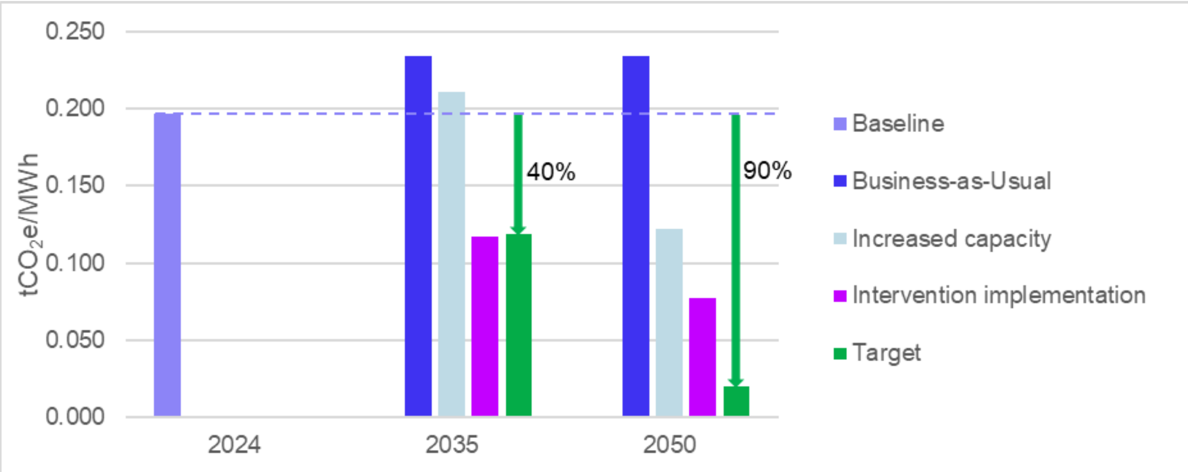

Figure 4-1 - Emission Intensity Reduction Targets Based Aligned to PATH

The residual emissions resulting from the medium and long-term targets are:

- In 2035: 7,164,703 tCO_2e – representing an increase on the absolute baseline emissions, but a reduction from peak emissions in 2029 of 9%.
- In 2050: 1,431,696 tCO_2e – representing a reduction from the absolute baseline emissions of 90%.

To further contextualise this Decarbonisation Plan, it is recommended that these total emissions are considered within the energy market decarbonisation as a whole, such that the absolute emissions reductions resulting from electrification of traditionally fossil-fuel based energy systems, are fully represented.

Further plans to reduce or offset residual emissions should be developed to enable the longer-term target of 90% reduction by 2050 to move towards a position of carbon neutrality. It is recommended that instead of offsetting, this reduction is achieved through increasing the roll out of renewable energy supplies through the 2040s and committing to the phase out of fossil fuels from CELEC EP’s energy mix. It is noted however that a decision to commit to phasing out fossil fuels is unlikely to be made in the short term, particularly given the recent blackouts of the Ecuador grid (2024) and the current availability of alternative energy sources. As such it is proposed that the next 5-yearly target update, as required by the PATH framework is a useful timeline to revisit the longer-term target and readiness for identifying new opportunities to drive for carbon neutrality by 2050.

5. Conclusions

CELEC EP operates up to 90% of Ecuador's power generation, as well as providing transmission and distribution of electricity to a wide range of end consumers. The need to ensure a low carbon electricity supply to support national and international climate goals is balanced against the increase in electrification needed to support the shift in Ecuador's economy from reliance on fossil fuels for energy needs. Additionally, climate change impacts have caused recent challenges with grid operation due to the large percent of hydroelectric power (at 74%) and high levels of drought, particularly in 2024.

CELEC EP's Decarbonisation Plan outlines a phased and pragmatic approach to reducing GHG emissions across its operations from now (2025) until 2050 in the context of a significant increase in CELEC EP's generation capacity of 183%. Through a set of agreed carbon reduction measures to be delivered in the short, medium and long term, the carbon intensity of generated electricity is modelled to fall from 0.197 tCO_2e/MWh in 2024 to 0.077 tCO_2e/MWh by 2050. The most substantial emissions savings were shown to arise from: converting plants from open to closed cycle gas turbines; driving plant energy efficiency through targeted audits; alignment with ISO 50001 and improved data monitoring and controls; implementing a loss monitoring strategy across the transmission and distribution network; and replacing emissions-intensive thermal plants with low carbon generation.

To effectively drive alignment to the Decarbonisation Plan and align with the EIB PATH requirements, CELEC EP must adopt a both mid-term emissions reduction target and long-term ambition to drive towards carbon neutrality. These targets are directly informed by the Paris-aligned benchmarks for 1.5°C and well-below 2°C pathways, provided by the TPI for electric utilities. [It is noted that CELEC EP already operates a relatively low carbon grid, due to the high percent of hydroelectric power, so these benchmarks are provided pro-rata, rather than as absolute intensity figures.]

