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Article

# Cordless Battery-Powered Tools in Urban Construction: Environmental and Operational Impacts in Brazil

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## Abstract

As constructions in cities transition from corded to cordless power tools, they navigate a complex balance of ecological impacts with practical benefits. This study examines influences on this shift on safety, lifecycle considering electricity demand at construction sites across São Paulo, Brazil. We analyzed data from 12 sites using the MECO framework (Materials, Energy, Consumption, Others) to compare conventional corded tools with battery-powered alternatives. While cordless tools resulted in 23% fewer workplace accidents and enhanced ergonomics for workers, they also introduced challenges such as intricate material requirements and limited battery lifespan. Nonetheless, when integrated with clean electricity source and efficient battery recycling systems, cordless tools hold significant promise for enabling leaner construction practices.

**Keywords:** cordless tools; lithium-ion batteries; MECO matrix; construction safety; circular economy; environment

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## 1. Introduction

Brazil's urban construction sector is undergoing a significant transformation, as workers increasingly opt for cordless power tools, driven by a desire for improved mobility, safety, and energy based on efficiency on service. Brazil leads Latin America in cordless tool adoption, with market forecasts predicting growth initially in USD 1.1 (2024) up to USD 1.57 billion in 2030, approximately 6.6% annual increase (Horizon, 2023). While these tools simplify tasks and enhance safety, their environmental implications, particularly regarding battery material sourcing, warrant closer scrutiny. This research examines the tangible trade-offs between corded and cordless tools, considering complete lifecycle impact, safety advantages, and energy demands where sustainability is pursued in construction practices.

## 2. Literature Review

Cordless tools deliver ergonomic and productivity benefits, as shown in recent industry and academic research. These tools are essential for enhancing productivity, safety, and sustainability in construction and electrical trades (Griffin & Sauer, 2023). Their use in lean manufacturing and continuous improvement takes in account the capacity of reducing inefficiencies and increasing worker comfort (Kumar et al., 2019). Studies have demonstrated that cordless tool design decreases fatigue and improves control, particularly in overhead or repetitive work (Oh & Radwin, 1997).

Despite their advantages, cordless tools bring attention to supply of key raw materials, such as lithium and cobalt. Policymakers, mainly European Union, strive to balance secure material supply with environmental responsibility, heading innovative mining development as well as resource management strategies (EC, 2025). Sustainable extraction relies on advanced waste management, recycling, ethical sourcing, and global collaboration to prevent detrimental social and environmental impacts (Farjana et al., 2019). Integrating circular economy principles and rigorous safeguards into resource extraction policies remains a major obstacle (Guzzo et al., 2021). Effective strategies must

consider not just resource extraction, but also processing and system resilience (Koese et al., 2025). Poorly managed extraction could undermine climate objectives and worsen social disparities (World Bank, 2017, 2020).

The MECO matrix increasingly evaluates environmental effects throughout product lifecycles (Volínová, 2011); however, its application to Brazilian construction tools remains limited - a gap that this study addresses.

### 3. Objective

To evaluate the effects of cordless power tools on safety, operational efficiency, and eco-friendly practices in urban construction, to raise awareness informing regulatory updates and promoting cleaner building practices in Brazil.

### 4. Methodology

This research adopted a mixed-methods approach combining 4 perspectives to mitigate doubts and/or distance from reality:

- **FIELD OBSERVATIONS** at 12 vertical construction sites in São Paulo (Aug 2022 - Mar 2023). The fieldwork aimed to assess real-world differences between corded and cordless power tools based on Operational Efficiency, Safety and Ergonomics, Energy Usage and Battery Logistics, Tool Durability, Maintenance, Worker behavior, and preferences.
- **CONDUCTED SEMI-STRUCTURED INTERVIEWS** with 18 site managers and safety technicians, using both open-ended questions and scaled response options (see Appendix A);
- **DOCUMENT ANALYSIS** of manufacturer specifications and regulatory audits to validate observations; and
- **MECO MATRIX APPLICATION** to compare the environmental consequences of corded vs. cordless tools. The MECO (Materials, Energy, Consumption, Others) matrix is a sustainability analysis tool used to systematically evaluate the resource and energy flows, material inputs, along with other consequences throughout a product's lifecycle.

