Blockchain for Traceability in Circular Economy

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- Traceability is the **backbone of circular value chains**.
- **Companies must trust** shared product and process data.
- **Circular flows need evidence** across multiple organizations.
- Blockchain adds **trust to distributed traceability**.
- It helps **prove origin, state, and transformation**.

The Traceability Problem Today

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- **Data is fragmented** across companies and systems.
- Records are **duplicated** and **hard to reconcile.**
- **Evidence** can be incomplete or **easy to alter.**
- **Audits** are slow, manual, and expensive.
- **Trust often depends on intermediaries.**

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Why Blockchain Fits This Problem

- It creates a **shared and tamper-evident record.**
- Every partner sees the **same trusted history.**
- Each event is **time-stamped and verifiable.**
- **No single actor controls** the whole ledger.
- **Trust** moves from organizations to **shared rules.**

What Should Be Tracked?

- Material **origin** and **composition**.
- **Product** ID, batch, and serial **events**.
- Repair, reuse, refurbish, and remanufacture **actions**.
- **Ownership**, custody, and location changes.
- Sustainability and compliance **evidence**.

How the Traceability Model Works

1. A real-world **event happens.**
2. The **event is validated** by the responsible actor.
3. A digital **record is created and signed.**
4. Its **proof is anchored** on blockchain.
5. The **lifecycle history becomes auditable** end to end.

On-Chain vs Off-Chain Architecture

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- Sensitive **industrial data** should **stay off-chain.**
- **Hashes and proofs** should go **on-chain**.
- Blockchain stores **evidence, not heavy files.**
- **Off-chain** systems keep operational **detail private**.
- This balances **trust, privacy, and scalability**.

Identity Is Essential

- Every **actor must be uniquely identifiable**.
- Organizations, users, and devices need **trusted IDs**.
- **Verifiable credentials** reduce unnecessary data sharing.
- Permissions must be role-based and auditable.
- **Trusted identity** enables trusted **traceability**.

Smart Contracts for Circular Processes

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- **Rules can be automated** across organizations.
- **Access** can depend on role, consent, or status.
- **Events** can trigger **validations and approvals**.
- Circular conditions can be **checked automatically.**
- **Shared workflows** become faster and more reliable.

Example in a CIRCULOOS-Type Project

- **Suppliers** register **material and component** events.
- **Manufacturers** record **production and transformation** steps.
- **Service partners** record **repair and refurbishment** actions.
- **Recyclers certify recovery** and **secondary material output**.
- The platform creates **trusted circular product histories**.

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Business Value and Key Limits

- Better **transparency** across the **supply chain**.
- Stronger **auditability** and **compliance evidence**.
- Higher **trust for reuse** and **remanufacturing models**.
- **Less reconciliation** between partners.
- Blockchain works best with **governance, identity, and data standards**.

Key Takeaway

- Blockchain **does not replace** enterprise systems.
- Blockchain becomes the **trust layer between them.**
- In circular economy, **trust unlocks traceability.**
- Traceability unlocks **circular business models.**
- **That is why blockchain matters.**

Thanks!

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