SDG BLOCKCHAIN ACCELERATOR

ROADMAP FOR FUTURE DEVELOPMENT

Challenge Definition

UNDP Challenge Summary

Zanzibar Electricity Corporation (ZECO), serving Zanzibar's 2 million population, has reduced electricity losses from 30% to 21% but faces remaining challenges distinguishing technical losses (equipment inefficiencies) from commercial losses (meter tampering, billing fraud). The remaining 21% losses represent +$16 million in annual revenue leakage, limiting ZECO's ability to expand infrastructure and integrate renewable energy—critical for Zanzibar's tourism economy. As an island utility with all generation and consumption within defined boundaries, ZECO is ideally positioned to pioneer blockchain-based energy transparency.

Relevance to UNDP CO Priorities and Resource Mapping

This project aligns with UNDP Tanzania's focus on sustainable development, institutional transparency, and climate action. It builds on existing energy sector governance initiatives while introducing innovative blockchain technology. UNDP Tanzania provides institutional support, stakeholder coordination, and access to ZECO through their Innovation Specialist and Programme Analyst roles. The project supports SDG 7, 9, 11 and 16.

Expected Impact (from CO perspective)

A successful pilot would demonstrate blockchain's practical value in strengthening utility governance, reducing energy losses, and improving revenue recovery, while informing regulatory and policy frameworks that enable wider technology adoption in public service delivery. The solution is expected to position Tanzania as a regional leader in innovative energy sector management, with clear outcomes such as enhanced stakeholder trust, improved data transparency for policy and investment decisions, operational efficiency gains, and a scalable model for other utilities and public services where accountability, fraud prevention, and service reliability are critical.

Target SDGs and SDG Indicators

SDG 7: Affordable and Clean Energy

- Target: By 2030, double the global rate of improvement in energy efficiency
- Indicator: Reduction in electricity losses from current 16% baseline
- AegisGrid Impact: Immutable consumption tracking reduces meter tampering and billing fraud

SDG 9: Industry, Innovation and Infrastructure

- Target: Develop quality, reliable, sustainable and resilient infrastructure
- Indicator: Number of electricity consumers with transparent, blockchain-verified billing
- AegisGrid Impact: Modernizes utility infrastructure with blockchain technology

SDG 11: Sustainable Cities and Communities

- Target: Reduce the adverse per capita environmental impact of cities
- Indicator: Improved energy efficiency in urban electricity distribution
- AegisGrid Impact: Better monitoring enables targeted loss reduction in urban areas

SDG 16: Peace, Justice and Strong Institutions

- Target: Develop effective, accountable and transparent institutions
- Indicator: Increased transparency in utility billing and consumption reporting
- AegisGrid Impact: Blockchain provides immutable audit trail for electricity transactions

User & Problem Mapping

Primary User Persona

ZECO Operations Manager - Mid-level utility executive responsible for monitoring grid performance and revenue collection. Works in a data-rich environment but struggles with fragmented information systems. Goals include reducing operational losses, improving billing accuracy, and demonstrating performance improvements to senior management. Challenges include limited real-time visibility into consumption patterns, fault detection, difficulty detecting fraud quickly, and managing customer disputes over billing accuracy.

User Story

"As a ZECO operations manager, I want to access real-time, verifiable electricity consumption data from all customer segments, so that I can quickly identify losses, fault detection, prevent fraud, and resolve billing disputes with transparent, immutable records."

Key Stakeholders/Partners

- **ZECO** - electricity utility providing data access and operational validation
- **UNDP Tanzania** - Innovation Specialist and Programme Analyst providing institutional coordination
- **Large Power Users** - Industrial customers participating in pilot testing

- **Ministry of Water, Energy and Minerals Zanzibar** - Regulatory oversight and policy alignment
- **Grinplus** - Solution development and blockchain implementation
- **Emurgo Labs** - Technical mentorship and Cardano ecosystem support

Solution Overview

Solution Summary

AegisGrid creates an immutable energy transparency platform using Cardano blockchain to record electricity generation and consumption data. The solution integrates directly with ZECO's existing meter infrastructure through secure APIs, creating a national energy ledger that enables comprehensive loss analysis and fraud detection. By tokenizing energy readings with 1 hour or 15-minute granularity, AegisGrid provides unprecedented transparency in utility operations while maintaining data security and regulatory compliance.

