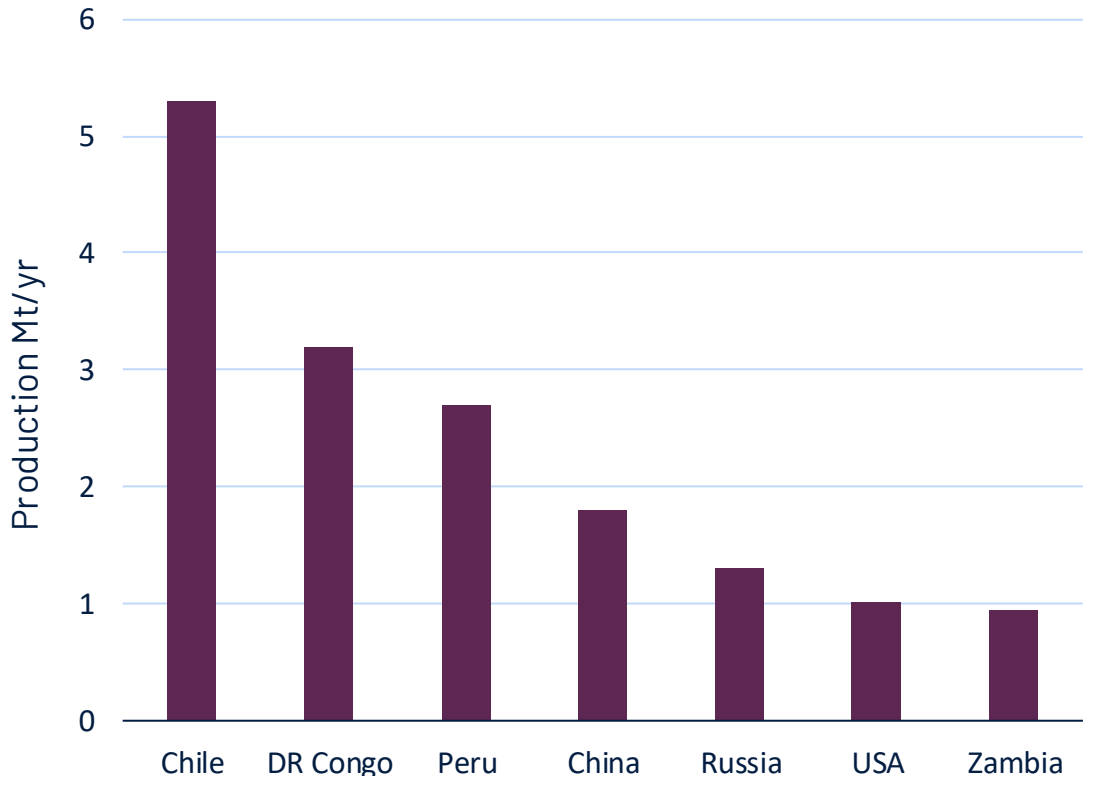
The Costs and Opportunities of the Energy Transition: Copper Mining in Zambia

Prof. Stephanie Hirmer, Associate Professor in Just Energy Systems, co-Lead Energy & Power Group

stephanie.hirmer@eng.ox.ac.uk

The energy transition is increasing demand for critical minerals

- Critical minerals **underpin elec. network expansion, RE and EVs**
- Africa holds **30% of global critical-mineral reserves**
- **42 of the 66 minerals** identified as needed for the energy transition are found in Africa
- Zambia, world's **7th largest copper producer** & 2nd largest in Africa
- Zambia plans to increase copper production from **~0.9 Mt to 3 Mt annually by 2031**



Global copper mine production, 2025 est.
From: US Geological Survey, *Mineral Commodity Summaries 2026*, Copper chapter, 2025 estimated mine production

Copper expansion: an electricity-system challenge and opportunity

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Growing demand

Copper expansion increases electricity needs for mining and processing.

Shared grid

Around half of Zambia's electricity consumption is linked to mining. Grid pressures affect other users too.

Renewable opportunity

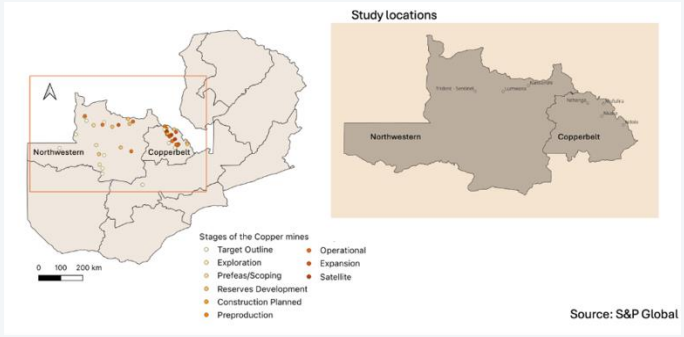
Mines can anchor renewable-energy investment—but shared benefits need grid integration.