The mid-term target is achieved through delivery of the actions included in the Decarbonisation Plan. This target is 40% reduction in emissions intensity by 2035, to a target value of 0.117 tCO_2e/MWh. This corresponds to an increase in absolute emissions due to the increased thermal generation capacity.

The longer-term ambition is for carbon neutrality by 2050 and therefore a minimum target of 90% reduction in emissions intensity by 2050 is chosen as a suitable goal, noting that the residual emissions can either be met by further emissions reductions or carbon removals. The absolute emissions reduction target is 72% from the baseline, representing a residual value of 1,431,696 tCO_2e. It is expected that these residual emissions will be reduced to zero by additional measures that accelerate the uptake of renewables and support the phase-out of fossil fuel plants. Such opportunities should be assessed at regular target reviews, at least every 5 years, as alternative technologies become more readily and economically available. The low carbon technologies that can support the move to carbon neutrality could include biogas and hydrogen, small nuclear modular reactors, higher levels of geothermal or solar PV combined with battery energy storage.

It is noted that the EIB supports investments associated with power generation with an emissions intensity less than 0.250 tCO_2e/MWh. The desire of financial institutions to focus investments on low carbon projects that deliver against climate goals, is likely to support the case for investment in the opportunities identified for CELEC EP's longer-term decarbonisation.

Overall, CELEC EP's Decarbonisation Pathway represents a solid foundation for climate action, leveraging commercially available technologies and operationally feasible strategies. With increased ambition and continued innovation, CELEC EP has the potential to further reduce its carbon footprint and contribute meaningfully to Ecuador's energy transition.

APPENDICES

Appendix A. Organisational Boundary

Table A-1 lists the business units and corresponding assets across the locations where CELEC EP operates, within the organisational boundary, for which GHG emissions have been quantified.

Table A-1 - Group Business Units and Assets

<table>
<tr><th>Sector</th><th>Business Unit</th><th>Asset Names</th></tr>
<tr><td rowspan="7">Hydroelectric & Wind Power Plants</td><td>Celec Sur</td><td>Central Mina San Francisco
Central Paute Mazar
Central Paute Molino
Central Sopladora</td></tr>
<tr><td>Coca Codo Sinclair</td><td>Central Coca Codo
Central Manduriacu</td></tr>
<tr><td>Gensur</td><td>Central Delsitanisagua
Central Villonaco (Wind Plant)</td></tr>
<tr><td>Hidroagoyán</td><td>Central Agoyán
Central Pucara
Central San Francisco</td></tr>
<tr><td>Hidroazogues</td><td>Central Alazan</td></tr>
<tr><td>Hidronación</td><td>Central Baba
Central Marcel Laniado</td></tr>
<tr><td>Hidrotoapi</td><td>Alluriquin
Mini Toachi
Sarapullo</td></tr>
<tr><td rowspan="5">Thermal Power Plants</td><td>Electroguayas</td><td>Central Álvaro Tinajero
Central Aníbal Santos
Central Gonzalo Zevallos
Central Santa Elena II
Central Enrique García
Central Santa Elena III
Central Trinitaria</td></tr>
<tr><td>Termoesmeraldas</td><td>Central Esmeraldas I
Central Esmeraldas II
Central La Propicia</td></tr>
<tr><td>Termogas Machala</td><td>Central Machala I
Central Machala II</td></tr>
<tr><td>Termomanabi</td><td>Central Jaramijó
Central Manta II
Central Miraflores
Central Miraflores I
Central Pedernales</td></tr>
<tr><td>Termopichincha</td><td>Central Boca Tiputini Central
Celso Castellanos Central
Chiroisla Central Cuyabeno
Central Dayuma Central El
Eden Central Floreana Central
Guangopolo I Central
Guangopolo II Central Isabela
Central ITT Central Jivino I</td></tr>
</table>

Sector	Business Unit	Asset Names
		Central Jivino II Central Jivino III Central Limonyacu Central Macas Central Nuevo Rocafuerte Central Ocaya Central Payamino Central Playas de Cuyabeno Central Puerto El Carmen Central Puná Central Quevedo II Central Sacha Central Samona Central San Cristobal Central Santa Cruz Central Santa Rosa Central Secoya Central Shushufindi Central Tiputini

Table A-2 lists the number of vehicles each business unit operates, within the organisational boundary, for which GHG emissions have been quantified.

Table A-2 - Group Business Units and Vehicles

Business Unit	Number of Vehicles
Celec Sur	131
Coca Codo Sinclair	88
Comision Rio Coca	5
Electroguayas	52
Gensur	18
Hidroagoyan	57
Hidroazogues	18
Hidronacion	41
Hidrotoapi	52
Matriz	14
Termoesmeraldas	26
Termogas Machala	18
Termomanabi	18
Termopichincha	74
Transelectric	175

Appendix B. Fuel Definitions

Fuel oils used in CELEC EP's thermal power plants:

- **Diesel**
  A distillate oil, which is more volatile and less viscous than residual oils and hence suitable for high-speed diesel engines

- **Fuel Oil No. 4**
  A blend of distillate and residual oil and is less volatile and more viscous than diesel fuel.

