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OPEN LETTER

REVISED Advancing data management in local energy trading: European policy, state-of-the-art, and real-world practice in FEDECOM and STUNNED

[version 2; peer review: 2 approved, 2 approved with reservations]

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Abstract

This Open Letter reflects on best practices for data management in energy exchange and trading in the context of European energy communities. It draws on European policy developments, selected literature, and practical experience from two Horizon Europe projects, FEDECOM and STUNNED, to highlight recurring challenges and emerging solutions related to interoperability, data governance, security, and scalability. Rather than presenting original empirical results, the paper adopts a practice-oriented perspective, using these projects as illustrative examples to bridge policy objectives, technical approaches, and real-world implementation. The intended audience includes researchers, technology providers, project developers, and policymakers involved in the digitalisation of energy systems. The Open Letter concludes with concrete recommendations and future research directions aimed at supporting interoperable, data-driven energy trading across Europe.

Keywords

data management, data governance, peer-to-peer energy trading, digitalisation, energy communities, interoperability, blockchain, smart grids, flexibility markets

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REVISED **Amendments from Version 1**

This revised version clarifies the scope and purpose of the Open Letter, strengthens the problem framing and legal terminology, and improves coherence across the luterature review, project descriptions, comparative analysis, and conclusions in response to the peer-review feedback. The revisions introduce clearer signposting, explicit evaluation criteria, and a more direct link between comparative insights and actionable recommendations for researchers, technology providers, and policymakers, while preserving the original focus and conclusions of the paper.

Any further responses from the reviewers can be found at the end of the article

Introduction

The European Union's drive for a clean, decentralised, and flexible energy system has placed energy communities and digitalisation at the heart of energy policy. The Clean Energy for All Europeans Package, together with the recast Electricity Market Directive (2019/944), establishes the framework for consumer empowerment, energy communities (including Renewable Energy Communities and Citizen Energy Communities as defined under EU law), and flexible demand-side participation. For readability, the term "energy communities" is used throughout this Open Letter to refer collectively to these legally recognised forms. These policies require robust digital infrastructures that can support the secure, real-time exchange of large volumes of diverse data—a challenge that is central to the modernisation of energy markets. Digitalisation—through advanced data management, open communication architectures, and robust cybersecurity—is widely recognised as an enabler of these ambitions. In parallel, the rapid evolution of market structures, including the rise of local and peer-to-peer (P2P) trading and flexibility services, is redefining the requirements for data management. The need to process granular, high-velocity data streams from a multiplicity of assets, market actors, and devices is driving the adoption of new architectures and standards. In this context, data management refers to the comprehensive processes of collecting, validating, storing, sharing, and analysing information from energy assets and market interactions, all within a framework that ensures security and regulatory compliance. The literature points to several interlinked best practices: comprehensive and secure data collection at the source, interoperable data models and application programming interfaces (APIs), advanced analytics for real-time operations, and open data governance models that balance transparency, privacy, and regulatory compliance.

At the intersection of policy ambition and technical innovation stand large-scale EU-funded projects, such as FEDECOM and STUNNED. These projects show how digital infrastructures—built on a foundation of state-of-the-art data management—are operationalising the new market and community paradigms envisaged by EU policy. This Open Letter is motivated by the growing gap between the conceptual discussion of data management in energy trading and its practical implementation in large-scale, policy-aligned European projects. Its primary contribution is twofold: first, it synthesises state-of-the-art literature and European policy developments to identify concrete data management requirements for energy exchange and trading; second, it shows through practical examples how these requirements are operationalised in practice through two complementary Horizon Europe projects, STUNNED and FEDECOM. The novelty of this work lies in its comparative, practice-oriented perspective, which connects policy, theory, and real-world implementation to derive actionable insights for researchers, technology providers, and policymakers. Despite increasing policy attention and technological progress, data management remains a critical bottleneck for scalable and interoperable energy exchange and trading. Fragmented data models, limited interoperability between platforms, and uncertainty around governance and responsibility continue to hinder cross-project learning and market integration. This Open Letter addresses the following guiding question: how are contemporary European research projects operationalising best practices in data management for energy trading, and what lessons can be drawn to inform future research, innovation, and policy design?

The remainder of this paper draws together current best practice and concrete project experience to inform both ongoing research and practical deployment across Europe. FEDECOM and STUNNED serve as leading European testbeds for the practical implementation of such digital infrastructures, each addressing complementary aspects of interoperable, market-oriented data management. The following sections review the historical and technical context, analyse the state of the art, and present in-depth case studies of both projects, culminating in a comparative analysis and recommendations for future research.