Planning generation and transmission together can turn mining demand into wider energy-system benefits.

Understanding mining impacts across people, places and infrastructure

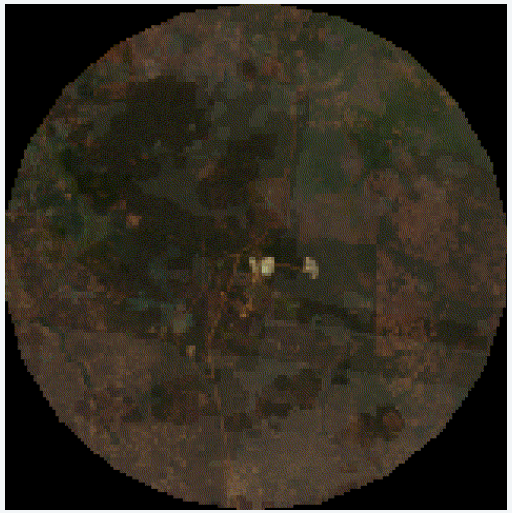
Community evidence

- 27 towns across the programme
- 500+ household interviews
- 27 focus groups / 168 participants
- 30+ key-informant interviews



Spatial evidence

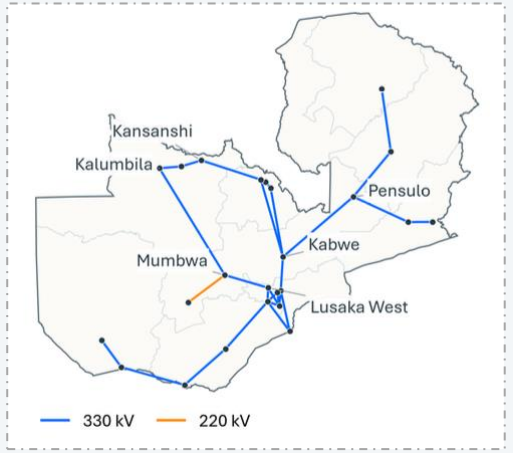
- Land-use change over time
- Mine–community proximity
- Spatial differences in exposure and impacts



Kansanshi GRP2 Chambishi

Electricity-system modelling

- 25 substation connection points
- 29 transmission routes
- 2,701 MW modelled mining peak demand
- 4 geographical demand scenarios



Evidence from multiple sectors is brought together into one government decision-support approach.

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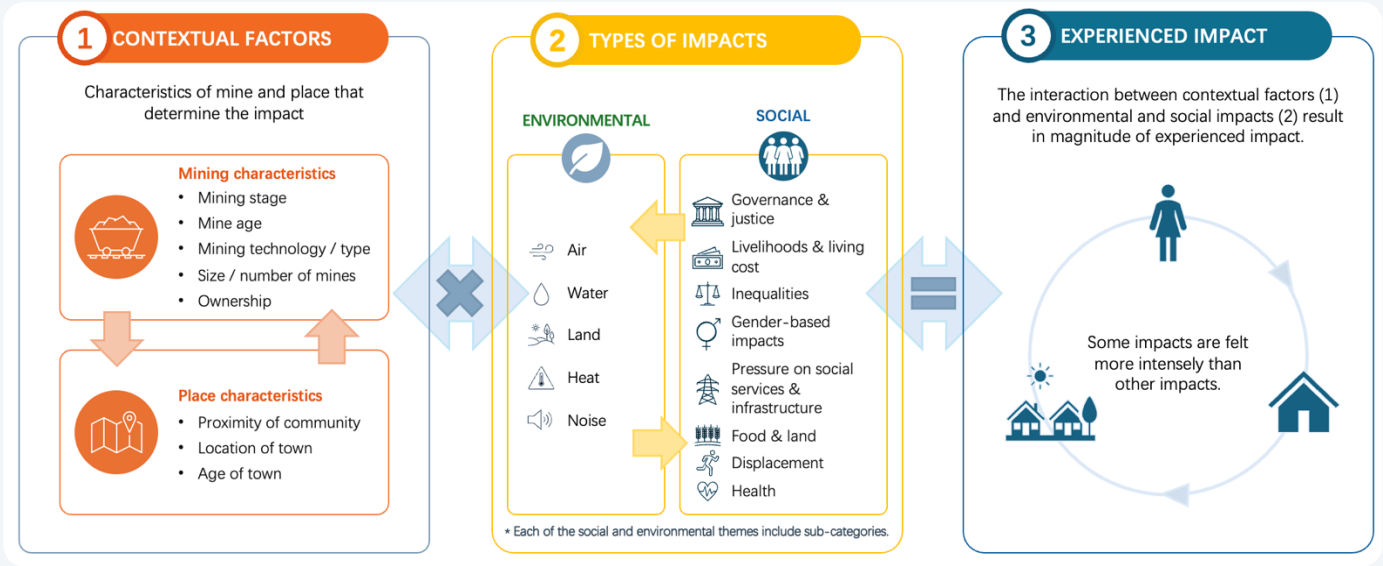
Build the evidence

Predict impacts

Community, spatial + infrastructure evidence
Learn + predict systems impact, e.g.,

- Emissions
- Power
- Water
- Land / environment
- Infrastructure
- Social risk

Place–based mining impact framework



Support decisions

Place shapes community impacts

Same copper. Different places. Different impacts.