- **Fuel Oil No. 6**
  A heavy residual and highly viscous oil that needs to be preheated before use.

- **Residual Oils**
  Heavy, viscous byproducts left over after the distillation of crude oil. These require extensive preheating and treatment to ensure proper combustion.

Appendix C. Forecasted increase in generation

Table C-1 - Projected Increase in Generation

Business Unit	Asset	Projected start of operations	Generation type	Gross generation (MWh)
Electroguayas	Central Aníbal Santos	2025	Thermal	159,205.89
Electroguayas	Central Enrique García	2025	Thermal	244,334.79
Electroguayas	Esmeraldas III	2025	Thermal	465,555.82
Electroguayas	Pascuales/Enrique Garcia	2025	Thermal	1,330,159.50
Termopichincha	Salitral	2025	Thermal	511,599.81
Termopichincha	Quevedo	2025	Thermal	255,799.90
Hidrotoapi	Alluriquin	2025	Hydroelectric	961,166.02
Hidrotoapi	Mini Toachi	2025	Hydroelectric	5,061.44
Electroguayas	Esmeraldas IV	2026	Thermal	767,399.72
Electroguayas	Duran	2026	Thermal	511,599.81
Electroguayas	Santa Elena IV	2026	Thermal	153,479.94
Termogas Machala	Machala Gas Tercera Unidad	2026	Thermal	510,000.00
Termomanabi	La Concordia	2026	Thermal	511,599.81
Hidroazogues	Mazar-Dudas: San Antonio	2026	Hydroelectric	44,900.00
Hidroazogues	Mazar-Dudas: Dudas	2026	Hydroelectric	37,700.00
Termogas Machala	Machala Gas Ciclo Combinado	2027	Thermal	690,000.00
CELEC Sur	Proyecto Eólico Pimo	2028	Wind	860,000.00
CELEC Matriz	Proyecto PV La Ceiba	2028	Solar	396,800.00
CELEC Matriz	Proyecto PV Matala	2028	Solar	171,400.00
CELEC Matriz	Proyecto PV Flotante Mazar	2028	Solar	292,000.00
CELEC Matriz	Proyecto Eólico Ducal Membrillo (VILLONACO 2)	2028	Solar	315,000.00
Undefined	Quijos	2028	Hydroelectric	355,000.00
Undefined	Chachimbro	2029	Geothermal	394,200.00
CELEC Sur	Proyecto Hidroeléctrico Santiago	2032	Hydroelectric	14,613,000.00
CELEC Sur	Proyecto Hidroeléctrico Cardenillo	2032	Hydroelectric	3,409,000.00

Business Unit	Asset	Projected start of operations	Generation type	Gross generation (MWh)
CELEC Matriz	Proyecto Geotérmico Chachimbiro	2032	Solar	394,000.00
Undefined	Pre-Feasibility Projects	2032	Hydroelectric	13,772,673.48
Undefined	Pre-Feasibility Projects	2032	Solar	1,820,743.22
Undefined	Pre-Feasibility Projects	2032	Wind	960,227.40
Undefined	Pre-Feasibility Projects	2032	Geothermal	2,341,548.00
			Thermal	**6,110,735.00**
			Hydroelectric	**33,198,500.95**
			Wind	**1,820,227.40**
			Solar	**3,389,943.22**
			Geothermal	**2,735,748.00**
			Total	**47,255,154.57**

Appendix D. Decarbonisation Interventions

Table D-1 - List of Decarbonisation Interventions

Theme	Intervention	Enabling Actions	Start Year	Completion Year
Plant Efficiency Measures	Improve monitoring of system processes through metering and energy audits. Consider aligning processes with ISO 50001 (Energy Management). The standard provides a framework for assessing energy management and increase efficiencies in operations. A further stage could involve getting certified to the standard, which could show the commitment of the company with energy management.	1. Actions contemplated in the Energy Efficiency Law and the National Energy Efficiency Plan (PLANEE) 2. Align with ISO 50001 certification 3. Increase/implement energy audits 4. Certify professionals as energy auditors 5. Provision contained in Official Letter No. MEM-SDCEE-2023-0364-OF, dated May 2, 2023, which motivates the implementation of energy efficiency plans.	2026	2031
Plant Efficiency Measures	Implement maintenance and digital monitoring of all plant systems. Improving what is currently in place. This would enable early detection of equipment wear, faults, and performance issues. Digital monitoring systems provide real-time data and analytics, allowing operators reduce downtime, and schedule maintenance proactively rather than reactively.	Upgrade the Operational Technology systems of CELEC EP's power plants.	2026	2031
Plant Efficiency Measures	Install Waste Heat Recovery systems to maximise energy conversion within steam generations processes (e.g. coolant loops). These systems capture and reuse heat that would otherwise be lost during the energy conversion process. The recovered heat can be used to produce additional electricity or to power other processes within the plant, reducing the need for extra fuel and lowering the overall energy consumption.	Identify the plants in which it is feasible to implement waste heat recovery systems to increase heat efficiency in the electricity generation process.	2031	2036
Plant Efficiency Measures	Use of oxygen-enriched flue gases / oxygen lancing in combustion chamber. By increasing the concentration of oxygen in the combustion air, fuels burn more completely, leading to improved thermal efficiency.	Identify the plants in which it is feasible to implement oxygen injection into the combustion chamber,	2031	2036