Literature review

Although Open Letters do not typically include formal literature reviews, this section serves a specific contextual purpose. Rather than aiming for exhaustiveness, it synthesises selected strands of policy-oriented and technical literature to identify recurring data management challenges in energy exchange and trading. This framing provides the necessary background to interpret the STUNNED and FEDECOM projects as practical responses to these challenges. This overview highlights that the core challenge addressed in this Open Letter is not the absence of technical solutions, but the difficulty of translating best practices into interoperable, scalable, and policy-aligned implementations.

Historical context and evolution

The transformation of energy markets—from centralised systems with minimal data requirements focused mainly on billing and grid operations to decentralised, competitive environments—has greatly increased the volume, complexity, and strategic importance of data management (Soto *et al.*, 2021; Zhou *et al.*, 2020). In earlier regimes, data was primarily used for billing and simple grid operations.

The liberalisation of energy markets in the late 20th century introduced new market actors, competitive trading, and dynamic pricing—each driving the need for more advanced data handling capabilities for pricing, risk management, and real-time market monitoring (Zahraoui *et al.*, 2023). The subsequent adoption of the Harmonised Electricity Market Role Model (HEMRM) in Europe was a pivotal step toward standardising data exchange frameworks across borders (Marinšek *et al.*, 2024). Meanwhile, the integration of renewable energy sources such as solar and wind, characterised by their intermittent and distributed output, has further amplified the demand for timely, accurate, and comprehensive data management (Cuenca *et al.*, 2021).

More recently, the emergence of P2P trading, blockchain, smart contracts, and IoT technologies directly addresses these intensified data management challenges, enabling secure, decentralised, and transparent energy transactions among a wider array of market participants (Bassey *et al.*, 2024). Collectively, these structural shifts have elevated data management from a supporting back-office function to a strategic capability that underpins market participation, operational reliability, and the integration of innovative business models in the energy sector. This evolving context sets the stage for a deeper analysis of the specific aspects and requirements of data management in modern energy systems, as explored in the following section.

Key aspects of data management

The transition to smart grids and digital energy systems has fundamentally expanded both the complexity and the centrality of data management in energy trading and community operations.

Modern energy systems rely on the continuous collection of data from diverse sources—including smart meters, IoT sensors, and digital market platforms—which generate exponentially larger data volumes than conventional infrastructure. For example, smart meters capable of transmitting readings at 15-minute intervals now produce millions of data points per day across a single utility's network. Each transaction in energy trading may reference dozens or even hundreds of supporting data points, including contractual, locational, and real-time consumption data. This explosion in data volume and diversity presents unprecedented challenges for data management, as traditional approaches struggle to aggregate, validate, and utilise such complex datasets for operational decision-making and market transparency.

Traditional data storage solutions, including legacy Energy Trading and Risk Management (ETRM) systems that rely on denormalisation and batch processing, have proven inadequate in the face of today's transaction volumes and complexity, often leading to system slowdowns and limited scalability. As a result, many energy organisations are shifting to centralised data stores or data lakes, which offer scalable, secure, and reliable repositories for aggregating, normalising, and analysing critical market and operational data (Capco, 2022). Newer decentralised approaches, such as Data Spaces, are also being developed to automate processes such as supplier switching and to enable secure, compliant data sharing across organisational boundaries (Rülicke *et al.*, 2024).

High data quality is essential for effective energy exchange. Accurate meter readings are non-negotiable for correct billing and operational efficiency, while data completeness ensures that forecasting and market planning remain robust and uninterrupted. Consistency across data sources prevents discrepancies that could undermine regulatory reporting or grid reliability, and timeliness ensures that critical functions like real-time trading and outage management can be performed without delay (Evangelista Bem *et al.*, 2023; Jha *et al.*, 2023). To support these aims, comprehensive data governance frameworks—encompassing standardisation, validation, security, and regulatory compliance—are increasingly seen as foundational requirements in energy data management (Depiver, 2022).

