VIEW POINT



FIVE WAYS BLOCKCHAIN HELPS ENERGY ENTERPRISES DRIVE SUSTAINABILITY

Abstract

Energy enterprises are leveraging blockchain technologies to reimagine business operations, waste management, energy trading, and more. Blockchain platforms offer several unique features, making them well suited to emerging applications across renewable energy generation, net-zero emissions, recycling, and circularity.

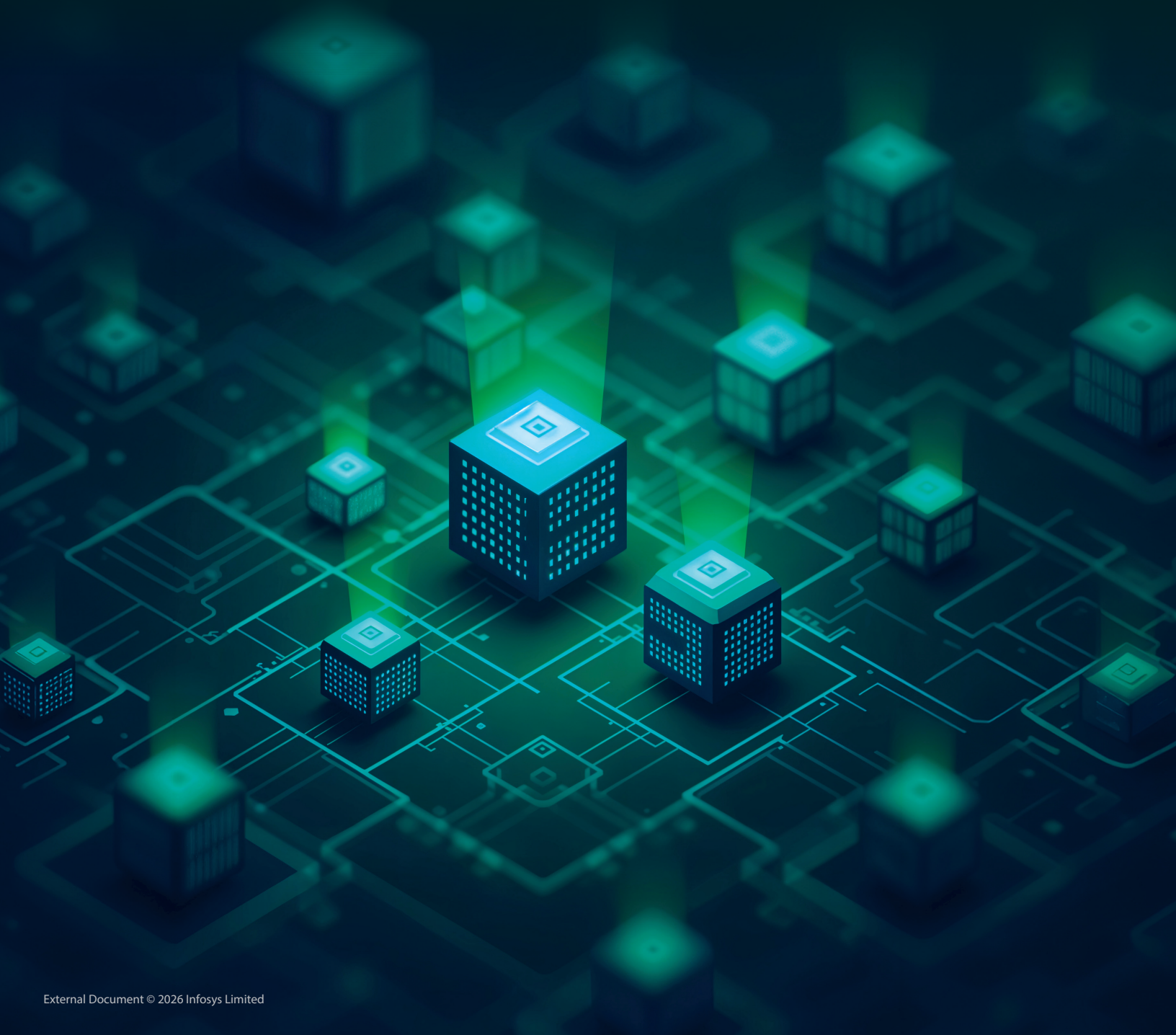
This paper examines five key opportunity areas for blockchain in the energy sector, from digital product passport to contract management. It explains how blockchain is helping enterprises transform operations, follow sustainability directives, and meet regulatory norms. The paper also highlights existing implementations as well as realized benefits.

