Availability, Affordability & Adequacy of Energy for Mining & Metals

Brazil

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Diego Araujo Campos
Head of Energy and Mining | Embassy of Brazil in Lisbon
diego.campos@itamaraty.gov.br

The views expressed herein are the author's own and do not represent the official position of the Brazilian Government.

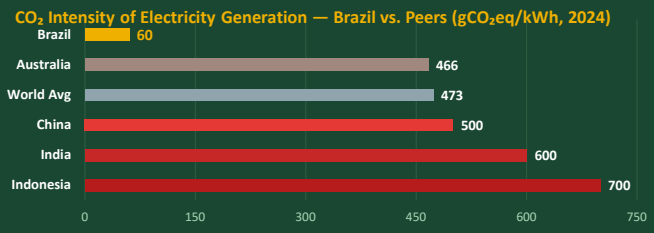
Panorama — Resilience Through a Multi-Tech Grid

2026 GRID
88.2%
Renewable electricity

NEW FIRM CAPACITY
19 GW
Contracted in 2026 (ANEEL/EPE)

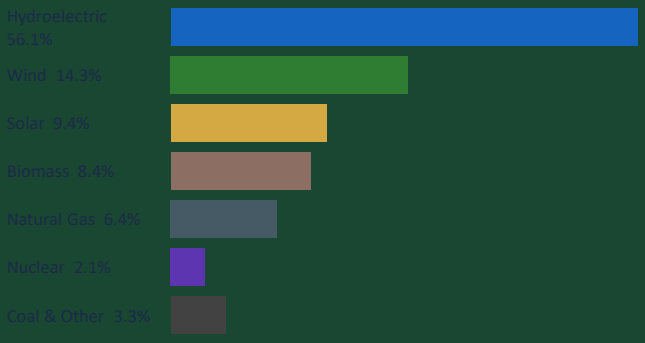
MIX
38%
Solar & Wind (intermittent)

62%
Baseload: Hydro, Gas & Nuclear



Sources: *CO_2 intensity — Ember Global Electricity Review 2025 (ref yr 2024) | 88.2% grid composition — EPE BEN 2025 (ref yr 2024) | 19 GW LRCAP — ANEEL/EPE, Mar 2026*

Brazil's Electricity Matrix (2024)



Source: EPE — BEN 2025 (ref. 2024) | World avg. renewables: ~30% (IEA, 2024)

Availability: Strengths & Challenges

STRENGTHS

- 209 GW installed — largest in Latin America (ANEEL, 2024)
- ~60 gCO_2/kWh — lowest carbon intensity in G20 (Ember, 2025)
- NE wind peaks in dry season — naturally complementary with hydro

CHALLENGES

- Drought risk reduces hydro dispatch (2021, 2024)
- Grid congestion in NE; CDE charges add 20–35% above generation cost

Peer Countries | Renewable Generation Share (2024)

Country	RE Gen. % (2024)	Main Source	RE Advantage for Mining?
Brazil	88%	Hydro + Wind + Solar	HIGH ★
Canada	67%	Hydro dominant	MED-HIGH
Chile	70%	Hydro + Solar + Wind	HIGH
Australia	36%	Solar + Wind	MEDIUM
South Africa	~17%	Coal ~82%; Solar+Wind growing	LOW
Indonesia	~19%	Coal ~62%; Geothermal + Hydro	LOW

Sources: EPE BEN 2025; ANEEL Jan 2025; Ember Global Electricity Review 2025; InvestChile / CEN 2024 (Chile 70%); Clean Energy Regulator Q4 2024 (Australia 36%); Canadian Centre for Energy Information 2025; IEA Africa Energy Outlook 2024

Affordability: Cost Competitiveness

I. The "Green" Cost Edge

- 88% renewable grid = natural hedge vs. LNG/coal price volatility *(EPE, BEN 2025)*
- CBAM advantage: low-carbon grid reduces EU carbon border levy for Brazilian mineral exporters *(European Commission, Reg. 2023/956)*

II. Free Market (ACL)

- ACL buyers save 20–30% vs. regulated tariffs; long-term contracts match mine production cycles *(Abraceel, 2024; CCEE)*

III. Self-Generation

- Vale: 100% renewable in Brazil since 2023 (Sol do Cerrado, 766 MWp; 2.6 GW portfolio). CDE exemption for self-generators reduces energy bills 15–20% *(Vale 2023 Integrated Report; ANEEL Res. 1,000/2021)*

Sources: *EPE BEN 2025 | European Commission Reg. 2023/956 (CBAM) | Abraceel (2024) | CCEE | Vale 2023 Integrated Report | ANEEL Res. 1,000/2021*

Adequacy: Reliability & Future Capacity

I. SIN Grid Architecture

- 185,000+ km of HV lines serving ~99% of load; hydro reservoirs act as multi-week dispatchable storage (ONS)

II. Seasonal Risk Mitigation

- 2021 drought: 91-year record drove prices up 50%+. NE wind (peaks Jun–Dec) now offsets dry-season hydro gaps (Reuters / Ember)

III. Capacity Pipeline

- 10.9 GW added in 2024 — 91% wind or solar, record high (ANEEL). Offshore wind: 244 GW pipeline, Law 15,097/2025

Sources: *Ember 2025 | Reuters 2021 | ANEEL Jan 2025 | MME/Official Gazette Apr 2026*

