

Urgent Installation of Micro Hydropower Plants in Unelectrified Villages and Territories of the Democratic Republic of Congo to Drive Industrialization

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Abstract— *The urgent deployment of micro hydropower (MHP) plants in the unelectrified villages and territories of the Democratic Republic of Congo (DRC) is a critical strategic intervention to stimulate sustainable industrialization. Despite the nation's immense hydropower potential, a profound energy deficit persists in rural areas, severely constraining socio-economic development. This article argues that localized electrification via micro plants provides a clean, stable, and adaptable energy solution tailored to rural communities. Employing a methodology that combines a literature review with field-based case analysis from 14 localities across five provinces, the study demonstrates that MHP deployment can significantly improve electricity access. The results indicate that this approach acts as a catalyst for job creation, fosters the development of local agro-industrial and artisanal activities, and directly reduces energy poverty. The discussion underscores that realizing this potential requires strong political commitment and the establishment of appropriate financing mechanisms. In conclusion, prioritizing these decentralized energy infrastructures is an essential lever for achieving sustainable and inclusive industrialization in the DRC.*

Keywords— *Micro hydropower plants; rural electrification; Democratic Republic of Congo; industrialization; renewable energy; rural development; energy poverty.*

I. INTRODUCTION

Access to reliable energy remains a primary impediment to socio-economic development in the Democratic Republic of Congo, particularly in rural regions where electrification rates are critically low. This energy poverty not only hinders improvements in basic living standards but also severely limits the local processing of abundant natural resources and the emergence of productive industrial activities. Paradoxically, the DRC possesses exceptional hydrographic potential, with numerous streams and rivers in landlocked territories offering ideal characteristics for micro hydropower generation. These lightweight, relatively low-cost, and context-appropriate infrastructures represent a major opportunity to support decentralized industrialization, stimulate job creation, and enhance community energy autonomy.

Given the scale of the energy challenge and the growing demand for electricity to power local production, the strategic installation of micro plants presents a viable solution for accelerating integrated rural development. Their capacity to deliver stable, renewable, and locally manageable energy makes them a crucial tool for territorial modernization. However, successfully implementing this alternative requires a thorough analysis of the available potential, the attendant challenges, the anticipated socio-economic impacts, and the enabling conditions needed for success. Consequently, this study aims to highlight the urgency and relevance of promoting MHP installations in the DRC, proposing context-specific solutions and recommendations to guide policymakers and practitioners.

II. MATERIALS AND METHODOLOGY

This study employs a mixed-methods approach, combining the analysis of secondary data from existing energy reports and hydrological studies with primary data gathered through field observations and interviews conducted across 14 localities in five provinces of the DRC.

The methodological framework is designed to address the multifaceted nature of MHP project implementation, ensuring environmental and social sustainability while aiming for economic viability. This framework encompasses several critical phases:

First, a **resource assessment** is conducted to evaluate the hydraulic energy potential of a site, determining key parameters such as flow rate and head to correctly size the plant. This is accompanied by **environmental and social impact studies** to minimize negative consequences on local ecosystems and communities. The **technical design** phase involves the hydraulic engineering of structures (dams, intakes, canals) suited to the local topography and flow characteristics, and the selection of appropriate electromechanical equipment, such as turbines (typically in the 21 to 500 kW range for micro power), generators, and electrical systems.

Subsequently, **construction planning** integrates consultation with local stakeholders and the design of compensatory measures for affected populations. Following commissioning, which includes the installation and testing of all equipment, a core focus is placed on **capacity building**. This involves training local community members in the operation, basic maintenance, and management of the plant to ensure its long-term sustainability. Parallel to this, a comprehensive **economic and financial analysis** is performed to evaluate project costs—which field data indicates range from \$2,000 to \$4,800 USD per kW—and ensure long-term viability. Finally, **regulatory coordination** with relevant authorities is maintained throughout to secure all necessary administrative authorizations.

III. RESULTS

The analysis of primary and secondary data yields several key findings that underscore both the potential and the current reality of rural electrification in the DRC:

3.1 Underutilized Hydropower Potential:

The assessment reveals a significant and largely untapped local hydropower resource. In the surveyed areas, over 60% of identified hydraulic sites possess an annual flow compatible with micro plant installations (10–500 kW). Direct measurements from seven rivers showed consistent flows ranging from 1.2 to 12.5 m³/s, confirming their technical suitability for low- and medium-head turbine technology.

3.2 Profound Rural Energy Deficit:

The study documents a severe structural energy deficit. In 12 of the localities studied, actual access to electricity was below 8%, despite the presence of permanent watercourses capable of power generation. This deficit forces households to rely almost exclusively on traditional biomass (fuelwood at 87% and charcoal at 9%), a dependency that accelerates deforestation and environmental degradation.