Kalumbila
(Northern-Western Province)



Context
- *Newer mining development*
- *Rapid in-migration*
- *Proximity to mine*
- *Land-based livelihood*

Key impacts identified
- Land loss & displacement
- Inadequate compensation
- Rising cost of living

Kitwe
(Copperbelt Province)



Context
- *Long-established mining town*
- *High population density*
- *Economic dependence on mining*
- *Existing infrastructure pressures*

Key impacts identified
- Job insecurity
- Infrastructure pressure
- Inequality

Chingola
(Copperbelt Province)



Context
- *Long-established mining town*
- *Close proximity to mine*
- *Historical legacies of mining*
- *High population density*

Key impacts identified
- Air/noise pollution
- Respiratory impacts
- Housing damage

Mining impacts cascade across systems & affect people differently.

Health



- Proximity to mines shapes exposure to dust and pollution.
- Water concerns can increase health risks and household labour.

> *There is a lot of dust. Many people have persistent coughs and breathing problems, especially children.*
> *- Women, Chingola*

Education



- Informal copper recovery can compete with schooling for young men.
- Girls may experience interrupted schooling linked to early pregnancy or marriage.

> *Everything has become expensive [...],There is so much alcoholism, prostitution and spread of HIV. This has increased after companies have set up processing units.*
> *- Women , Solwezi*

Livelihood



- Mine households may gain purchasing power while others face rising prices.
- Land degradation can reduce future livelihood options.

> *The water we used to get is no longer the same. Sometimes it smells and we are worried about using it for our children.*
> *-Women, Kalumbila*

Infrastructure costs depend on location and design

More transmission investment can reduce wider electricity-system costs

$448m – Lower transmission expenditure in the North-Western scenario

$398m – Higher expenditure on additional power

- Mining location shapes electricity flows and network losses.
- Lower transmission investment can increase generation requirements.
- Modelled comparison against the initial mining-demand allocation, not observed expenditure.

Plan generation, transmission and voltage support together — not as separate budgets.

Mining demand could anchor shared renewable investment

UP TO 47%* lower modelled solar LCOE for selected Zambian mines versus sovereign financing

- Large mining loads and long-term purchases can underpin bankable renewable projects.
- Some mining firms have a financing advantage relative to sovereign borrowers.
- Grid-connected generation could also serve other businesses and households.



Critical material mining in Africa (a) Africa's 259 operating mines (b) Zambia's Copperbelt region. (c) primary commodity (# of mines) and origin of largest shareholder (in %)

*21 Zambian mines show potential savings; institutional design determines who benefits.

Two levels of decision-making, one development challenge

Upstream investment choices and locally tailored responses need to reinforce one another.

Upstream: shape the conditions

- Mining location and licensing
- Generation and transmission investment
- Power-market access and financing
- Shared infrastructure obligations

Local: shape the outcomes

- Environmental and social safeguards
- Livelihoods, health and services
- Community participation and accountability
- Capacity to monitor and enforce

From anticipating impacts to place-based policy responses

NATIONAL | Shape investment	LOCAL | Anticipate impacts
Plan infrastructure together • Coordinate mining expansion, generation and transmission investment. **Build shared benefits into rules** • Use concessions and market arrangements to enable mine-backed renewable power that serves the wider grid.	**Identify location-specific risks** • Assess mine characteristics, ownership, proximity, livelihoods and existing services. **Tailor and resource responses** • Target GBV prevention and reporting, livelihood safeguards, environmental monitoring and service provision.

EVIDENCE → ANTICIPATE → DESIGN → MONITOR

From anticipating impacts to place-based policy responses

1) Strengthen environmental & social safeguards
2) Govern across systems, not sectors
3) Anticipate who bears the costs—and who captures the benefits
4) Enable sub-national governance to respond to place

Place-based impacts require place-based governance.

NATIONAL
Sets frameworks, standards and priorities

↓

SUB-NATIONAL
Identifies local impacts, inequalities and opportunities

↓

CAPACITY TO ACT
Mandate, evidence, resources, enforcement capacity

National averages can tell us how mining is developing; local evidence tells us where intervention is needed and for whom.

The transition is global.
Its costs are local—and unequal.



stephanie.hirmer@eng.ox.ac.uk