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Introduction

The energy industry faces disruption from electrification, decarbonization, circularity, and decentralization of energy systems. As energy value chains become more interconnected and data-driven, enterprises need reliable, transparent, and verifiable data to make decisions, demonstrate compliance, and support sustainability claims. However, fragmented systems, rising data volumes, and evolving regulatory requirements undermine data trust across the ecosystem.

Blockchain technology offers a transformative solution to these challenges. It provides a secure, decentralized, and immutable framework for stakeholders to record and share information. By enabling trusted data exchange, blockchain can help energy enterprises verify sustainability data with ease and accuracy, while enabling circularity for business growth.



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The Data Trust Challenge in Sustainability

Across the globe, there is a pressing need for greater transparency and sustainability across energy supply chains and processes. Tightening regulations, the demand for circularity, increasing electrification, and grid decentralization underscore this need. In such a landscape, energy enterprises find it difficult to verify sustainability data due to the following challenges.

- **Fragmented systems:** Energy industry ecosystems involve several participants. Energy value chains comprise energy generators, transmission system operators, retailers, consumers, and prosumers. Oil and gas value chains have refiners, tankers, regulatory bodies, and others. Each of these participants often rely on legacy infrastructure and fragmented systems, where data resides in silos. This impedes secure access to complete, accurate, and real-time information on financial, operational, and sustainability performance.
- **Tracking provenance:** Even as governments nudge enterprises toward using clean energy, it is necessary to track the true origin of green power. Energy attribute documents, such as guarantees of origin (GOs) and renewable energy certificates (RECs), promote the use of green energy. However, incidents of double counting, claim mismatch, and regulatory non-alignment still occur. These issues hinder the ability to trust and verify sustainability claims.
- **Managing large data volumes:** Energy prosumers are increasingly generating green energy through rooftop solar panels, small wind turbines, and micro biomass systems. The sale of excess energy through peer-to-peer (P2P) energy trading is disrupting business models and grid operations. These participants transact with each other, manage volumes, and handle risk within the network. Each transaction creates large streams of localized data that must be securely shared, governed, protected, and audited.
- **Compliance burdens:** Energy enterprises also spend significant resources evaluating large datasets to prove compliance with regional regulations. Complex reporting processes run the risk of data misuse and breaches.

These challenges result in low data trust, a key obstacle to achieving a circular economy and ensuring sustainable business practices.

Blockchain: Enabling Immutable Data Trust

The market size of blockchain in the energy sector is estimated to reach US $3.46 billion in 2026, up from US $2.80 billion in 2025[1]. Energy enterprises leverage blockchain for its ability to decentralize, digitalize, and decarbonize operations, which are key themes in the energy industry. Moreover, blockchains possess unique characteristics such as[2]:

- **Transparency:** All participants can view details such as transaction history and certificates, thereby building trust among stakeholders and driving auditability for regulators.
- **Security:** Blockchains use cryptographic encryption for data integrity, thereby reducing the risk of fraud, data fabrication, and unauthorized access.
- **Decentralization:** Distributed ledger technology ensures there is no single authority controlling the data, thereby empowering individual participants and reducing dependency on intermediaries.
- **Smart contracts:** These automated, self-executing agreements are coded directly into the blockchain to validate preset conditions before any transaction occurs.