Core Functionalities

- **Real-time Data Recording** - Smart contracts capture and verify all energy production and usage data, creating tamper-proof records accessible to stakeholders
- **Automated Loss Detection** - Real-time comparison of total generation vs consumption identifies grid losses and irregular patterns with mathematical precision
- **Fraud Prevention System** - Machine learning algorithms analyze consumption patterns, automatically minting alert tokens when anomalies suggest meter tampering
- **Transparent Stakeholder Portal** - Role-based interfaces for ZECO operators, large power users, and regulators providing relevant energy analytics and blockchain verification

Tech Stack Overview

- **Frontend**: React.js with responsive dashboard interfaces
- **Backend**: Python with FastAPI, PostgreSQL database
- **Blockchain**: Cardano with Plutus/Aiken smart contracts
- **Integration**: Secure APIs for ZECO meter data systems
- **Analytics**: Machine learning algorithms for anomaly detection
- **Infrastructure**: Cloud hosting with enterprise-grade security

Cardano-Specific Elements

- **Native Asset Minting**: Each energy reading tokenized as unique Cardano native token with consumption metadata
- **Smart Contract Logic**: Plutus/Aiken contracts for energy data validation and fraud alert generation
- **Metadata Tagging**: SDG indicators embedded in transaction metadata for transparency tracking
- **UTxO Management**: Batch processing for efficient transaction handling and cost optimization

Prototype Plan (Sprint-Based)

Prototype Goal

Build a functional energy transparency system demonstrating electricity data recording on Cardano blockchain, with basic fraud detection and stakeholder verification capabilities.

Expected Outputs

- Working blockchain integration with energy token minting functionality
- Dashboard interface displaying consumption data with blockchain verification links
- Basic anomaly detection system identifying consumption pattern irregularities

Sprint Timeline

Day	Description	Outcome
1	Define scope & SDG Indicators	Scope clarity
2	UX & flow design	Figma/Flow ready
3	UI implementation	Frontend in place
4	Chain integration	VC/token tested
5	Mid-review & QA	Testing link ready

6-7	Stakeholder testing	Feedback gathered
8-9	Iteration & polish	Demo-ready version
10	Final submission	All deliverables done

Success Metrics & Milestones

Sprint Phase

Focus: Rapid prototyping, initial user testing, and validation of core functionality.

Category	Baseline Metric
Blockchain Interaction	Energy reading tokenization with SDG metadata on Cardano testnet
User Interface	Functional dashboard displaying consumption data with blockchain verification
Stakeholder Testing	Testing sessions and demo video with UNDP Tanzania
SDG Integration	Energy consumption metadata includes SDG 7 indicators for efficiency tracking
Demo Readiness	Live demo link with video walkthrough showcasing end-to-end functionality

Post-Sprint Refinement

Focus Area	Baseline Metric
Feedback Integration	Implementation of 2+ stakeholder-driven improvements in interface and logic
MVP Stabilization	Functional testing with 99%+ transaction success rate and no critical bugs

Stakeholder Alignment	UNDP Tanzania and ZECO technical team approval and next-phase planning session completed

Pilot Readiness

Goal Area	Suggested Metric
Institutional Buy-In	CO expresses interest in pilot exploration; early MoU or agreement in discussion.
Solution Readiness	MVP tested in an extended or external environment; improvements implemented.
Sustainability Path	Initial plan for post-program ownership or funding drafted.

Cumulative Tracking

- % completion of prototype milestones
- % of users tested
- % of stakeholder feedback items received & integrated
- % SDG contribution implemented in technical flow
- Progress toward pilot validation (e.g., 0–100 scale)

MVP Planning Table

Component	Prototype Status	Improvement for MVP
UI/UX	Basic dashboard with consumption display	Add mobile interface and advanced analytics
Blockchain	Token minting with metadata	Implement batch processing and optimization
SDG Tags	Basic metadata tagging	Create filterable SDG impact reporting
ZECO Integration	Use test data	Test data connection and then production API integration

Fraud Detection	Simple anomaly alerts	Advanced ML algorithms with accuracy tuning
Users covered	Large Power Users	Large Power Users, Energy Generators, Transmission and Distribution Systems

Risk & Assumptions

Risk/Assumption	Description	Risk Level	Risk Mitigation Strategy
ZECO API Access	Delays in obtaining production data access	Medium	Start with test data, parallel development approach
Blockchain Complexity	Team learning curve for Cardano development	Low	Leverage Emurgo Labs mentorship and community resources
Stakeholder Adoption	Resistance to new technology adoption	Medium	Gradual onboarding, comprehensive training, clear value demonstration
Regulatory Compliance	Potential regulatory barriers to blockchain implementation	Low	Early engagement with Ministry of Energy, transparent development