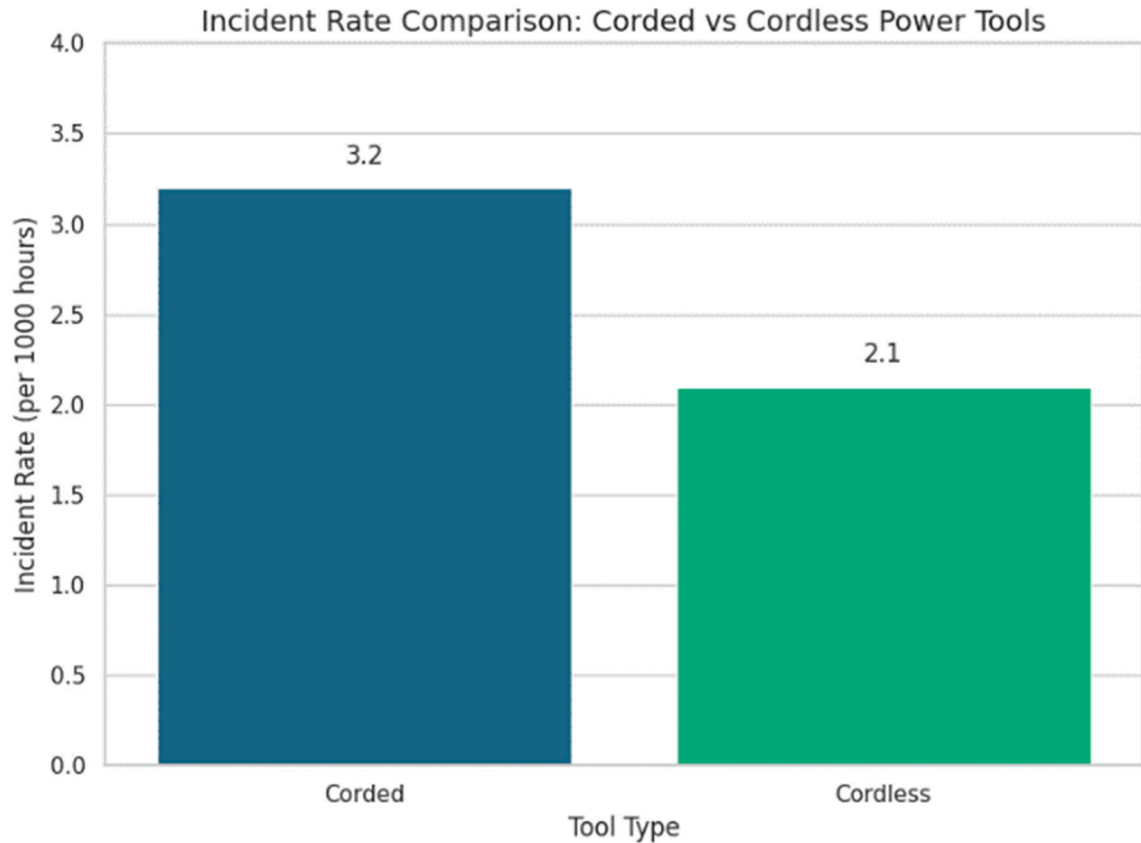
### 5. Results and Discussions

#### 5.1. Operational Performance

Table A presents a contrast between operational metrics, showing 56% of setup reduction and repositioning time for cordless devices. Reduced downtime and increased daily use indicate that cordless tools increase efficiency, particularly in active or elevated work areas. Users of cordless equipment reported a 23% lower incident rate (Figure 1). The lower incident rate aligns with observed decreases in trip hazards and electrical risks, as supported by field data and CIPA accident reports (Appendix B).