These features are proving instrumental in addressing the challenges of low data trust in the energy industry. Blockchain can drive significant process innovation within energy enterprises and their broader ecosystem in the following ways:

- Digitizing documents on the distributed ledger, thereby reducing fraud, duplication, and administrative costs
- Enabling traceability to strengthen responsible sourcing practices, track carbon emissions as well as movement of critical materials across energy supply chains, and ensure verifiable provenance of assets as well as energy
- Creating tamper-proof, immutable, and auditable records of all kinds of data, including supplier audits, verification records, compliance certificates, recycled components, and carbon emissions

Apart from reducing cost, these capabilities improve transparency without compromising privacy. They also ensure clear data traceability and regulatory compliance, which are crucial to build trust among stakeholders in the energy ecosystem.

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Blockchain Solutions for Sustainability in Energy

1. Digital Product Passport

Blockchain can assign a tamper-proof digital identity for energy equipment and storage assets, thereby preserving the full asset lifecycle history. This unique digital identifier, or digital product passport, contains the serial number and equipment batch. It can also capture information, such as approved specifications, data sheets, quality checkpoints, and test certificates. Enterprises can use this information to verify requirement conformance, maintenance trail, and overall asset credentials from asset manufacturing to decommissioning.

Digital passports capture key information related to product provenance, reducing the likelihood of counterfeiting and forgery. This improves asset reliability in critical infrastructure. In 2024, an international industry association with a membership of over 90 leading oil and gas organizations announced the introduction of a Material Digital Passport (MDP) system to combat material fraud and reduce financial losses as well as safety risks. The new system provides an interoperable, tamper-proof electronic lifecycle record for battery components. All battery-related information is stored in a centralized data library. The MDP has helped oil and gas enterprises achieve end-to-end traceability, fraud reduction, and audit-ready compliance across material procurement and operations[3].

Digital passports also support independent authentication of certification data, inspection reports, and compliance approvals. They also simplify compliance with regulations such as the Ecodesign for Sustainable Products Regulation (ESPR), Regulation (EU) 2023/1542 (or the EU Battery Regulation), and the Carbon Border Adjustment Mechanism (CBAM). Further, such passports strengthen responsible sourcing practices by enabling multi-tier traceability of critical materials across energy supply chains. For a Swedish multinational luxury vehicle manufacturer, blockchain supports battery material traceability across its electric vehicle (EV) line. The solution enables immutable provenance and chain-of-custody for cobalt and mica, driving circularity through ethical sourcing and verifiable sustainability claims[4].

2. Digital energy trading

Blockchain can lower document reconciliation costs in energy trading. It can digitize letters of credit, guarantees, and settlement documents and create shared, immutable, time-stamped records for traders, banks, and regulators. This approach reduces fraud, duplicate paperwork, and administrative costs. It also provides a verifiable audit trail from contract execution to settlement.



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Such transparency can support several innovations. It enables disintermediation by allowing direct energy trades through shared, tamper-proof records that remove intermediaries and manual reconciliation. An instant, single-step exchange of payment and delivery reduces costs and delays, improving trust among stakeholders. As an example, a global company specializing in post-trade processing has built a pioneering industry-wide blockchain platform for commodities trading. The platform acts as a single source of truth for all trades, thereby eliminating the need for manual reconciliation and tedious paper-based processes[5].

3. Connected recycling

Blockchain creates verifiable end-to-end lifecycle data, linking material origin, operational use, and end-of-life status. It can track the provenance of assets and capture carbon intensity data to support circularity through appropriate due diligence of the asset data. It also allows a shared chain of custody for compliant, closed-loop material flows. These capabilities can help enterprises comply with ESPR while driving positive environmental change.

In 2022, Japan leveraged a blockchain platform and digital product passports to track discarded plastic bottle caps and recycle these into high-quality consumer goods. Considering Japan has collected nearly 20 million bottle caps over 30 years, this initiative is critically relevant6. It demonstrates the deep transformative impact that blockchain-based DPPs can bring to waste management and resource use.