Theme	Intervention	Enabling Actions	Start Year	Completion Year
Plant Efficiency Measures	Where it is not possible to install oxygen injection to the combustion chamber, install turbochargers to increase the amount of airflow to the combustion chamber, leading to improved fuel combustion.	Identify the plants in which it is feasible to implement turbochargers.	2031	2036
Plant Efficiency Measures	Replace aging, inefficient models with newer high efficiency furnaces to maximise plant lifespan, reduce energy losses, and enhance combustion performance. Older furnaces often suffer from wear, corrosion, and outdated designs that limit heat transfer and increase fuel combustion. Modern furnace technologies offer better insulation, advanced burners, and improved control systems that ensure more complete fuel combustion and optimal heat distribution.	Identify the plants in which it is feasible to replace boilers that have completed their useful life or present inefficiencies in the operation.	2031	2036
General Improvements	Upgrade network transformers. Modern transformers are designed with advanced materials and improved core designs that minimise resistive and magnetic losses. These upgrades can lead to more efficient voltage regulation, lower heat generation, and enhanced load-handling capabilities.	1. "Energy inventory", in which the losses of the current transformers used in the auxiliary services of the powerhouse and related installations are identified. 2. Identify the transformers of auxiliary services of powerhouses and related installations subject to possible change.	2031	2036
General Improvements	Implement a loss monitoring strategy. By continuously tracking losses, CELEC EP could pinpoint inefficiencies such as overloaded lines, aging equipment, or inefficient power factors. This data-driven approach could enable targeted upgrade.	1. Preparation and initial diagnosis consisting of an "energy inventory" and identification of energy performance indicators. 2. Training and internal culture on issues related to energy management, ISO 50001 requirements, integration of these requirements into internal procedures. 3. Implementation of supervision tools, such as continuous measurement systems for electricity consumption, their integration into platforms that facilitate reporting and analysis. 4. Establish a system of periodic energy audits. 5. Document management and processes. Adapt and create O&M procedures aligned with ISO 50001 requirements. Define an action plan with short- and medium-term energy efficiency goals.	2031	2036

Theme	Intervention	Enabling Actions	Start Year	Completion Year
Plant Efficiency Measures	Conversion of plants from OCGT to CCGT. CCGT utilises waste heat from the gas turbine to generate additional electricity through a steam turbine. This dual-stage energy conversion process makes better use of the fuel's energy content and therefore reducing the fuel consumption per unit of electricity produced.	Identify plants where it is feasible to harness waste heat from gas turbines to implement a steam turbine and shut down the combined cycle.	2026	2031
General Improvements	Procure more energy from Peru, which has a cleaner electricity grid (powered through natural gas). Decommission older and higher polluting plants.	Execute the Ecuador - Peru 500 kV interconnection	2026	2031
General Improvements	Assess the operation and design efficiency of transmission infrastructure. Consider design efficiency by shortening transmission distances, building grid interconnectivity, and right-sizing infrastructure.	Identify the primary equipment in which it is feasible to carry out a replacement and/or technological update that allows reducing the use of polluting gases.	2026	2031
Plant Efficiency Measures	Improve combustion efficiency by pre-heating the fuel prior to combustion, this ensures that fuels burn more completely, leading to improved thermal efficiency and power output.	Identify the plants in which fuel preheating systems can be installed and/or optimized.	2026	2031
Plant Efficiency Measures	Perform an efficient HFO6 and diesel fuel blending process to improve fuel quality to decreasing unscheduled MCI unavailability and improve the efficiency of pre-fuel-injection boosters		2026	2031
Plant Efficiency Measures	Implement a fuel hierarchy which includes commitments / targets to move away from carbon-intensive fuels. For example, reduce the amount of residue oil used for combustion, transition operations to Fuel Oil 6 and eventually Fuel Oil 4. For plants that are compatible, convert engines to use natural gas instead (for example: Miraflores).	Implement a plan to change from heavy to light fuels for CELEC EP's electricity generation.	2031	2036
Plant Efficiency Measures	Currently, CENACE's decision making cost-based; CELEC EP could work with CENACE to incorporate information regarding which plants are carbon-intensive (less efficient) into decision-		2026	2031