Adequacy: Nuclear & Natural Gas Backbone

IV. Nuclear: Baseload Insurance

- Angra 1 & 2 (~1.9 GW net); Angra 1 licence extended 20 yrs (CNEN, 2024)
- Angra 3 (65% built, 1,405 MW): decision pending — Lula set mid-2026 deadline (BNDES cost: BRL 23.9B)
- SMR roadmap with Rosatom (MME, 2025); Brazil endorsed tripling nuclear by 2050

V. Natural Gas: Path to Self-Sufficiency

- Pre-salt output: 193 MMm³/day (Jan 2026, ANP) — but ~56% reinjected; Bolivia contract expires 2026
- Domestic routes (Raia 2028, SEAP I/II 2030) replace Bolivian volumes; US/Qatar LNG as backup (~6% of grid, IEA 2024)

Sources: *CNEN/Eletronuclear (2024) | BNDES (Nov 2025) | ANP (Jan 2026) | IEA (2024)*

Policy & Regulatory Landscape

I. National Energy Transition Plan (PNTE)

- PDE 2034: 85%+ renewables sustained; 115 GW new capacity; R$2T investment over the decade (MME/EPE)
- 2035 NDC: 59–67% net GHG cut vs. 2005, submitted at COP29 (UNFCCC, Nov 2024)

II. Green Hydrogen Framework (2024)

- Law 14,948: Rehidro tax suspension (2025–2029) + BRL 18.3B PHCB credits (2028–2032, Law 14,990)

III. Regulated Carbon Market (SBCE, Dec 2024)

- Law 15,042: Brazil's first cap-and-trade; covers >25,000 tCO_2e/yr emitters; full rollout ~2030
- Offshore Wind Law 15,097 (Jan 2025): 244 GW pipeline; Open Carbon Coalition at COP30 Belém (18 countries)

Sources: *MME/EPE PDE 2034 | UNFCCC NDC (Nov 2024) | Law 14,948/2024 | Law 14,990/2024 | Law 15,042/2024 | Law 15,097/2025*

Investment Opportunities

Green Hydrogen & Ammonia

- 18.9 Mt/yr H_2 potential (EPE); BRL 18.3B tax credits (2028–2032)
- Hubs: Pecém, Suape, Port of Açu — all in Export Processing Zones (ZPEs)

Green Steel & Industrial Decarbonisation

- MG "iron valley": eucalyptus charcoal = world's lowest-carbon pig iron (Brazil Report)
- Green H_2 DRI pathway attracting European steelmakers because of CBAM (EPE/RIFS-Potsdam)

Sources: *CMS Law (Nov 2024) | World Bank (Jul 2025) | Fastmarkets (Jan 2026)*

Critical Minerals Hub

- #1 niobium (~90% global supply), #2 rare earths & graphite, #6 lithium (IBRAM, 2026)
- US DFC: US$565M to Serra Verde; US$76.9B sector investment forecast 2026–2030 (IBRAM)

Sources: *IBRAM (Oct 2025)*

Key Challenges & Risks

I. Transmission Bottleneck

- 20.6% of solar & wind wasted in 2025 = BRL 6.5B in losses; NE corridors saturated (Volt Robotics / Rystad)
- Fix: 15,000 km new lines + BRL 56B by 2030; but 96% of curtailment may be demand-side by 2029 (ONS, EPE)

II. Hydro-Climate Vulnerability

- 2021 drought: spot prices +50%; ~70% of untapped hydro is in Amazon protected areas — politically unviable (Trade.gov)

III. Regulatory & Cost Distortions

- SBCE carbon market: full operationalization targeted ~2030 — no price signal until then (ICAP, Dec 2024)

Sources: *Volt Robotics (Feb 2026) | EPE/pv-magazine (Sep 2025) | Trade.gov (Aug 2025) | INESC/Absolar (2023) | ICAP (Nov 2024)*

Recommendations & Strategic Outlook

1. **Accelerate grid expansion.** Front-load EPE's BRL 56B plan — prioritise NE-to-SE HVDC corridors. 20.6% curtailment = highest-ROI policy action available.
2. **Deploy utility-scale storage.** Execute ANEEL/ONS BESS auction (Apr 2026). By 2029, 96% of curtailment will be demand-side — storage is essential.
3. **Operationalise green hydrogen.** Finalise PHCB/Rehidro rules. NE stranded generation monetised via H_2 hubs (Pecém, Suape, Açu) directly reduces curtailment.
4. **Reform energy tariffs.** Introduce time-of-use tariffs and demand-response.
5. **Develop critical minerals value chain.** Scale the Serra Verde / US DFC model (US$565M) for rare earths, lithium & niobium. Streamline licensing; advance BNDES FIP fund.

Sources: (1) EPE, PDE 2034 — BRL 56B / 15,000 km NE–SE HVDC (2028–30); curtailment, Intersolar 2025. (2) MME/ANEEL/ONS, LRCAP-2026 — first BESS auction, 2 GW, Apr 2026; 10-yr contracts (MME Consultation, Nov 2025). (3) INESC (Nov 2024) — fossil subsidies 4.52× renewables in 2023 (BRL 81.7B vs BRL 18.1B). (4) MME / PHCB & Rehidro — Lei 14.948/2024 (Green H_2); hubs Peçém, Suape, Açu. (5) Serra Verde / US DFC — US$565M financing (Feb 2026); Pela Ema rare earths, Goiás. (6) BNDES FIP Mineração Estratégico — lithium & niobium value-chain fund.

Thank You

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