Building on these foundations, energy organisations are increasingly leveraging advanced analytics to extract actionable insights, support grid optimisation, and develop sophisticated trading strategies (Sun *et al.*, 2024). Visualisation tools are also crucial, enabling stakeholders to interpret complex data in accessible formats and thereby improve decision-making (Brodny & Tutak, 2023). With the growing emphasis on consumer data protection (Chiarini & Compagnucci, 2022), emerging solutions such as blockchain now offer secure, transparent methods for data sharing and transaction verification, especially in P2P markets where integrity and privacy are paramount (Wang *et al.*, 2021). However, the adoption of these technologies also requires overcoming significant regulatory and integration challenges. As the complexity and criticality of data management in energy trading increases, the role of policy and regulation becomes ever more central—a theme addressed in the next section.

European policy and regulatory framework

European energy policy not only shapes market structures but directly defines the technical requirements for data collection, exchange, and security in energy trading and community systems. A range of EU directives—including the Energy Efficiency Directive, the Renewable Energy Directive, and the EU Emissions Trading System (ETS)—establish binding requirements for the collection, monitoring, and reporting of energy data (Bel & Joseph, 2018; Herweg, 2017; Hu *et al.*, 2024; Stoicescu *et al.*, 2023). For instance, the Energy Efficiency Directive mandates robust systems for tracking energy consumption improvements, while the Renewable Energy Directive requires accurate measurement and integration of renewable generation into national and EU-wide reporting systems. The ETS, as a market-based mechanism to reduce greenhouse gas emissions, relies fundamentally on the integrity of emissions data for both compliance and trading.

However, significant fragmentation persists across Member States, with differing regulatory structures resulting in disparities

in energy prices and creating barriers to seamless, cross-border data exchange (Faure-Schuyer *et al.*, 2017). Recognising these challenges, the EU has launched initiatives such as the Data Governance Act and is working towards a Common European Energy Data Space, both designed to facilitate secure, standardised, and interoperable data flows at scale. Achieving effective policy coordination and technical harmonisation remains essential for the realisation of a unified European energy market (Teixeira *et al.*, 2014). These policy frameworks, while ambitious, create both challenges and opportunities for technical innovation in data management—a dynamic explored in the next section.

Technological state-of-the-art

The rapid evolution of data management technologies is fundamentally reshaping how energy systems operate, addressing emerging challenges in data volume, velocity, and complexity. Modern smart grids rely on extensive networks of IoT devices that generate continuous, high-frequency data from across the system, enabling advanced real-time monitoring and automated control. At the core of these capabilities are multi-layered communication infrastructures—including Home Area Networks (HANs), Business Area Networks (BANs), and Neighbourhood Area Networks (NANs)—that must deliver high bandwidth, low-latency, and secure data transmission through a mix of wired and wireless technologies. Particularly, Advanced Metering Infrastructure (AMI) builds on these communication layers and represents a crucial part of the smart grid that turns conventional one-way metering into a two-way interactive network, enabling end-users and utilities to manage energy more intelligently. It can facilitate automated billing reads, remote meter monitoring, and control commands including dynamic price signals and remote service connection (E-CIGRE, 2024). This comprehensive architecture ensures seamless data flow between end users, system operators, and market platforms. Emerging grid-sensing technologies, such as synchrophasors, provide operators with precise, real-time measurements of voltage and current phase angles, enhancing situational awareness and supporting grid stability even as the system becomes more dynamic and decentralised (Jha *et al.*, 2023)[9].

Blockchain and distributed ledger technologies are increasingly employed to ensure data integrity, transparency, and security in energy trading. By automating and validating transactions via smart contracts, these systems can enable more efficient and reliable market operations (Chiarini & Compagnucci, 2022; Evens *et al.*, 2023). In parallel, P2P trading models are redefining the energy landscape by allowing consumers and prosumers to buy and sell surplus energy directly, circumventing traditional utilities and leveraging decentralised, blockchain-based platforms. These innovations offer significant potential for market transparency and user empowerment but also introduce new challenges in integrating with existing regulatory and technical infrastructure (WINSSolutions, 2023). However, integrating blockchain and decentralised trading with existing market infrastructures remains a significant technical and regulatory challenge.

Evidence from pilot projects suggests that blockchain-based platforms can substantially reduce trading costs—by as much as 30–40%—through automation, improved data transparency, and streamlined inter-system communications (EnergiesMedia, 2023). These efficiency gains are motivating broader adoption, though practical implementation at scale remains hampered by interoperability and regulatory hurdles. Artificial intelligence (AI) and machine learning (ML) techniques are being deployed to forecast energy demand and generation with greater accuracy, optimise grid operations, and inform strategic trading decisions (Bortoletto *et al.*, 2023). These tools enable more proactive, adaptive, and resilient system management. While these technological advances are rapidly expanding the capabilities of data management in energy systems, they also highlight the need for continuous attention to interoperability, standardisation, and cybersecurity as core pillars of sustainable digital energy infrastructure.