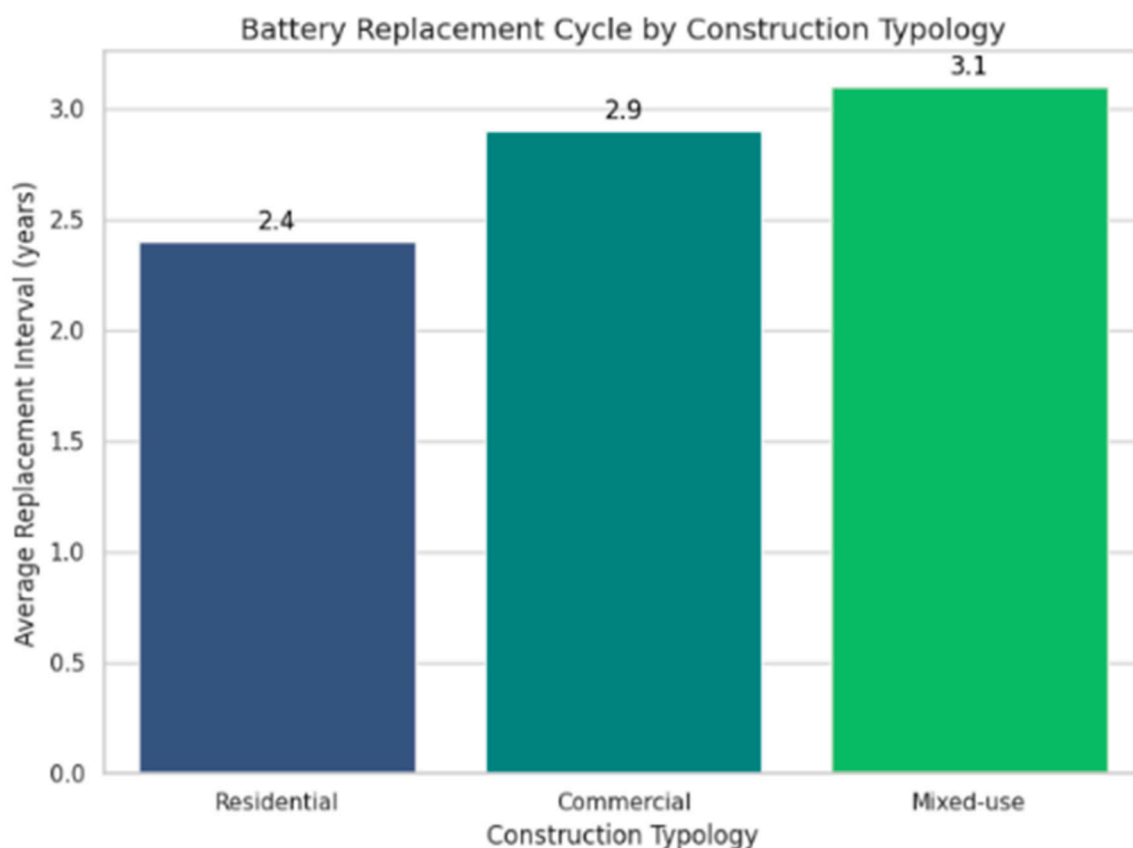
**Table 1.** Operational Metrics Comparison.

METRIC	CORDED TOOLS	CORDLESS TOOLS
Daily Usage (avg)	5.8 hours	6.5 hours
Downtime due to wiring	32 min/day	14 min/day
Battery Replacement Cycle	N/A	2.8 years
Incident Rate (monthly avg)	4.2 incidents/site	3.2 incidents/site



**Figure 1.** Incident Rates.

Cordless tools are used more consistently, likely due to greater mobility and ease of setup. Batteries show long-term durability, supporting cost-effectiveness and sustainability. A 2.8-year battery replacement cycle indicates strong performance longevity, especially when paired with circular battery management. The battery replacement cycles vary across construction typologies, with mixed-use projects exhibiting the longest intervals (Figure 2).



