27th World Mining Congress
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INSTITUTO DE INGENIEROS DE MINAS DEL PERÚ

# WORLD MINING CONGRESS

**Luis Miguel Castilla, 2026**

# Natural Gas and Mining in Peru
## A balanced energy transition strategy

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STARTING POINT

# The dual challenge of Peruvian mining

The energy transition raises demand for critical minerals while, at the same time, requiring lower emissions. Peru must expand production and decarbonize without losing what makes it competitive: **low cost**.

### More minerals

copper, lithium, nickel and rare earths: global decarbonization depends on what Peru produces.

### Fewer emissions

ESG frameworks, investor mandates and NDCs push to cut emissions while production scales up.

### Without losing cost

unlike Canada or Australia, Peru's advantage is anchored in low costs, not in institutions.

**Energy is at the heart of the challenge.** Being cheap is not enough: it must be reliable, dispatchable and predictable across a mine's investment horizon

SECTION 2

# Energy as a condition of viability

**Mining is energy-intensive**: extraction, haulage, processing and ventilation require continuous energy. Energy shifts from an operating variable to a strategic determinant of the project.

**15%-40%**
of operating costs is energy — often exceeding labor cost.

**7x**
more energy per unit when copper grade falls from 0.4% to 0.2%.

**+100%**
more fuel consumption per tonne of copper as ore grades decline.

## Reliability is not a preference, it is a binding condition

A cheap but unreliable and non-dispatchable source is not, in practice, a viable solution. Brief interruptions halt processes, disrupt value chains and hit revenue directly.

SECTION 3

# Natural gas: a system enabler

**Gas does not compete with renewables: it enables them.**

It provides firm, dispatchable capacity that stabilizes the system and makes integrating variable energy operationally viable, reframing the false “renewables vs. gas” dilemma.

## Firm capacity

Controllable output, independent of weather: ensures grid stability, covers peak demand and sustains industrial continuity.

## Operational flexibility

CCGT for efficient large-scale generation; OCGT for rapid response to peaks and contingencies. Together, a flexible backbone.

## Cost predictability

Combines firm capacity with stable costs, reducing exposure to volatility and to oversizing the system.

***The world's second-largest source of power generation (>1/5 of the total) and the lowest-emission fossil fuel.***

SECTION 3

# Firm capacity and economics of the system

## An advantage with a time window

The case for gas is strongest in the short-to-medium term, **≈2026–2035**, and weakens as battery storage matures.

**Supply chain dependence**. Gas reliability is only as strong as the network that delivers it. The crises in Europe (2022) and Texas (2021) confirm this.

**The gap between available gas and deliverable energy is where Peru's argument is most vulnerable — and where investment is most urgent.**

**200-300 MW**

of firm, dispatchable capacity is required for every GW of variable renewables installed — even with storage.

**-30 to -40%**

of total system cost with 15–25% firm gas capacity, versus 100% renewable systems with massive storage.

SECTION 4

# The structural advantage: Camisea and the grid mix

Peru's grid mix combines hydropower as a base, gas as firm backup and expanding renewables (~1,260 MW under construction in early 2026). An uncommon complementarity among mining jurisdictions.

## Camisea creates advantage across three dimensions

### Cost and predictability

Regulated prices (below international prices) and lower dependence on imported fuels stabilize margins.

### Reliability

Dispatchable gas generation that reduces the risk of supply interruption.

### Decarbonization pathway

Displaces more carbon-intensive fuels (diesel) and provides flexibility to integrate renewables.

**Structural unknown to watch:** Camisea's reserve horizon. If production declines before 2040, the entire hybrid architecture requires review and an accelerated timeline. Monitoring reserves and upstream investment (blocks 57, 58, 88) is a policy priority.

CORE ANALYSIS

# Three 2030 grid-mix scenarios for mining

| Indicator | High-gas | Balanced hybrid | Accelerated renewable |
|---|---|---|---|
| Gas share | 35-40% | 25-30% | 20-25% |
| Renewables (wind+solar) | 20-25% | 25-35% | 35-40% |
| Hydropower | 35-40% | 35-40% | 28-35% |
| System cost index | 0.85 | 1.00 | 1.30-1.45 |
| Indicative price (USD/MWh) | 40-45 | 45-50 | $5-60 |
| Reliability risk | Low | Low-medium | Medium-high |
| Scope 2 reduction vs. 2024 | ~2% | ~40% | ~60% |
| Infrastructure readiness | High | Medium | Low |

*The balanced hybrid achieves ~40% emissions reduction at a system cost equal to or lower than the high-gas case, without the reliability risks of the accelerated scenario. Infrastructure readiness is the binding short-term constraint.*