Case studies

To illustrate how the best practices and technical challenges discussed in the previous sections are being addressed in real-world settings, this section presents two major European projects—STUNNED and FEDECOM. Both projects serve as leading testbeds for the practical implementation of advanced data management in energy communities, offering valuable insights into both the opportunities and remaining obstacles in the digitalisation of energy trading. The two projects presented in this section are not treated as formal case studies in the methodological sense, but as illustrative examples drawn from the authors' direct involvement in European research and innovation activities. FEDECOM and STUNNED were selected because they address similar data management challenges in energy trading from complementary perspectives and at different stages of maturity. Together, they allow for a comparative reflection on how policy objectives and best practices are translated into technical and organisational solutions in real-world projects.

The STUNNED project

The STUNNED project (Horizon Europe Grant 101172968), implemented by a consortium of research institutions, technology providers, and market actors, exemplifies a cutting-edge approach to operationalising advanced data management in European energy communities. The project aims to unlock the flexibility and demand response potential of residential and industrial buildings aggregated in energy communities and energy districts by deploying secure, modular digital platforms capable of aggregating diverse energy assets and enabling innovative market participation models. Key objectives include the integration of building energy management systems (EMS), distributed energy resources (DERs), and electric vehicle (EV) charging infrastructure, alongside the development of advanced analytics for system optimisation and the validation of scalable, replicable business models for flexibility services.

The following description focuses on how STUNNED addresses data management challenges identified in the literature, rather than providing a comprehensive technical specification of the project.

Technically, STUNNED's digital architecture is designed as a modular, interoperable platform stack to ensure secure, efficient, and privacy-compliant data flow between distributed assets, local EMS, and market interfaces. Leveraging IoT and industrial-grade control and automation, STUNNED aims to enable integration at different application layers through both industry-standard and vendor-specific protocols. Standardised and secure communication protocols support both real-time and batch data exchanges, facilitating robust and flexible data management across varied operational contexts.

Modular design of the STUNNED platform ensures compatibility with arbitrary type of legacy equipment onsite, from industrial-grade EMS systems to lightweight IoT thermostats in buildings. It envisions local data-management hubs as gateways to distributed assets, allowing for decentralised data acquisition and real-time local control while safeguarding the operational processes of flexibility providers. To address interoperability challenges caused by diverse range of assets and external platforms, the design of STUNNED platform includes a dedicated semantic interoperability module, serving as a unified dictionary that comprehensively defines the relevant features required to accurately describe each asset and its interface.

STUNNED Cloud Platform (SCP) is the core of the STUNNED architecture, and manages the components that govern the whole infrastructure: Ontology, Semantics, Time Series, KPI definitions, Operational Hierarchies, and Access Control are part of the SCP.

The Broker service attached to the SCP is the bridge within the STUNNED Cloud Platform and external agents deployed on each location, to both send data and receive instructions.

Data is organised in hierarchies, and gathered within the STUNNED Cloud Platform Data Lake, from where it's shared with authorised partners via its interoperability layer (API). That modular and interoperable design enables both local and remote analytics to support optimisation and effective participation in energy markets with a complete view of the data and its semantic meaning.

Advanced algorithms—including game-theoretic and multi-objective optimisation—form the backbone of the platform's forecasting, bidding, and demand response capabilities. To assess progress toward these objectives, STUNNED defines a set of key performance indicators, including the volume of flexibility activated through aggregated assets, the accuracy and timeliness of forecasting and optimisation outputs, the reliability and latency of data exchanges across integrated systems, the level of participation of buildings and prosumers, and the successful validation of flexibility-related business models under real operational conditions. Compliance with FAIR (Findable, Accessible, Interoperable, Re-usable) data principles and the General Data Protection Regulation (GDPR) is embedded throughout, ensuring privacy and transparency in all operations.

The platform's technical design prioritises modularity and interoperability, allowing for seamless integration of new devices and the rapid scaling of community participation. Security is upheld through end-to-end encryption, role-based access controls, and ongoing system monitoring for vulnerabilities. Notably, STUNNED's architecture is innovative in its planned integration of flexibility services with both local grid operators and wholesale market platforms, allowing for scalable participation in multiple market layers and regulatory environments.