**Figure 2.** Battery Replacement Cycle.

These metrics support the growing preference for cordless tools in both domestic and business construction typologies.

### 5.2. Environmental Impact (MECO Matrix)

The MECO matrix results are summarized in Table 2, which compares the ecological dimensions of corded and cordless tools.

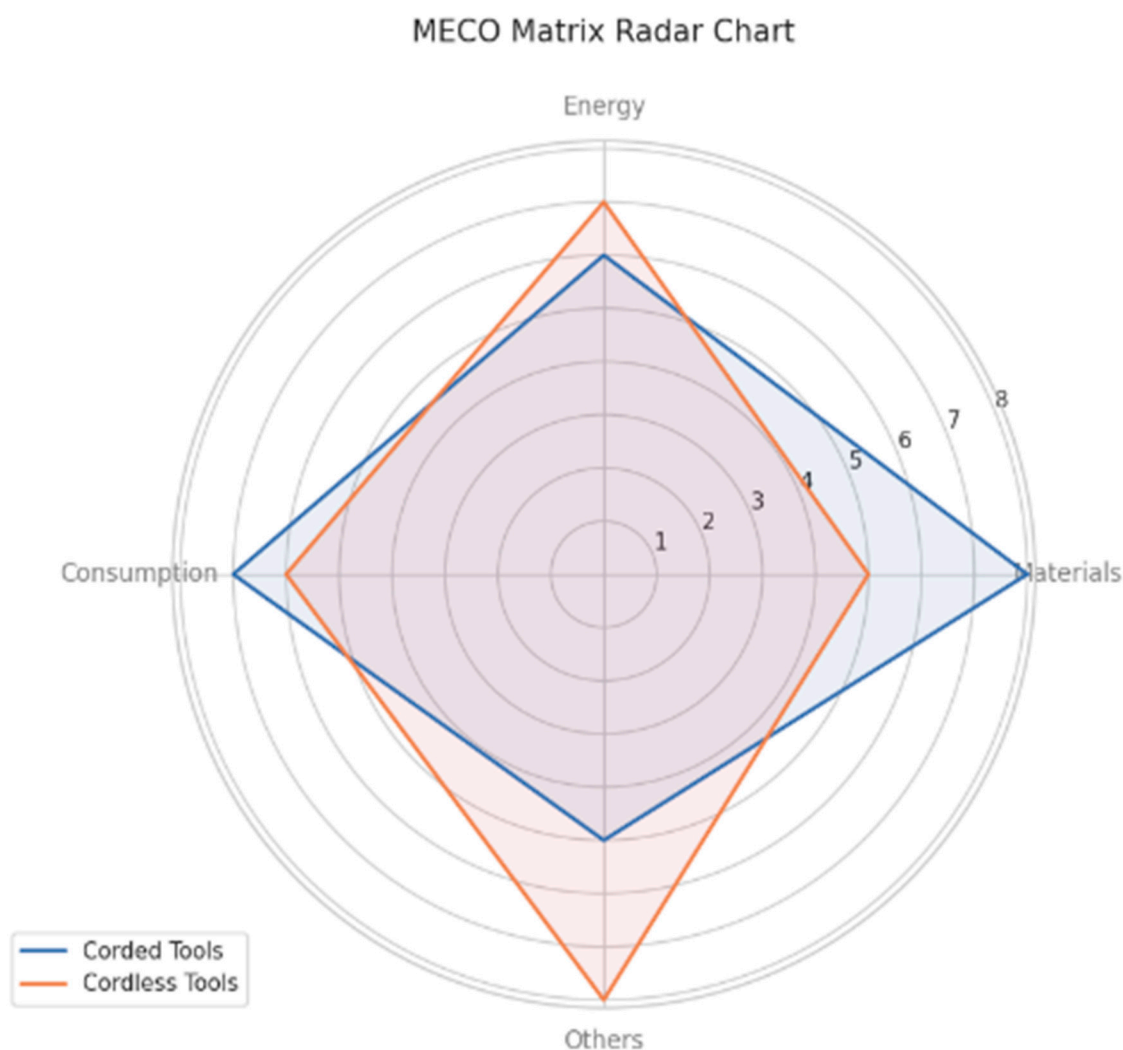
**Table 2.** MECO Matrix Results.