Theme	Intervention	Enabling Actions	Start Year	Completion Year
	making, and opt to reduce the use of thermal plants when sufficient hydroelectric power is available.			
Thermal Requirements	Opportunities to install pilot projects, e.g. floating solar arrays that can be used to increase the proportion of energy that is delivered by renewables in Ecuador. Increasing the capacity of renewables could allow the older, less efficient thermal plants to be shut down / reduce operations.	Manage the development of studies for renewable projects complementary to CELEC EP's power plants.	2031	2036
Plant Efficiency Measures	Produce a digital twin of the plant systems to optimise the throughput of all systems and processes within plant. This would allow operators to run simulations and predict potential failures before they occur. By analysing data from sensors and equipment, the digital twin can help make informed decisions and to sine-tune processes for better energy use.	1. Training and internal culture on issues related to digitalization. 2. Preparation and collection of information on the facilities to be digitized. Identification of critical facilities. 3. Implementation of tools for the digitization of the systems identified as critical. 4. Create procedures for the simulation of the facilities. 5. Define a periodic test plan for the simulated models.	2026	20351
General Improvements	"Cold" reserve of the power transformers. This strategy could help prevent overloading of operational transformers and allow the system to operate closer to optimal load levels. Cold reserve reduces transmission losses and support a more efficient and stable power delivery across the grid.	Continue with the analysis of the Transmission Expansion Plan.	2031	2036
General Improvements	Map and optimise grid network to identify and overcome bottlenecks / pinch points where there are inefficiencies in the network.	Compliance with the Transmission Expansion Plan.	2031	2036
General Improvements	Transition fleet of vehicles to be electric, switch to hybrid vehicles where full electric conversion is not feasible.	Aligned with the National Energy Efficiency Plan (PLANEE) Aligned with the Sustainable Mobility Plan of the Electricity Sector Develop a plan to replace the fleet of fossil fuel vehicles with electric vehicles	2026	2031

Theme	Intervention	Enabling Actions	Start Year	Completion Year
Plant Efficiency Measures	Install carbon scrubbers on exhaust chimneys, especially in the larger, less efficient plant. This captures carbon and will reduce combustion emissions.	Carry out a technical-economic study of the best alternatives for the installation of carbon filters in the exhaust chimneys of CELEC EP's thermoelectric power plants, considering the particularities of each case (geographical location, operating time, fuel, technology, among others).	2031	2036
Increasing Renewable Output	Opportunity to install turbines in spillway channels for downstream dams that need to maintain ecological flow.	1. Contract pre-feasibility and feasibility studies for the design, supply, installation and commissioning of the turbine downstream of the MLDW Power Plant.	2036	2050
Capacity Increase	Expansion of renewables to reflect CELEC EP's Generation Expansion Plan (2023-2032).	Feasibility assessment to ensure operation of target sites is secured as defined in the plan. This also assumes there will be no challenges in securing the right levels of capital investment	2025	2032
Capacity Increase	Expansion of renewables to reflect CELEC EP's Generation Expansion Plan beyond 2032, including the pre-feasibility plant, including LA UNIÓN.	Feasibility assessment to ensure operation of target sites is secured as defined in the plan. This also assumes there will be no challenges in securing the right levels of capital investment	2032	2050

Appendix E. Modelling Assumptions

E.1 Baseline

Table E-1 - Baseline Modelling Assumptions

Scope	Category	Assumptions/Exclusions
Scope 1	**Power plants**	For the baseline year 2024, we have used the below conversion factors[22] as published by the US Environmental Protection Agency, for different types of fuel to CO_2 equivalent: • For petrol consumption: 2.3278 $kgCO_2e$/litre petrol • For diesel consumption: 2.7438 $kgCO_2e$/litre diesel • For natural gas consumption: 0.0545 $kgCO_2e$/kcf natural gas • For fuel oil no 4 consumption: 2.9049 $kgCO_2e$/litre fuel oil no 4 • For fuel oil no 6 consumption: 2.9868 $kgCO_2e$/litre fuel oil no 6 • For residue consumption: 2.9868 $kgCO_2e$/litre residue These values have been validated through a desktop review and cross-referencing exercise, including sources such as the EIB's and the Department for Energy Security and Net Zero (DESNZ) data methodologies. AtkinsRéalis have adopted the US-based carbon factors published from the US EPA as they represent the most recent and geographically relevant emissions factors suitable for international application.
	Buildings	No activity data associated with fuel consumption or refrigerant leaks has been provided and therefore included in this assessment

[22] US Environmental Protection Agency, Emission Factors for Greenhouse Gas Inventories. Available at: https://www.epa.gov/system/files/documents/2025-01/ghg-emission-factors-hub-2025.pdf