Pilots within STUNNED are being deployed across a variety of regulatory and market contexts, including residential districts, commercial properties, industrial sites, and mixed-use developments (Italy, France, and Spain). These contexts were selected to reflect diverse regulatory and market conditions. Each pilot site integrates a suite of distributed assets with the STUNNED platform, rigorously testing both the technical integration and the business model innovations in operational environments. By deploying a modular and interoperable digital platform, STUNNED aims to validate not only the technical feasibility but also the market viability of advanced data management strategies for energy communities. The project's capacity to support automated data sharing, secure transactions, and real-time optimisation is expected to enhance grid flexibility, increase consumer and prosumer participation, and generate robust business cases for community-led trading and demand response. Precisely, the impact of STUNNED solution will be measured against a designated set of key performance indicators (KPIs) including peak power reduction, self-consumption, self-sufficiency, hours of flexibility activated for grid services, operating costs and revenues, among other. The pilots will provide actionable blueprints for replication in diverse European contexts and will inform ongoing policy development on data governance and market integration.

The FEDECOM project

The FEDECOM project (Horizon Europe Grant 101075660), coordinated by a multidisciplinary consortium encompassing technology developers, utilities, research institutions, and community representatives from several EU countries, advances a federated "system-of-systems" approach to data management in energy exchange and trading. Moving beyond the limitations of isolated pilots, FEDECOM is designed to enable cross-border, multi-vector energy trading and flexibility sharing through interoperable digital platforms and robust, open data management architectures. The central objectives are to illustrate the scalability and interoperability of digital platforms supporting diverse energy assets—including electricity, heating,

mobility, and hydrogen—across communities, while maintaining open, secure, and GDPR-compliant data management and governance frameworks.

FEDECOM's technical strategy is built upon several foundational pillars. First, secure communication middleware enables both real-time and batch data acquisition from a heterogeneous range of field assets and pilot sites, ensuring data can be ingested and utilised regardless of local technology configurations. Second, a canonical data model (CDM), mapped to international standards, harmonises data semantics and structures to facilitate interoperability among a wide variety of stakeholders, platforms, and market actors. Third, the project integrates the Grid Singularity Exchange (GSY DEX), a blockchain-based decentralised energy marketplace, to support transparent, secure, and automated P2P and cross-community trading. This system enables real-time performance monitoring, automated measurement and verification (M&V), and seamless settlement of transactions. The analytics engine further supports the tracking of key performance indicators such as community self-sufficiency, self-consumption, peak load management, and user engagement. Governance is maintained through a comprehensive data management plan fully aligned with FAIR and GDPR principles, guaranteeing data integrity, privacy, and regulatory compliance.

FEDECOM's pilot activities are structured around three main "federations," each representing a distinct technical and regulatory context. The Virtual Green Hydrogen Federation in Spain brings together municipal buildings, renewable generation, and hydrogen production in a unified trading and flexibility ecosystem, illustrating secure data sharing and automated settlement across diverse actors. The Residential Hydropower Federation in Switzerland, coordinated by SUPSI and local partners, aggregates distributed hydropower, storage, and community loads, optimising local use and market participation through interoperable and secure data management. The E-Mobility and Local Energy Federation, spanning Belgium and the Netherlands, focuses on integrating commercial and community sites—including the Brussels Brico Retail Community, Voorhout Village, and Besix HQ & Eemnes Community—connecting EV infrastructure, photovoltaic (PV) generation, battery storage, and flexible loads under a common digital umbrella.

Through these pilots, the FEDECOM platform is being actively deployed from field-level data acquisition to blockchain-based market operations, enabling intra- and inter-community optimisation, real-time energy and flexibility exchange, automated performance verification, and transparent remuneration. KPIs tracked include latency and reliability of data transactions, user privacy compliance, market integration efficiency, and levels of community and prosumer participation.

The impact of FEDECOM is anticipated to be substantial. By enabling secure, interoperable, and scalable energy trading among a diverse range of actors, FEDECOM increases prosumer and community participation in local and regional markets, enhances grid flexibility and resilience, and accelerates the adoption of renewable and multi-vector energy solutions. Data, insights, and lessons from these pilots are synthesised to inform policy, support market design, and create replicable blueprints for market-ready, consumer-centric energy systems across the European Union, thus advancing Europe's clean energy transition and digitalisation objectives.

Comparative analysis: synergies, best practices, and lessons learned

The following comparison between STUNNED and FEDECOM is intended to highlight converging and diverging approaches to data management in energy trading under similar European policy constraints. While limited to two projects, this comparison allows for a focused discussion of interoperability, governance, and scalability without diluting the analysis across multiple heterogeneous initiatives.

