



GLOBAL
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ADAPTATION

Technical Brief

ENERGY

Climate resilient electricity T&D networks in Africa

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INTRODUCTION

Electricity transmission and distribution (T&D) networks are critical to economic growth, regional integration, and access to clean energy. Yet these systems are increasingly exposed to the intensifying impacts of climate change—including extreme heat, flooding, wildfires, landslides, and sand and dust storms—that threaten their reliability, lifespan, and financial viability. Strengthening the resilience of T&D infrastructure is therefore essential to safeguard access to clean energy and sustain development gains.

This technical brief outlines a practical framework for assessing climate risks and implementing targeted adaptation measures across the project cycle. Drawing on lessons from the GCA technical assistance projects delivered under the Africa Adaptation Acceleration Program⁽¹⁾, it offers tested methodologies, cost–benefit evidence, and actionable solutions that utilities, financiers, and project developers can apply to design, operate, and maintain climate-resilient power systems.



The Songo-Matambo Transmission Line Project (AfDB) project enables Mozambique to supply hydropower to Malawi and Zambia, but only if the transmission corridor remains operational under flooding, extreme heat, and wildfire conditions.

WHAT MAKES TRANSMISSION AND DISTRIBUTION UNIQUE IN CLIMATE ADAPTATION?

While climate adaptation in the energy sector often focuses on power generation, electricity networks—including T&D infrastructure—face unique vulnerabilities that demand targeted attention beyond a conventional infrastructure concern :

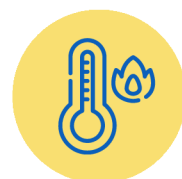
- **Scale of Investment:** Transmission and Distribution (T&D) accounts for 60–70% of power sector investment in Africa and many developing regions. Given the scale of capital deployed, enhancing the resilience of these assets is critical to safeguarding long-term investment value and minimizing climate-related losses.
- **Long Asset Life and Climate Uncertainty:** T&D assets last 40-50 years, so infrastructure built today must withstand future climate conditions that historical data cannot predict. This requires adaptive design and stress-testing to avoid premature degradation and systemic vulnerabilities.
- **Critical Role Across the Electricity Value Chain:** As the backbone of the electricity value chain, resilient T&D infrastructure is indispensable for translating generation capacity into reliable electricity supply. Its performance ultimately determines the reliability, value, and impact of investments across the broader power system.
- **Extensive Geographic Footprint:** Unlike most energy assets, T&D networks span extensive and diverse landscapes, exposing individual assets to a wide range of climate hazards. This spatial complexity necessitates targeted, context-specific resilience measures rather than uniform adaptation approaches.
- **Cross-Border System Interdependencies:** Regional interconnections create shared dependencies across power systems, meaning that climate-induced disruptions in one country can propagate across interconnected networks. This calls for coordinated resilience planning and investment at the regional—not only national—level.

Regional power pools such as the Southern African Power Pool (SAPP), West African Power Pool (WAPP), and Eastern African Power Pool (EAPP) depend on reliable cross-border transmission links.

- **Enabler for Renewables and Energy Access:** Africa's transition to renewable energy depends on resilient T&D infrastructure. Solar and wind resources are often located far from load centres, requiring long transmission corridors that traverse diverse climate zones. Climate-proofing these evacuation lines is essential to unlock renewable potential and ensure reliable power delivery.
- **Underrepresentation in Climate Planning:** T&D resilience often receives less attention than generation or renewables in climate strategies, despite its role in reliable power delivery. Addressing this gap ensures energy systems remain robust and adaptive to climate challenges.

KEY CLIMATE HAZARDS AND IMPACTS

HEAT STRESS



- Increased conductor sag reduces ground clearance, raising safety risks.
- Reduced ampacity limits power transfer capacity.
- Accelerated aging of insulators, transformers, and other equipment shortens asset life and increases maintenance needs.

Impact : 1°C increase implies a 2% loss of ampacity for conductors (2)
Ethiopia project : 9–13% reduction in conductor service life

WILD FIRES



- Direct flame exposure damages insulators and transformers.
- Ash and smoke cause insulator flashovers.
- Increased safety risks for operations and maintenance staff.