SECTION 4

# Benchmark international: lessons for Peru

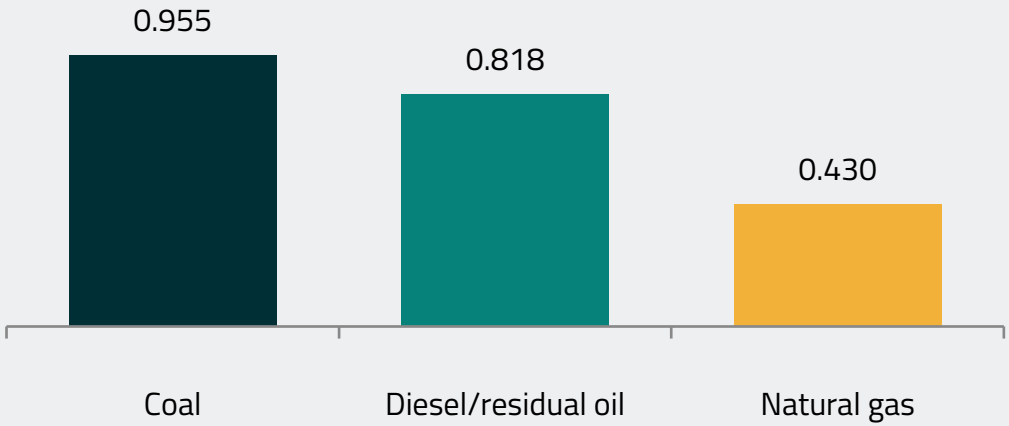
| Jurisdiction | Lesson for Peru | USD/MWh |
|---|---|---|
| **Chile** | High renewable penetration demands parallel infrastructure; speed without flexibility creates new costs. | 166 |
| **Colombia** | Even low-carbon systems need dispatchable backup; reliability cannot be assumed. | 203 |
| **Canada** | Modular solutions and LNG close remote gaps, but scale remains a challenge. | 108 |
| **Australia** | Domestic gas as a price anchor works, but requires long-term contracts. | 240 |
| **Peru** | A real but conditional advantage — value-chain integrity and infrastructure investment are the decisive variables. | 162 |

***Consistent pattern: structural advantages are worth only as much as their execution. Chile's renewable success created new constraints; Colombia's hydro dominance, new vulnerabilities. Peru's gas advantage follows the same pattern absent investment.***

SECTION 5

# Decarbonization: quantified impact

## $CO_2$ emission factor — power sector ($tCO_2/MWh$)




*Gas emits ~55% less $CO_2$/MWh than coal and ~47% less than diesel.*

**101.7 Mt $CO_2e$**

emissions avoided with natural gas (2005–2030) — a 20.9% reduction versus the no-gas scenario.

### Reduction of pollutants (2005-2030)

| 92.0% | 76.4% | 62.8% |
|---|---|---|
| $SO_2$ | PM 2.5 | $NO_x$ |

**Social co-benefit.** Lower $NO_x$, $SO_2$ and particulate matter improves air quality in underground mining and communities — a direct factor in sustaining the social license in Peru.

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Source: Libélula (2024), commissioned by the Camisea Consortium; data from the official national energy balance.

SECTION 5

# Decarbonization: quantified impact

## The advantage is conditional on three things

1. **Physical availability**
   of gas through a resilient supply chain.
2. **Sustained investment**
   In infrastructure with sufficient redundancy
3. **Clear sequencing**
   That preserves optionality toward cleaner technologies

***Without these conditions, the advantage erodes into vulnerability.***

## Key risk register

**Methane leakage:** Non-negotiable. The climate benefit disappears if leakage exceeds ~3.2%. Well-to-burner MRV is a prerequisite.

**Supply chain:** Pipeline dependence creates exposure to outages. Invest in pipelines, storage and LNG alternatives.

**Reserve horizon:** If Camisea declines before 2040, the advantage diminishes. Attract upstream investment and explore blocks 57/58.

**ESG threshold:** Investors with gas-exclusion policies. Demonstrate credible Scope 1/2 trajectories backed by MRV.

SECTION 6

# Roadmap for a balanced transition

## Phase 1: Foundation

**2026-2028**

***Reduce exposure to expensive fuels; build data and capabilities.***

- Reduce exposure to diesel. Greater efficient reserve
- Renewable PPAs with gas firmness mechanisms
- Auditable Scope 1 and 2 MRV systems
- Gap assessment across Camisea's value chain

## Phase 2: Scaling

**2029-2033**

***Strengthen flexibility and security; reduce fuel-based backup.***

- Scale generation with operational and contractual flexibility
- Expand CNG and LNG transport corridors
- Align new capacity with transmission and reserves
- Sustainability-linked financing with verified data

## Phase 3: Consolidation

**2034-2040**

***Optimize the grid mix; assess emerging technologies, secure progress***

- Optimize the grid mix based on observed performance and costs
- Integrate storage, green hydrogen and alternative fuels
- Strengthen reporting for ESG and regulatory requirements
- Position Peru as a competitive, low-carbon mining destination

SECTION 7

# Conclusions: a pragmatic strategy

1. **Gas is a system enabler.** The “renewables vs. gas” framing is unproductive.
2. **The gas endowment is a structural advantage.** Camisea and its regulated prices enable a lower-cost, more reliable hybrid.
3. **The advantage is conditional.** Availability, redundant infrastructure investment and clear sequencing. Today they are not fully met.
4. **Risks must be actively managed.** methane, lock-in, Camisea's horizon and the ESG threshold are not theoretical concerns.
5. **Mining plays a catalytic role.** as an anchor consumer, it improves the bankability of gas and renewable infrastructure.

***Peru's transition is defined not by the speed with which it replaces one source with another, but by its ability to design a system that aligns its advantages with the realities of decarbonization.***

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**Thank you**