FEDECOM advances a system-of-systems architecture grounded in a canonical data model and a decentralised marketplace (GSY DEX) for transparent, secure, and automated P2P and inter-community transactions, whereas STUNNED emphasises modular, federated data management with secure, standardised communications and strong local control. Both initiatives converge on the foundational principle that interoperability—across data models, application programming interfaces (APIs), and market interfaces—is essential for achieving scalable, replicable, and market-ready solutions. FEDECOM illustrates a system-of-systems architecture grounded in a canonical data model and blockchain-based trading through the Grid Singularity Exchange (GSY DEX), enabling transparent, secure, and automated P2P and community-to-community transactions. In contrast, STUNNED adopts a modular, federated data management approach, prioritising secure, standardised communications and local control, which facilitates the flexible integration of heterogeneous assets and supports seamless aggregation of flexibility services at both the community and district levels.

Both projects showcase how secure and scalable communication infrastructures, coupled with advanced analytics engines, are fundamental for ensuring operational reliability, real-time responsiveness, and transparency in market operations. FEDECOM's approach underscores the value of a decentralised marketplace, providing intrinsic transparency, auditability, and automated settlement, whereas STUNNED's focus on federated, modular platforms highlights the need for adaptability across different regulatory and business environments. Importantly, both projects incorporate robust data governance frameworks—aligned with FAIR (Findable, Accessible, Interoperable, Re-usable) principles and the General Data Protection Regulation (GDPR)—reinforcing the fact that privacy, compliance, and open governance are now prerequisites for regulatory approval and stakeholder trust. Both case studies also respond directly to challenges highlighted in the literature, including the need to process high-velocity and high-volume data streams, the importance of data quality and standardisation, and the operational complexities introduced by distributed resources and P2P trading models.

Despite their shared objectives, FEDECOM and STUNNED diverge in their primary architectural paradigms and implementation strategies. FEDECOM leverages blockchain technology to address issues of market trust, transparency, and automated settlement at scale, whereas STUNNED employs a federated approach to enhance local autonomy and facilitate the rapid adaptation to new asset types and evolving market requirements. Taken together, these complementary approaches point toward a harmonised European energy data ecosystem, where modularity, interoperability, and robust governance work synergistically to unlock the full value of flexible, consumer-centric energy communities. The insights from both projects not only validate best practices identified in the academic literature but also offer actionable blueprints for future projects and policy frameworks seeking to accelerate the clean energy transition in Europe through advanced data management. These observations echo challenges identified in the literature on data governance, interoperability, and platform-based energy systems, reinforcing the relevance of the comparative insights beyond the two projects discussed.

Conclusions and recommendations for future research

The collective experience of the STUNNED and FEDECOM projects illustrates that aligning technical best practices with European policy objectives can unlock substantial new value in energy trading, flexibility markets, and community participation. Both projects show that achieving genuine interoperability, robust security, and open data governance is feasible with today's digital technologies, though significant challenges remain regarding scalability, user engagement, cross-border harmonisation, and regulatory adaptation. The insights and recommendations presented are relevant not only for researchers and technology providers, but also for policymakers involved in shaping the regulatory and governance frameworks for digital energy markets.

The following recommendations are directly derived from the comparative insights discussed in the previous section. For practitioners and researchers, several concrete recommendations emerge from these case studies. First, future data management initiatives should prioritise modular, standardised architectures that enable seamless integration and interoperability across platforms, assets, and regulatory regimes. Second, security measures—including end-to-end encryption, strong authentication, and privacy-by-design principles—should be integrated at every layer of system design and operation, to comply with GDPR and FAIR requirements and to foster lasting trust among consumers and market participants. Third, frameworks for data quality—addressing accuracy, completeness, consistency, and timeliness—should be institutionalised, with continuous validation and monitoring to support both operational efficiency and regulatory compliance. Fourth, the development and deployment of analytics and decision-support tools should be centered on the needs of users, including communities, prosumers, and grid operators, to ensure that data-driven insights are both accessible and actionable. In parallel, deploying FAIR-aligned governance with clear role-based access controls and auditability is essential to maintain trust while scaling data sharing across organisational and national boundaries. These recommendations are intended to be directly actionable by future European research projects, which can adopt the outlined architectural principles, governance approaches, and evaluation metrics when designing interoperable, data-driven energy trading platforms.