Scope	Category	Assumptions/Exclusions
	Car fleet	For the baseline year 2024, we have used the below conversion factors[22] as published by the US Environmental Protection Agency, for different types of fuel to CO_2 equivalent: • For petrol consumption: 2.3278 $kgCO_2e$/litre petrol • For diesel consumption: 2.7438 $kgCO_2e$/litre diesel These values have been validated through a desktop review and cross-referencing exercise, including sources such as the EIB's and the Department for Energy Security and Net Zero (DESNZ) data methodologies. AtkinsRéalis have adopted the US-based carbon factors published from the US EPA as they represent the most geographically relevant emissions factors available.
Scope 2	**Electricity Distribution Network**	Transmission & Distribution (T&D) losses were excluded from this assessment, as the vast majority (estimated at 80-90% as provided by CELEC EP, depending on the season) of the electricity transmitted by CELEC EP is self-generated. While a portion of electricity is fed into the grid by other producers, associated losses are note expected to be material. High voltage transmission typically results in minimal energy loss, and given the small share of third-party generation, the impact on the overall GHG emissions footprint is considered negligible.
	Electricity Consumption	Since CELEC EP generates 100% of the electricity it consumes, and owns and operates its own transmission infrastructure, its Scope 2 emissions are reported as zero. However, any efficiency gains or reductions in electricity consumption remain important. These will be factored into the decarbonisation roadmap, as lower electricity demand will directly reduce Scope 1 emissions - by decreasing the amount of energy CELEC EP needs to generate.

E.2 Business-As-Usual (BAU)

Table E-2 - BAU Modelling Assumptions

Scope	Category	Assumptions/Exclusions
Scope 1	**Power Plants**	To estimate fuel use for assets under construction, the HFO consumption of the Central Santa Elena II plant has been used as a proxy. This plant was selected because: ▪ Its nominal capacity (90.1 MW) closely aligns with two of the four assets under construction (planned capacities of 100 MW and 91 MW). ▪ Its plant factor (73%) falls within an operational range of 70–90%, which is assumed to be applicable for the new assets. All HFO-fired plants operate with a combination of diesel and HFO (types 4 and/or 6). It is assumed that the new assets will follow the same fuel mix and usage proportions as Central Santa Elena II. Specifically, HFO consumption is expected to be split evenly between HFO 4 and HFO 6 across these new facilities. Based on the above the below assumptions have also been used for the BAU modelling: ▪ Diesel and HFO consumption are projected to increase from 2025 onward, aligning with the commissioning of the new assets. ▪ Demand for other fuels (natural gas, petrol, residue) is assumed to remain constant through to 2050. ▪ Emission factors for all fuels are assumed to remain at their 2024 levels through the projection period. No decrease in plant generation capacity has been modelled in the BAU.
	Buildings	No financial commitments.
	Car fleet	No financial commitments.
Scope 2	**Electricity Distribution Network**	No financial commitments have been shared.
	Electricity Consumption	No financial commitments that could alter kWh consumption have been shared.

E.3 Decarbonisation

Table E-3 - Decarbonisation Modelling Assumptions

Scope	Intervention details	Assumptions/Exclusions
- Scope 1 Generation Capacity Increase in emissions	Expansion of CELEC EP thermal plant, increasing capacity through Esmeraldas IV, Duran, Santa Elena IV and La Concordia plant	- Assumes all pipelined expansion projects go ahead as outlined in the referenced document. - Assumes there are no barriers to unlocking capital investment to allow for construction and operation to occur as planned. - Assumes that an increase in CELEC EP'S thermal capacity will not directly enable CELEC EP to decrease the reliance on the more inefficient thermal power plant operation, as Ecuador's energy demand is assumed to rise in line with these new plant.
- Scope 1 Generation Capacity Increase in emissions	Expansion of renewables and thermal plant to reflect CELEC EP's Generation Expansion Plan (2023-2032).	- Assumes all pipelined expansion projects go ahead as outlined in the referenced document. - Assumes there are no barriers to unlocking capital investment to allow for construction and operation to occur as planned - Bloque 1 and Bloque 2 “Reposición Parque Termoeléctrico” were omitted from the model. - Assumes that an increase in renewable capacity will not directly enable CELEC EP to decrease the reliance on thermal power plant operation, as Ecuador's energy demand is assumed to rise in line with these new plant.
- Scope 1 Generation Capacity	Expansion of renewables to reflect CELEC EP's Generation Expansion Plan beyond 2032, including the pre-feasibility plant.	- Assumes all pipelined expansion projects go ahead as outlined in the referenced document. - Assumes there are no barriers to unlocking capital investment to allow for construction and operation to occur as planned. - Assumes that an increase in renewable capacity will not directly enable CELEC EP to decrease the reliance on thermal power plant operation, as Ecuador's energy demand is assumed to rise in line with these new plant.

