# SDG BLOCKCHAIN ACCELERATOR

## MENTORSHIP FEEDBACK FORM

**Team:** Grinplus
**Project Title:** *Electricity Losses, Billing Transparency and Renewable Energy Integration*
**Country Office:** UNDP Tanzania
**Mentor:** ELV Solutions Architect
**Reporting Period:** September–October 2025
**Mentorship Focus:** Blockchain-Enabled Energy Tracking, Data Tokenization, and Utility Integration

# 1. Executive Summary

Grinplus successfully developed a Proof of Concept (PoC) for a blockchain-based system to enhance billing transparency, reduce electricity losses, and improve energy data accountability for TANESCO, Tanzania's national utility provider.

The PoC captures consumption readings from smart meters and mobile billing endpoints, converts them into tokenized digital records, and anchors those readings on the Cardano testnet, creating an immutable audit trail for electricity usage data.

Mentorship focused on refining the solution architecture, ensuring data integrity across hybrid systems, and aligning the platform with regulatory and operational requirements for national-scale deployment.

# 2. System Architecture Overview

The Grinplus system integrates three core layers:

- On-Chain Tokenization Layer:
  Each energy reading is represented as a UTxO-based transaction using PyCardano, embedding metadata such as timestamp, meter ID, and consumption value.
- Off-Chain Aggregation and Control Layer:
  A Python orchestration engine manages data collection, transaction submission, and reconciliation with off-chain billing systems.
  Blockfrost APIs are used for network queries and submission endpoints.

- User Interface Layer:
  A React-based dashboard provides real-time monitoring, audit logs, and visualization of energy readings and tokenized records.
  Administrators can track discrepancies, monitor consumer usage, and verify readings through a visual ledger.

The hybrid design ensures immutable recordkeeping on-chain while maintaining scalable data analytics off-chain, a pragmatic approach for utilities handling large data volumes.

## 3. Regulatory Context and Alignment

Grinplus engaged with UNDP Tanzania and energy-sector stakeholders to align the prototype with national standards for:

- Electricity consumption reporting and meter data transparency.
- Data protection and consumer privacy regulations.
- National goals for renewable energy integration and efficiency.

This proactive regulatory collaboration strengthens the solution's readiness for pilot deployment and provides a foundation for policy-aligned blockchain adoption in the Tanzanian energy sector.

## 4. Mentorship Focus and Guidance

### A. Data Architecture and Tokenization Workflow

The mentorship guided the team in:

- Structuring energy readings as verifiable on-chain tokens tied to identifiable meter events.
- Designing metadata schemas that balance audit transparency with data minimization principles.
- Introducing a consistent timestamp and ID synchronization framework for reliable data lineage.

### B. Transaction and Integration Design

As a Solutions Architect, the mentor emphasized:

- Streamlining PyCardano transaction assembly and wallet operations for improved throughput.
- Designing a modular architecture allowing easy integration with existing utility systems via REST APIs.
- Ensuring future compatibility with smart contract validators for automated dispute and refund mechanisms.

### C. Visualization and Data Flow

Recommendations included:

- Enhancing the React dashboard to display aggregated trends, loss indicators, and historical traceability.
- Structuring off-chain databases to maintain reconciliation between the blockchain and TANESCO's billing data.

- Defining data validation checkpoints to ensure accuracy between the on-chain record and legacy billing datasets.

## 5. Technical Challenges

| Category | Description |
|---|---|
| **Meter Integration** | Achieving reliable data ingestion from diverse meter sources and mobile billing systems. |
| **On-/Off-Chain Synchronization** | Maintaining data consistency and transaction order across both layers under real-time conditions. |
| **Scaling Limits** | Current PoC tests were limited to controlled datasets; scalability testing required for city-level loads. |

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|---|---|
| **Smart Contract Maturity** | No automated validator testing yet; manual submission workflows limit audit reproducibility. |
| **Regulatory Compliance** | Continuous collaboration with authorities needed to formalize blockchain-based billing standards. |

## 6. Key Learnings

- **Hybrid solutions** offer an achievable path for early blockchain adoption in critical infrastructure sectors.
- **Python and PyCardano** provide a lightweight, accessible stack for rapid prototyping.
- **Immutable tokenization** enables verifiable audit trails that directly address billing integrity challenges.
- Early involvement of **utility stakeholders** ensures smoother adoption and trust in digital infrastructure changes.

## 7. Recommendations and Roadmap

1. **Smart Contract Integration:**
   Develop Aiken or Plutus validators to automate disbursement and verification processes.
2. **Performance Optimization:**
   Test higher transaction throughput and implement **batch submission scripts** for scaling.
3. **Predictive Analytics Dashboard:**
   Add energy loss forecasting and efficiency scoring using machine learning models.
4. **Database Hardening:**
   Transition from temporary storage to **PostgreSQL with versioned state tracking**.

5. **Regulatory Engagement:**
   Establish a **regulatory sandbox** with UNDP and Tanzania's energy authorities for controlled pilot validation.

## 8. Mentor's Reflections

Grinplus demonstrates how blockchain can enhance energy accountability without disrupting existing systems. Their Python-based hybrid model balances innovation with practicality, creating a clear path toward digital transparency in national utilities. The next step is to operationalize smart contracts and predictive analytics to bring measurable efficiency gains.

## 9. Post-Accelerator Collaboration

Grinplus and Mentor agreed to continue cooperation post-accelerator, with planned collaboration on:

- Smart contract implementation and testing for automated data validation..
- Scaling benchmarks and database optimization.
- Regulatory compliance documentation and certification support.