Risk factors: Dry season vegetation or immediate proximity with fire-prone forest/vegetation, proximity to agricultural burning, drought conditions

LANDSLIDES



- Tower collapse or tilting on steep slopes, severing transmission lines.
- Conductor damage from falling debris.

Risk factors: Slope >15°, high rainfall intensity, deforested corridors, weak soil conditions.

SAND & DUST STORMS



- Abrasion of tower foundations and conductor hardware due to aerial erosion
- Insulator contamination leading to flashover.
- Accelerated corrosion when combined with humidity.

Mauritania-Mali project : PV efficiency losses of up to 15% annually due to soiling.

FLOODING



- Erosion and collapse of tower foundations.
- Substation inundation causing equipment damage and prolonged outages.
- Battery damage in solar PV plants.

SECONDARY RISKS



Wind:

- Tower stability.
- Line swing and galloping.

Threshold: >90 km/h gusts exceed typical design standards and require structural upgrades.

Drought:

- Exacerbates wildfire risks.
- Reduces vegetation stability in rights-of-way, increasing erosion and landslide susceptibility.

SOCIO-ECONOMIC IMPACTS

Climate-related power outages have wide-ranging socio-economic consequences, particularly in regions where livelihoods depend on electricity for irrigation, food processing and small enterprises. Disruptions can lead to crop losses, reduced productivity, and greater food insecurity, while also deepening energy poverty among vulnerable communities.

Workforce safety is also critical, as staff face increased exposure to extreme heat and hazards, which can lead to higher risks of accidents, heat-related illnesses, and operational disruptions.

MAURITANIA-MALI TRANSMISSION LINE PROJECT

Without adaptation, the project could face :

- Direct risks ≈ 10% of asset value
- Revenue losses up to 24% without adaptation

MOZAMBIQUE SONGO-MATAMBO TRANSMISSION LINE PROJECT

Without adaptation, the project could face :

- Direct losses up to €10M (~11% asset value)
- Indirect losses up to €12M (~12.5% revenue)

A gender-lens analysis of Mozambique's Songo Matambo and Ethiopia's Eastern Grid Reinforcement projects shows that women bear greater risks during power outages.

In Mozambique, female-headed households, women farmers, and those with limited communication access—especially in the agricultural and economic hubs of Cuamba and Milange—are most vulnerable.

In Eastern Ethiopia, women face severe disruptions in Dire Dawa and Jijiga, key economic centers, due to their heavy reliance on electricity. This impact is exacerbated by limited access to alternative energy sources and decision-making roles in energy planning.

(2) Bartos et al. (2016) quantify the impact of rising ambient temperatures on transmission line ampacity using thermal conductor models coupled with climate projections. Their results indicate a reduction in transmission capacity of approximately 1.9% to 5.8% under projected temperature increases. This corresponds to an order-of-magnitude sensitivity of roughly 1–3% per °C, supporting the use of a 2%/°C ampacity derating factor as a reasonable engineering approximation.

ADAPTATION MEASURES

SITE SELECTION	ENGINEERING DESIGN UPGRADES	O&M RESILIENCE	NATURE-BASED SOLUTIONS	INSTITUTIONAL & POLICY INTEGRATION
• Avoid flood-prone and landslide-prone areas • Integrate climate risks into early design stages • Use geotechnical and hazard assessments	• High-temperature conductors (HTLS, ACCC) • Elevated and reinforced foundations • Slope stabilization • Flood-resilient substations	• Vegetation management • Dust cleaning • Post-event inspections • Emergency Restoration Systems (ERS)	• Vegetation buffers and slope greening • Runoff reduction and erosion control • ‘Green belts’ to protect asset from dust storm and desert encroachment	• Design standards for future climate • Operational protocols for extreme events • Enhanced maintenance schedules • Capacity building for utilities

COST-BENEFITS EVIDENCE

- High-temperature conductors (Mauritania–Mali): BCR of 15-25. These deliver exceptional returns by maintaining ampacity under heat stress, reducing outage risks, and extending asset life.
- Tower relocation (Ethiopia): BCR of 1.6-3.1. Relocating towers from landslide or flood zones avoids catastrophic failure costs and service disruptions.
- Routine O&M for wildfire prevention: Low cost, high return. Vegetation clearing and fire break maintenance prevent costly equipment damage and service interruptions.