Further research is urgently needed in several areas: the development and standardisation of frameworks that facilitate the integration of advanced analytics and decentralised trading into legacy grid environments; the design of robust, user-friendly platforms that lower barriers to community participation and data governance; and the harmonisation of cross-border regulatory and market practices to enable frictionless, pan-European energy data exchange and trading. Evaluating consumer and stakeholder acceptance of these digital platforms across Europe is also essential, given the diversity of regulatory, technical, and cultural contexts. Finally, clustering and knowledge exchange—through joint workshops, further research projects, and thematic working groups—should be expanded to accelerate innovation, share lessons learned, and inform ongoing policy development at both national and European levels.

By addressing these priorities and harnessing technological advancements, the European energy sector can fully realise the potential of modern data management, creating sustainable, resilient, and participatory energy systems that support Europe's ambitious decarbonisation and digitalisation goals.

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Open Peer Review

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Version 2

Reviewer Report 14 April 2026

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✔ **Binod Koirala**
Federal Laboratories for Materials Science and Technology,, Überlandstrasse 129,, 8600 Dübendorf,, Switzerland

The open letter is a nice attempt. It highlights the data management practices employed in FEDECOM and STUNNED projects.

However, it is not well justified why the focus is on these projects. It is a mere coincidence, or are the data management practices in both projects actually complementary? It also lacks details on, for example, semantic ontologies, knowledge graphs, and digital twins used in these projects to ensure harmonization in data management practices.

The lesson learned and the recommendation for future research are well elaborated and understandable. It can be further extended to include data harmonization, data security, ethical considerations, and the role of novel AI tools.

Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)
Yes

Does the article adequately reference differing views and opinions?
Yes

Are all factual statements correct, and are statements and arguments made adequately supported by citations?
Yes

Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)

Yes

Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to implement guidelines or recommendations and/or constructively engage in the debate)
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Energy communities, digital twins, energy system modelling, urban energy systems

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 25 March 2026

https://doi.org/10.21956/openreseurope.24544.r71271

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Lefteris Topaloglou
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1. Summary of the Article
The open letter 'Promoting data management in local energy trading: European policy, recent developments and practical applications in the FEDECOM and STUNNED programmes', examines the role of data management in implementing modern, decentralised energy systems across Europe. The article contextualises the discussion within the evolving political landscape of the EU, emphasising the growing importance of digitisation, interoperability, and governance within energy communities.
The article takes a practical approach, combining:
- a review of policy and literature on energy data management;
- a discussion of technological developments (e.g. smart grids, the Internet of Things (IoT) and blockchain);
- Examples from two projects in the 'Horizon Europe' programme: STUNNED and FEDECOM.
Its main contribution is to connect political objectives, theoretical ideas and real-world applications, while also making recommendations to improve the interoperability, scalability and governance of data-driven energy trading systems.

2. Overall Assessment
The Open Letter successfully addresses a relevant and timely issue, combining political, technical and practical perspectives. It is well structured and informative, and the use of real projects adds value.

However, while the document is strong in conceptual terms, several aspects require improvement to achieve full scientific credibility.
- The justification and definition of the problem are not always clear.
- The engagement with different perspectives is limited.
- Some claims are not adequately supported by references.
- The recommendations, while useful, remain somewhat general.

3. Detailed Evaluation

3.1 Rationale and Problem Framing

Justification and definition of the problem
Advantages: (1) The article clearly identifies the key challenges (e.g. interoperability, data governance and fragmentation). (2) It sets out a general objective of connecting policy, literature and application.
Limitations: (1) The main problem is not clearly defined from the outset. (2) The justification is somewhat vague and descriptive, particularly in the introduction and literature review. (3) Although a guiding question exists, it is not emphasised enough.
Recommendations for improvement: Clearly state the main problem in the first 1–2 paragraphs. (1) What is the main problem? (2) Why is it important now? (3) What gap does this open letter cover?
Also summarise the justification for the Open Letter in 2–3 sentences. Additionally, state explicitly: This Open Letter addresses the gap between X and Y by [...]

3.2 Referencing Differing Views and Opinions

Advantages: (1) The article refers to a wide range of literature. (2) It covers multiple fields (politics, technology and markets).
Limitations: (1) It does not explicitly compare or contrast different perspectives. (2) There is little discussion of: - Competitive approaches (e.g. centralised versus decentralised systems);
- Contradictory evidence;
- Exchange or debate.
Recommendations: (1) Include brief comparative discussions, for example: Blockchain versus traditional platforms; centralised versus federated data architectures; and political versus market-driven approaches. (2) Add proposals such as: 'While some studies support X, others highlight Y...' (3) Provide a brief discussion of the limitations or criticisms of current approaches.