Scope	Intervention details	Assumptions/Exclusions
N/A – This intervention was not considered in the model	Procure more energy from Peru, which has a cleaner electricity grid (powered through natural gas). Decommission older and higher polluting plants.	- During high hydrology periods (April - September), Ecuador would export ~450 GWh per month to Peru. - During lower Hydrology periods (October - March), Ecuador would import ~400 GWh per month from Peru. - This would lead to an increase in Scope 2 emissions, but allow for a decrease in the requirement of CELEC EP's thermal operations between October and March). This net-export of 50 GWh of electricity is assumed to already be covered by the company's increase in generation capacity, and was not modelled.
- Scope 1 Mobile Combustion Emissions Decrease	Transition fleet of vehicles to be electric, switch to hybrid vehicles where full electric conversion is not feasible.	- The timeframes for the rollout of this intervention have been extended through to 2036 to allow for the infrastructure availability to improve in Ecuador. - A 50% transition to electric vehicles (EVs) have been assumed, with the remaining 50% of vehicles transitioning to plug in hybrid vehicles (PHEVs). - Emission factors for each vehicle class have been taken from the 2025 DESNZ emissions factor library, to outline the potential savings from this intervention.
- Scope 1 Emissions Decrease	Conversion of plants from OCGT to CCGT. CCGT utilises waste heat from the gas turbine to generate additional electricity through a steam turbine. This dual-stage energy conversion process makes better use of the fuel's energy content and therefore reducing the fuel consumption per unit of electricity produced.	- Start date of intervention pushed back to 2027 to allow for sufficient planning. - Only applicable for Termomanabi (Miraflores TG1 plant), Termogas Machala (Gas Machala I and Gas Machala II) and gas turbines at Electroguayas. - Miraflores TG1 plant is currently not in operation, it is assumed that it will be brought online by 2027 and converted to a CCGT using natural gas. This will lead to an increase in capacity as well as Scope 1 emissions. - Rate of uptake assumed to be linear over the 5-year period, to represent a 'phased' approach to bringing these plants online.

Scope	Intervention details	Assumptions/Exclusions
N/A - This intervention is already present within the relevant Business Units	Perform an efficient HFO6 and diesel fuel blending process to improve fuel quality to decreasing unscheduled MCI unavailability and improve the efficiency of pre-fuel-injection boosters	
N/A - This intervention is already present within the relevant Business Units	Improve combustion efficiency by pre-heating the fuel prior to combustion, this ensures that fuels burn more completely, leading to improved thermal efficiency and power output	
- Scope 1 Emissions Decrease	Improve monitoring of system processes through metering and energy audits. Consider aligning processes with ISO 50001 (Energy Management). The standard provides a framework for assessing energy management and increase efficiencies in operations. A further stage could involve getting certified to the standard, which could show the commitment of the company with energy management. Produce a digital twin of the plant systems to optimise the throughput of all systems and processes within plant. This would allow operators to run simulations and predict potential failures before they occur. By analysing data from sensors and equipment, the digital twin can help make informed decisions and to sine-tune processes for better energy use.	- Applicable for plant at Electroguayas, Termoesmeraldas, Termogas Machala and Termopichincha. - It is assumed there is a maximum efficiency improvement of 5% that can be achieved by this intervention. A linear rate of uptake across the time period has been assumed to reflect the gradual efficiency improvements across all plant. - Given the nature of CELEC EP's energy provision relationship with CENACE, it is assumed that any efficiency improvement enables CELEC EP to use less fuel. This is because CENACE state the amount of energy required by each plant facility at any given time.
N/A - To be classed as an enabling action - no direct benefit modelled	Assess the operation and design efficiency of transmission infrastructure. Consider design efficiency by shortening transmission distances, building grid interconnectivity, and right-sizing infrastructure.	
N/A - To be classed as an enabling action - no direct benefit modelled	Currently, CENACE's decision making cost-based; CELEC EP could work with CENACE to incorporate information regarding which plants are carbon-intensive (less efficient) into decision-	