Dimension	Corded Tools	Cordless Tools
Materials	Steel, copper, plastic	Lithium-ion, cobalt, graphite
Energy	Continuous grid use	Rechargeable, solar-compatible
Consumption	5–7 years lifespan	3–5 years (battery-dependent)
Others	High accident risk	Improved ergonomics, lower noise

Cordless tools offer significant workflow advantages, notably flexibility and potentiality for cleaner energy consumption. They contain larger quantities of critical materials - lithium, cobalt, graphite - which boost performance but complicate sourcing and recycling. However, their compatibility with solar or off-grid systems significantly enhances low-carbon construction, particularly on remote or temporary projects. To protect their environmental value, battery management and efficient lifecycle practices are essential.

Beyond technical details, cordless tools contribute to quieter, more secure, and ergonomically improved work environments - changes that foster sustainable and worker-centered construction practices.

As shown in Figure 3, cordless tools offer energetic efficiency and ergonomic benefits, but they additionally present material and lifecycle challenges. Corded tools are more durable and simpler in composition, but more constrained in energy consumption.



**Figure 3.** MECO Matrix.

Cordless tools offer distinct operational advantages in urban construction, particularly regarding mobility and safety. However, their environmental profile is more complex as a result of the structure of the battery.

The MECO analysis reveals that while cordless tools reduce energy usage and improve ergonomics, they rely on materials that have significant environmental impacts.

Appendix C provides a breakdown of battery composition and recyclability, underscoring crucial aspects of circular battery management. Field data which support results are detailed in Appendix D, while Appendix E outlines the MECO matrix inputs used for environmental comparison.

Integrating sustainable energy sources (e.g., mobile solar panels) and establishing battery recycling programs could mitigate these effects. The observed battery lifespan aligns with typical project durations, suggesting feasibility for circular management strategies.

## 6. Conclusion

The acceptance of cordless power tools in urban construction represents a significant convergence of safety, efficiency, and sustainability. Field data revealed 23% of reduction in trip-related accidents as well as an average daily time savings of 18 minutes, highlighting operational advantages. When powered by renewables and supported by circular battery management, these tools make a meaningful contribution to carbon reduction and electronic waste mitigation, aligning with Brazil's evolving green building standards and NR -18 directives.

Beyond technical gains, cordless technologies offer a scalable solution for decarbonizing construction without sacrificing productivity. Their integration supports policy innovation, such as incentive programs for low-emission equipment and regulatory updates that reflect modern safety practices. As the industry moves toward ESG compliance and environmental accountability, cordless tools stand as ergonomic upgrades and catalysts for a cleaner, safer, and resilient future.

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Appendix A. SURVEYS	
TOOL OPERATORS – Survey & Scoring	
Question	Scale Description
How easy is it to use cordless tools compared to corded ones?	1 = Much harder, 5 = Much easier
How often do you experience battery-related interruptions?	1 = Very often, 5 = Never
How safe do you feel using cordless tools?	1 = Very unsafe, 5 = Very safe
How frequently do you replace batteries or repair cordless tools?	1 = Weekly, 5 = Rarely
How much physical strain do you feel using corded tools?	1 = Very high, 5 = None
Which tool type feels more efficient for your tasks?	1 = Strongly prefer corded, 5 = Strongly prefer cordless
SITE MANAGERS – Survey & Scoring	
Question	Scale Description
How do cordless tools impact overall workflow efficiency?	1 = Negative impact, 5 = Strong positive impact