RECOMMENDATIONS



EMBED CLIMATE RESILIENCE IN DESIGN

Adopt climate thresholds and projected climate parameters in all design standards and Terms of Reference (TORs) to future-proof infrastructure and ensure long-term reliability.



STRENGTHEN INSTITUTIONAL CAPACITY

Institutionalize robust operations and maintenance (O&M), safety protocols, and gender-sensitive monitoring to enhance system reliability and inclusivity.



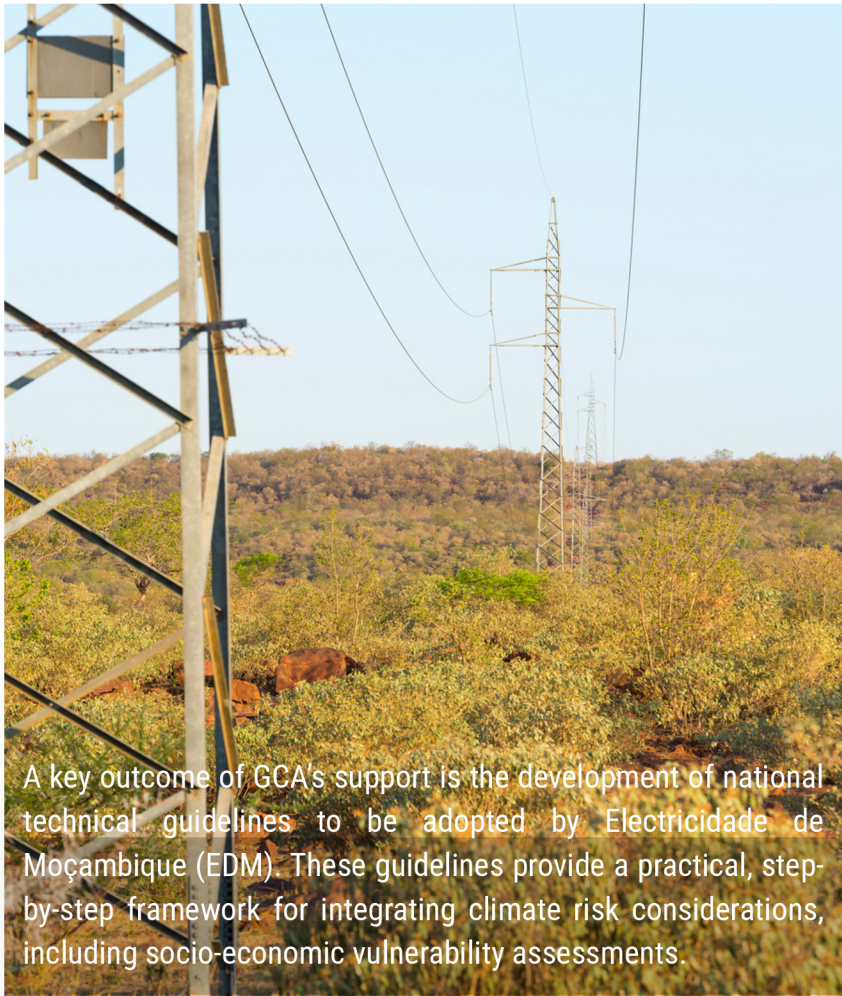
LEVERAGE DATA FOR PRECISION PLANNING

Update project analyses context-specific data during the design phase to optimize resilience strategies and reduce uncertainty.



PROMOTE COMMUNITY-LED VEGETATION MANAGEMENT AND NBS IMPLEMENTATION

Engage local communities in maintaining green belts and NbS, through training, partnerships, and incentives for sustainable land management.



A key outcome of GCA's support is the development of national technical guidelines to be adopted by Electricidade de Moçambique (EDM). These guidelines provide a practical, step-by-step framework for integrating climate risk considerations, including socio-economic vulnerability assessments.

CONCLUSION

T&D networks are increasingly exposed to climate hazards, leading to faster asset degradation, reduced capacity, and more frequent outages that disrupt electricity supply for households, businesses, and essential services.

At the same time, resilient transmission systems are critical to integrating renewable energy by reliably connecting often remote generation sites to demand centers.

Proven, cost-effective adaptation measures already exist. Scaling their deployment is now essential to strengthen power system resilience and ensure reliable electricity supply in a changing climate.