Team Profile

Solution Makers

Team Name
Grinplus

Team Members & Roles

- Pablo Ferrari – Chief Technology Officer
- Federico González – Lead Blockchain Developer

- Matilde Maccio – Backend Developer (blockchain integration, API development)
- Nicolás Bartesaghi – Frontend Developer
- Diego Blixen – Chief Executive Officer (project management, stakeholder coordination)
- Ignacio Estrada - Renewable Energy Advisor (domain knowledge, testing, project management)
- Other technical staff: as needed (for example: electrical engineer)

Challenge Owners

Challenge Owner Organization Name:
UNDP Tanzania

Team Members & Roles:

- Elia John - ICT Associate
- Peter Nyanda - Head of Accelerator Lab
- Aaron Cunningham - Project Manager
- Jolson Masaki - Communications Analyst
- Kaare Manyama - National Energy Efficiency Analyst
- Sayuni Mbwilo - National Energy Efficiency Analyst

Area of Focus:
Energy sector transparency, utility governance, and sustainable development technology implementation.

Notes & Insights

Use this section to capture key learnings, challenges, or insights discovered during prototyping. This could include quotes from stakeholders, reflections on usability, or ideas for future iterations.

Pilot Vision & Scalability Plan

Pilot Vision (6–12 months)

Demonstrate measurable reduction in electricity losses through blockchain-verified consumption tracking with 50+ large power users. Validate fraud detection accuracy above 90% and achieve stakeholder satisfaction rating of 4/5+. Establish foundation for national deployment by proving

technical feasibility, cost-effectiveness, and regulatory compliance within Zanzibar's energy sector framework.

Target Users or Communities for Pilot

Primary focus on large industrial and commercial electricity users in Zanzibar. Secondary expansion to medium-scale consumers and residential areas with smart meter infrastructure. Target ZECO operational teams, regulatory officials, and customer service representatives as system users.

Scalability Plan

Proven Tanzania implementation creates a replicable template for utility transparency across Africa. Core blockchain infrastructure and smart contracts can be adapted for other utilities with minimal customization. Partnership framework with UNDP enables rapid expansion to additional UNDP country offices facing similar utility governance challenges.

Support Needed

Technical support for production-scale blockchain infrastructure, policy guidance for regulatory framework development, and funding for expanded pilot implementation. Ongoing partnership with UNDP for institutional credibility and stakeholder coordination across multiple countries.

Sustainability & Business Model (optional)

Business or Funding Model

- Phase 1 Funding (Months 1-6): Project Catalyst grant and other support ($150K) for technical foundation development
- Phase 2 Funding (Months 7-12): Seeking financing ($200K-500K) for operational pilot expansion
- Phase 3 Funding (Years 2-3): Revenue-generating model through utility service fees, government transparency contracts, and international licensing agreements
- Long-term Sustainability: Revenue sharing with implementing utilities based on demonstrated loss reduction, technology licensing fees for multi-country deployment, and consulting services for utility sector blockchain implementations.

Key Resources & Partnerships

Technical Infrastructure

- **Cloud hosting services** - for production deployment and data processing
- **Cardano network access** - Blockfrost API subscriptions and node infrastructure for blockchain operations
- **Database services** - PostgreSQL hosting for off-chain data storage and analytics
- **Security services** - SSL certificates, encryption tools, and security monitoring for utility-grade protection

Development Resources

- **Cardano developer community** - Ongoing access to Plutus/Aiken expertise and technical support
- **Machine learning tools** - Services for fraud detection algorithm development and training
- **API integration tools** - Middleware and monitoring services for ZECO system connections
- **Testing environments** - Cardano testnet access and staging infrastructure

Institutional Partnerships

- **UNDP Tanzania** - Continued institutional support, stakeholder coordination, and regulatory guidance
- **ZECO technical team** - Ongoing data access, system integration support, and operational validation
- **Emurgo Labs** - Technical mentorship and Cardano ecosystem development support
- **Ministry of Water, Energy and Minerals Zanzibar** - Regulatory compliance guidance and policy alignment

Specialized Expertise

- **Energy sector consultants** - Domain knowledge for utility operations and loss analysis methodologies
- **Blockchain security auditors** - Smart contract security reviews and penetration testing
- **Legal and regulatory advisors** - Compliance framework development for blockchain in utility sector
- **Business development support** - Expansion planning for additional African utility partnerships

Growth Resources

- **International development networks** - Access to other UNDP country offices for scaling opportunities
- **Utility sector conferences** - Industry connections for partnership development
- **Funding networks** - grants, investors and development bank relationships for development and expansion

Long-Term Ownership / Maintenance

Phase 1-2 (Years 1-2): Grinplus Leadership Grinplus will maintain primary ownership and technical responsibility during pilot and initial scaling phases. This ensures rapid iteration, quality control, and consistent development as the solution matures from proof-of-concept to operational system.