4. ESG visibility

Blockchain creates and stores tamper-proof records of environmental, social, and governance (ESG) data. It can tokenize carbon emissions, energy attributes, sustainability data, and track carbon as well as green credits for singularity of claim. This helps enterprises navigate net-zero roadmaps with credible disclosures and faster assurance. For instance, a recent collaboration between leading energy companies resulted in a tamper-proof, audit-ready blockchain system, providing regulators with a single trusted view of methane leak reduction, emissions accounting, and carbon credits[7].

Blockchain links measurements, certifications, and disclosures into a single, verifiable source of truth. Enterprises can use this data to evaluate performance, supplier reporting, and compliance across the energy value chain. It can track feedstock origin, batch movements, and sustainability documents—such as point-of-sale records, certifications, and greenhouse gas data—on a shared, tamper-evident ledger.

This practice inherently complies with the EU Renewable Energy Directive (RED) II and III schemes, such as International Sustainability and Carbon Certification (ISCC) and REDcert. They support verifiable, chain-of-custody records and audit-ready reporting. Using blockchain for ESG data also enhances compliance with the EU Methane Regulation, Corporate Sustainability Reporting Directive (CSRD), and European Sustainability Reporting Standards (ESRS).

Blockchain also creates a verifiable chain of custody for wastewater, hazardous materials, and industrial byproducts from generation to disposal. It can collect data from operators, transporters, and treatment facilities to automate processes, reduce fraud, and track the provenance of waste materials. A fitting example is of an industry-leading oil and gas consortium using blockchain to auto-validate volumes of produced water haulage from wellhead to disposal. The system also automates field readings and invoice payments. With a tamper-evident chain of custody and verifiable waste tracking support, it triggers smart contract payments and audit-ready regulatory compliance[8].

Finally, blockchain can also link energy attribute and carbon intensity data to products and operations. It can provide on-chain credits as evidence of emissions reductions, strengthening defensible low-carbon claims and eligibility for incentives as well as green finance.

5. Contract management

Through smart contracts, blockchain can create a tamper-proof, time-stamped single source of truth across operators, joint venture partners, contractors, regulators, and buyers. Smart contracts can automate the complete cycle of contract management, including creation, approval, amendments, and renewals. They can also embed governance and approvals, thereby reducing delays and disputes.

By enabling continuous and trusted monitoring of contractual obligations, milestones, delivery commitments, and performance guarantees, blockchain can reduce the risk of penalties. Immutable audit trails strengthen

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compliance, statutory reporting, and long-term dispute resolution. Smart contracts can also support compliance with regulations like RED II and III, which include biofuels, renewable fuels of non-biological origin (RFNBOs), and recycled carbon fuels (RCFs). They can also improve adherence to CSRD and ESRS.

A global oil exploration company uses smart contracts to automate commercial agreements. The system automatically collects rig and logistics data to auto-calculate daily rate charges, generate invoices, and post approved payments to the enterprise resource planning (ERP) system. This has reduced reconciliation errors and disputes, while ensuring a tamper-proof audit trail[9].

Conclusion

The energy industry is moving toward a decentralized, decarbonized, and electrified future. Trusted, verifiable data will become critical to the way energy enterprises collaborate with different stakeholders and operate across multiple regions.

Most energy enterprises struggle with fragmented systems, large data volumes, and evolving compliance requirements, making data access and trusted data exchange challenging. Blockchain, with its distributed ledger technology, offers a secure, transparent, and immutable foundation to address these gaps.

It powers innovative use cases such as digital product passport, energy trading, ESG reporting, connected recycling, and contract management. With its tamper-proof and secure framework, blockchain can help energy enterprises strengthen data trust while advancing their sustainability objectives of responsible sourcing, effective waste management, net-zero emissions, and verified circularity.



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Rohini is a distinguished technology leader specializing in blockchain, sustainability, and digital asset consulting. With extensive experience in building and scaling emerging technology practices, she has been instrumental in driving innovation and business value across industries. As Practice Head for blockchain and sustainability service lines at Infosys, Rohini leads strategic thought leadership, develops market-leading solutions, and helps Fortune 500 clients accelerate their transformation journeys.

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