Scope	Intervention details	Assumptions/Exclusions
	making, and opt to reduce the use of thermal plants when sufficient hydroelectric power is available.	
- Scope 1 Emissions Decrease	Implement a fuel hierarchy which includes commitments / targets to move away from carbon-intensive fuels. For example, reduce the amount of residue oil used for combustion, transition operations to Fuel Oil 6 and eventually Fuel Oil 4. For plants that are compatible, convert engines to use natural gas instead (for example: Miraflores)	- Applicable to Electroguayas, Termopichincha, Termoesmeraldas and Termomanabi plant. - Fuel hierarchy involves the gradual transition from heavy fuel oils towards cleaner, more efficient fuels. - Assumes Ecuador will have sufficient availability and purchasing power to leverage refineries to provide desired fuel types and quantities. - Rate of uptake is assumed at a linear rate to allow for transition planning. - Fuel Hierarchy - Residue Oil -> HFO 4 - HFO6 -> HFO 4 - HFO 4 -> Diesel / HFO 4 (50:50 Blend) - Diesel -> Natural Gas / Diesel (70:30 Blend)
- Scope 1 Emissions Decrease	Install Waste Heat Recovery systems to maximise energy conversion within steam generations processes (e.g. coolant loops). These systems capture and reuse heat that would otherwise be lost during the energy conversion process. The recovered heat can be used to produce additional electricity or to power other processes within the plant, reducing the need for extra fuel and lowering the overall energy consumption.	- Applicable to Termogas Machala Units and all plant at Termopichincha. - A linear rate of uptake across the time series has been assumed to allow for sufficient design planning. - A 0.9% increase in energy conversion has been assumed, based on a review of supporting documents. Any increase in efficiency leads to a direct reduction in fuel consumption and thermal emissions, as demand is decreased proportionally.
- Scope 1 Emissions Decrease	Use of oxygen-enriched flue gases / oxygen lancing in combustion chamber. By increasing the concentration of oxygen in the combustion air, fuels burn more completely, leading to improved thermal efficiency.	- Oxygen enrichment in combustion chambers at 30 mol% can reduce fuel consumption by 8% (as per referenced source). - Intervention applied at a linear rate across the time series to allow for sufficient design planning. - Assumed Ecuador will have sufficient infrastructure and supply chains to allow this intervention to become fully realised

Scope	Intervention details	Assumptions/Exclusions
		- Applies to: Central Esmeraldas I, and all plant within Termopichincha.
N/A - This intervention is already present within the relevant Business Units	Where it is not possible to install oxygen injection to the combustion chamber, install turbochargers to increase the amount of airflow to the combustion chamber, leading to improved fuel combustion	
- Scope 1 Emissions Decrease	Install carbon scrubbers on exhaust chimneys, especially in the larger, less efficient plant. This captures carbon and will reduce combustion emissions	- This intervention only applies at Termoesmeraldas for the Central Esmeraldas I plant. - Intervention has been applied at a linear rate across the time series to allow for sufficient intervention planning. - The installation of carbon scrubbers is anticipated to extract up to 40% of the CO_2 emissions from flue / exhaust emissions (as per reference material).
N/A - This intervention is already present within the relevant Business	Opportunities to install pilot projects, e.g. floating solar arrays that can be used to increase the proportion of energy that is delivered by renewables in Ecuador. Increasing the capacity of renewables could allow the older, less efficient thermal plants to be shut down / reduce operations	
N/A - This intervention is already being applied at relevant sites / facilities as part of maintenance regime and pipeline of projects	Replace aging, inefficient models with newer high efficiency furnaces to maximise plant lifespan, reduce energy losses, and enhance combustion performance. Older furnaces often suffer from wear, corrosion, and outdated designs that limit heat transfer and increase fuel combustion. Modern furnace technologies offer better insulation, advanced burners, and improved control systems that ensure more complete fuel combustion and optimal heat distribution.	
N/A - This intervention is already being applied at relevant	Upgrade network transformers. Modern transformers are designed with advanced materials and improved core designs that minimise resistive and magnetic	

Scope	Intervention details	Assumptions/Exclusions
sites / facilities as part of maintenance regime and pipeline of projects	losses. These upgrades can lead to more efficient voltage regulation, lower heat generation, and enhanced load-handling capabilities.	
- Increase in generation capacity through renewable sources	Opportunity to install turbines in spillway channels for downstream dams that need to maintain ecological flow	- It is assumed that the additional capacity will have insignificant effect on the operation of CELEC EP's thermal facilities, therefore no direct decrease in emissions have been modelled. - Assumes 100% uptake of the intervention from the start date. - Does not take into account the seasonal variation in water availability, which would determine how often the spillway channels are operational for energy production. - Primary impacts include increasing the total generation capacity for CELEC EP, which will further contribute to the share of renewable-derived energy sources. - Applicable for: - Minas San Francisco - Agoyan - Pucara - Central San Francisco
- Scope 1 Emissions Decrease	Implement a loss monitoring strategy. By continuously tracking losses, CELEC EP could pinpoint inefficiencies such as overloaded lines, aging equipment, or poor power factors. This data-driven approach could enable targeted upgrade.	- This intervention's impacts are experienced across all of CELEC EP's facilities, reducing the requirement for additional fuel combustion due to higher transmission efficiencies and lower network losses - Rates of network enhancements are aligned with Ecuador's 2023-2032 Electricity Master Plan, reaching a maximum decrease in losses of 9%
- Scope 1 Emissions Decrease	Replace emissions-intense thermal plant with an intensity of >0.75 tCO_2e/MWh with renewable energy	
- Scope 1 Emissions Decrease	Replace emissions-intense thermal plant with an intensity of >0.70 tCO_2e/MWh with renewable energy	

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