Phase 3+ (Year 3 onwards): Hybrid Public-Private Model

- **Technical Infrastructure**: Grinplus retains ownership of core blockchain platform and continues development of new features
- **Operational Management**: ZECO assumes day-to-day operational oversight with Grinplus providing technical support
- **Regulatory Oversight**: Ministry of Water, Energy and Minerals Zanzibar provides policy framework and compliance monitoring

Maintenance Structure

Grinplus Responsibilities:

- Smart contract upgrades and blockchain infrastructure maintenance
- Security monitoring and vulnerability management
- New feature development and algorithm improvements
- Technical support and training for ZECO staff

ZECO Responsibilities:

- Data quality management and meter integration oversight
- User support and stakeholder relationship management
- Operational procedures and internal process integration
- Local infrastructure maintenance

UNDP Role:

- Institutional coordination and policy advocacy
- Knowledge transfer to other country offices
- Performance monitoring and impact assessment

Deliverables Checklist

- ☐ Prototype demo link
- ☐ Source code / GitHub repo
- ☐ Documentation / ReadMe
- ☐ SDG metadata logic
- ☐ Feedback summary
- ☐ Video walkthrough
- ☐ Feedback from Country Office
- ☐ Next steps agreed (e.g., pilot planning?)

Team Reflection

UNDP Tanzania and Grinplus are uniquely positioned to lead blockchain adoption for development in Tanzania. Together, they reaffirm their commitment to advancing inclusive, transparent, and scalable digital solutions that align with national priorities and global development goals.

- **UNDP Tanzania** brings policy influence, development expertise, and convening power to align blockchain with national priorities.
- **Grinplus** offers technical innovation, agile prototyping, and local capacity building to deliver scalable blockchain solutions.

Jointly, UNDP Tanzania and Grinplus will:

- Pilot blockchain use cases in public service delivery.
- Support regulatory sandbox initiatives.
- Build inclusive digital ecosystems for youth, women, and entrepreneurs.
- Promote blockchain for climate resilience, financial inclusion, and governance reform.

Challenge Owner's Perspective

The ZECO SDG Blockchain Challenge is a blueprint for how Tanzania can harness blockchain to accelerate its development goals. As the country moves toward upper-middle-income status, blockchain offers a transformative pathway for governance, inclusion, and sustainability.

Solution Maker's Perspective

- *"Building on Cardano through the accelerator gave our team confidence to position blockchain as a solution for critical infrastructure challenges beyond what our previous experience with small solar generators entailed. We now see clear pathways for utility sector adoption across multiple African markets."*
- *"We discovered that batch tokenization on Cardano significantly reduces transaction costs while maintaining the granular data needed for effective loss analysis. This technical insight became central to our scalability strategy for processing millions of energy readings."*

Additional information - Phases for future development

Phase	Scope	Period	Features
I - Rapid PoC Sprint	Focus on use of electricity, specifically on Large Power Users. Use data from one Large Power User for prototype demo.	August 2025	Web portal where demo Large Power User can login and view information on their electricity consumption for selected time periods; alerts for anomalies; and can access for each date the blockchain explorer where the Cardano blockchain data can be viewed with more granularity and is inmutable. Screens include: 1) Consumption Overview 2) Consumption Detail 3) Sample Invoice 4) User settings
II - MVP &	Expand to analyze not	October	Would be a web portal,

Demo Prep	only consumption data, but also generation data and where losses might occur (a challenge detailed by Aaron). The MVP could be used / be useful for ZECO as well as organizations supporting ZECO in reducing power losses.	2025 - April 2026	similar to Prototype. Exact screens to be confirmed depending on which data is available. Covering the whole country (with all generation units, transmission and distribution, and consumers) might be challenging at this phase; but perhaps analysis can be done for 1 substation and the users connected to that substation.
III - Testing & Piloting	Real-world testing	November 2025 - April 2026	
IV - Full Pilot	Would expand on the Prototype, to include other electricity consumers; as well as MVP, to include the country's full list of electricity generators, transmission, consumers, etc. The pilot could be used / be useful for ZECO as well as organizations supporting ZECO in reducing power losses.	May 2026 - October 2027	Would be a web portal, but could also be done as a mobile app if useful for ZECO. Screens and features would need to be agreed upon depending on priorities, but a wide arrange of technologies (blockchain, machine learning, etc.) would be used.