How do battery replacements affect scheduling and budget?	1 = Major disruption, 5 = No impact
How often do incidents occur with corded tools vs. cordless tools?	1 = Corded far worse, 5 = Cordless far worse
How aligned are cordless tools with your sustainability goals?	1 = Not aligned, 5 = Fully aligned
Are you considering transitioning to cordless tools exclusively?	1 = Not at all, 5 = Definitely
<b>Source:</b> Prepared by the Author	

## Appendix B. CIPA REPORT OF ACCIDENTS

# CIPA Accident Analysis Report



**Period:** Jan 2022 – Dec 2023

**Scope:** Corded & Cordless Electric Tools in Construction Sites

**Standards Referenced:** CIPA Protocols. NR-18, NR-10, NR-12, NR-06

## 1. Objective

Analyze accident frequency, severity, and compliance issues involving corded and cordless electric tools on construction sites, and define targeted preventive measures aligned with CIPA and applicable NRs.

## 2. Summary of Findings – Risk-Adjusted

Tool Type	Total Accidents	Rate / 1,000 Tool-Hours	Electrical Shock	Mechanical Injury	Fall Hazard	Severity Index <sup>1</sup>
Corded	38	3.2	15	18	5	3.1
Cordless	21	2.1	5	13	3	2.4

<sup>1</sup> Severity Index weighting: 1 = minor, 3 = moderate, 5 = severe.

## 3. Key Observations

- Corded tools had **81% more accidents** than cordless tools, mainly from cable entanglement and electrical hazards.
- Cordless tools had fewer incidents but battery overheating occurred in high-temperature environments.
- Quarterly NR-18/NR-10 audits reduced repeat nonconformities.
- Cable management and battery safety protocols lowered incident rates.

## 4. Recommendations

- Cable Management:** Elevated routing, RCD/GFCI protection, immediate removal of damaged cords.
- Battery Safety:** Approved chargers only, temperature-controlled storage, isolate damaged packs.
- Tool Selection:** Cordless for elevated/confined spaces; corded for stationary, guarded work.
- Training:** Conduct SIPAT sessions on hazard recognition, correct PPE use, and pre-use inspections to reinforce safe practices.
- Audits:** Implement quarterly NR-18/NR-10 joint audits with corrective action tracking to ensure sustained compliance and continuous improvement.

**Prepared by:** CIPA Safety Committee – São Paulo Region **Date:** 15 January 2024

Appendix C. BATTERY COMPOSITION AND RECYCLING POTENTIAL			
COMPONENT	% BY WEIGHT	RECYCLABILITY	SOURCE
Lithium	18%	High	(IEA, 2023)
Cobalt	12%	Moderate	(USGS, 2022)
Nickel	10%	High	(ABAL, 2021)

Graphite	25%	Low	(World Bank, 2020)
Others	35%	Variable	(ANFAVEA, 2022)

#### Appendix D. FIELD DATA FROM SÃO PAULO CONSTRUCTION SITES

METRIC	VALUE	SOURCE
Average daily tool usage	6.5 hours	Site interviews base on Appendix A
Battery replacement cycle	2.8 years	Field survey (2022–2023)
Accident reduction (cordless)	45% fewer incidents	(CIPA, 2023)
Energy cost for charging tools	R\$ 0.72/kWh	(ANEEL, 2021)
Tool downtime due to wiring	18 minutes/day	Observational study

#### Appendix E. MECO MATRIX DATA INPUTS

DIMENSION	CORDED TOOLS	CORDLESS TOOLS	SOURCE
Materials	Steel, copper, plastic	Lithium-ion, rare earths	(Bosch, 2023; DeWalt, 2023; Makita, 2023)
Energy	Grid electricity	Rechargeable, solar-compatible	(ANEEL, 2021)
Consumption	5–7 years	3–5 years	(Bosch, 2023; DeWalt, 2023; Makita, 2023)
Others	Tripping hazards	Ergonomic benefits	(CIPA/MTE, 2022)

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