3.3 Positive Socio-Economic Impacts of Existing MHP Projects:

Case studies of operational micro plants in communities such as Idjwi, Minova, Luvungi, and Lubero demonstrate transformative effects. The primary impact has been a 35% to 70% increase in local agro-industrial production, including the processing of flour, coffee, palm oil, and dairy products. Reliable electricity has also spurred the creation of energy-intensive micro-enterprises in welding, carpentry, brick-making, and refrigeration, generating substantial new employment. Furthermore, social services have improved markedly; for instance, health centers reported a 50% reduction in cold-chain breaks for vaccines, and students benefited from an average increase of two hours of study time per day with electric lighting.

3.4 Project Viability and Performance:

The investigated MHP projects demonstrated encouraging economic and operational metrics. The installation costs were observed to be between \$2,000 and \$4,800 per kW, with an estimated return on investment period of 3 to 5 years, varying by the management model (cooperative, public-private partnership, or private entrepreneur). Notably, these plants maintained an average operational availability rate of 92%, indicating a reliable and stable energy supply.

IV. DISCUSSION

4.1 MHP as a Catalyst for Rural Industrialization:

The results confirm that micro-hydropower is a potent enabler of small- and medium-scale industrialization in rural territories. By providing continuous, low-carbon, and locally managed power—a stark contrast to expensive and intermittent diesel

generators—MHP fosters energy autonomy. This reliable electricity supply acts as a direct catalyst for adding value to local production, particularly in agricultural processing, which constitutes over 60% of rural economic activity.

4.2 Technological and Contextual Suitability:

Micro plants are uniquely suited to the geographical and infrastructural realities of the DRC. Their relatively lightweight components facilitate transport to remote, landlocked areas, and their low ecological footprint (avoiding the large reservoirs of mega-dams) minimizes environmental impact. This makes them a more sustainable and scalable solution compared to isolated solar home systems, which are often insufficient for powering continuous industrial loads.

4.3 Persistent Structural Bottlenecks:

Despite the confirmed technical and economic potential, significant barriers persist. These include security instability in eastern regions, which deters investment; the absence of a specific national policy and regulatory framework for mini-grids and micro-power, stalling public-private partnerships; limited access to financing for crucial preliminary studies; and a shortage of local technical expertise in hydropower engineering. These obstacles highlight that a successful energy transition depends not only on natural resources but also on concurrent institutional strengthening and human capacity development.

4.4 Strategic Opportunities for Alignment:

Significant opportunities exist to overcome these challenges. MHP development directly supports multiple Sustainable Development Goals (SDGs 7, 8, 9, and 13). There is growing interest from international donors and development agencies (e.g., African Development Bank, European Union, UNIDO) in decentralized renewable energy. Furthermore, MHP can serve as the anchor for creating integrated rural industrial clusters and contribute to the socio-economic stabilization of fragile regions.

V. RECOMMENDATIONS AND PHASED SOLUTIONS

To harness the potential of MHP for rural industrialization, a coordinated, multi-stakeholder approach is required.

5.1 Policy and Institutional Reforms:

It is imperative to develop and implement a specific regulatory framework for small-scale hydropower to de-risk and incentivize private, community, and public investment. Energy planning centered on MHP must be harmonized with local and regional development programs. Furthermore, the government should actively facilitate public-private partnerships (PPPs) to share investment risks in challenging rural markets.

5.2 Technical and Capacity-Building Measures:

A national protocol for standardizing hydrological assessments should be established. Technology transfer and adaptation programs should promote resilient, easy-to-maintain equipment suited to the Congolese context. Creating regional technical maintenance units and developing local training programs are essential to ensure the long-term operational sustainability of installations.

5.3 Integrated Socio-Economic and Ecological Planning:

Support should be provided to develop robust local energy management entities, such as cooperatives. Financing and business development services must be channeled to help establish agro-processing and artisanal units that utilize the new electricity supply. All projects must prioritize low-impact civil works and be subject to streamlined yet rigorous environmental impact assessments to protect aquatic and riparian ecosystems.

5.4 Phased Implementation Roadmap:

- **Short Term (0-3 years):** Focus on rapid identification of priority sites, implementation of pilot projects to validate models, securing targeted financing for equipment, and training local technicians for daily operations.

- **Medium Term (3-7 years):** Scale up to develop formal rural mini-grids, promote the creation of dedicated agro-processing hubs, establish sustainable financial instruments (e.g., micro-credit, results-based subsidies), and strengthen community governance structures for energy systems.
- **Long Term (7-15 years):** Plan for the strategic interconnection of mature mini-grids with the national grid, foster a local manufacturing industry for hydropower components, establish a national center of excellence for small hydropower research and training, and fully integrate MHP into the national industrial development strategy.

VI. CONCLUSION

Micro hydropower plants represent a reliable, economically viable, and socially transformative energy solution for the rural DRC. The evidence presented demonstrates that their strategic development is an urgent priority to stimulate local industrialization, secure essential social services, reduce destructive energy dependency, create durable jobs, and strengthen overall community resilience. Given the country's exceptional hydrographic endowment, a concerted national policy to accelerate small hydropower—buttressed by innovative financing and dedicated local capacity building—has the potential to fundamentally transform the rural economic landscape. The path to inclusive and decentralized industrialization in the Democratic Republic of Congo is inextricably linked to this decentralized energy transition.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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