3.3 Accuracy and Use of Citations

Advantages: (1) The article is generally well referenced. (2) Many claims are supported by references.
Limitations: Some statements are overly general (e.g. 'widely recognised', 'significant impact') and not directly supported by references. (2) The descriptions of the works rely heavily on storytelling rather than evidence.
Recommendations: (1) Add references to:
- General claims about trends or consequences
- Quantitative statements
- Claims about the effectiveness of technologies
(2) Where it is not possible to provide references, limit the statements to 'expected to' or 'early

indications suggest'. Where it is not possible to provide references, limit the statements to phrases such as 'expected to' or 'early indications suggest'. (3) Clarify whether statements in work sections are empirical findings or expectations.

3.4 Recommendations and Next Steps

Advantages: The recommendations are clearly structured and relevant. They align with the key challenges that have been identified.
Limitations: (1) The recommendations are often high-level (strategic rather than operational) and do not always clearly connect to specific findings or examples. (2) There are limited guidelines on how to implement them.
Recommendations: (1) Make the recommendations more applicable by adding examples (e.g. from FEDECOM/STUNNED), specifying who should act (e.g. researchers, policymakers or industry) and indicating how (e.g. tools, frameworks or steps). (2) Strengthen the connection by starting recommendations with 'Based on the comparison of STUNNED and FEDECOM, we recommend...'.

4. Key Required Revisions (Must Address)

To ensure that the article is scientifically sound, the following must be addressed:
Essential: (1) Strengthen the formulation of the problem and justification. The main problem and contribution must be formulated clearly, concisely and in a timely manner. (2) Improve the referencing. Ensure that all key claims are supported by references or are appropriately substantiated.
Recommended: (1) Increase the analytical depth. Make more explicit reference to different perspectives. (2) Facilitate the implementation of recommendations. Clearly link them to the findings and provide implementation guidelines.

5. Final Recommendation
The Open Letter is valuable and relevant, and is almost ready for indexing. However, it requires moderate revisions to enhance conceptual clarity, analytical depth, and substantiation. With these improvements, it can make a significant contribution to the field of energy transition and digital energy systems.

Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)
Partly

Does the article adequately reference differing views and opinions?
Partly

Are all factual statements correct, and are statements and arguments made adequately supported by citations?
Partly

Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)

Yes

Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to implement guidelines or recommendations and/or constructively engage in the debate)
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Just Energy Transition, Energy, Climate & Environmental Justice, Place-Based Governance

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Version 1

Reviewer Report 24 December 2025

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?

Loïc Cobut
UCLouvain Saint Louis Bruxelles, Bruxelles, Belgium

Overall speaking, this is an interesting piece on a timely topic. The two projects are both insightful, and the authors bring interesting thoughts forward. I would encourage the authors to consider my comments, which could help improve the piece:

- **Abstract:** it is an heavy abstract which could be more concise and to the point, especially if we are talking about an open letter. It is a bit unclear what is meant by critical review of best practices (through what lenses?), “policy and technical context”, which are too broad concepts, and then linking with ongoing projects (why?) - all that in one sentence. What you qualify as the European research and innovation landscape is broad and abstract, please identify your audience more precisely. In the abstract you talk about an analysis, but then I understand that this is an open letter – you need to clarify what you do with this piece.

- **Introduction**
  - Local energy communities do not exist under EU law, do you mean renewable energy communities or citizen energy communities, or both?
  - Adding a few references in the first paragraph would help embed your open letter in

existing literature, so you situate it directly and it helps the reader to understand where you speak from.
    - This introduction lacks a clear problematisation, even it we talk about an open letter and not a research article: what is the problem at stake? What are the objectives of this piece? What is the leading question (and hypothesis)? In what literature does this article finds itself?
- **Literature review**
    - I'm not sure to understand the need of a literature review in an open letter? It can be done, but then you need to justify and explain why you do this.
    - The literature review is wide and opens many doors. However, it does not precise the type of problem that is at the center of this paper. The authors should have in mind that the piece should address a concise problem, shed light on a phenomenon that is puzzling for some reasons. Here, the literature review rather describes history, policy and technology evolution.
- **Case studies**
    - This section operates both as a method section (presenting cases of what method?) and a presentation of the empirical framework of the research (two EU projects). However, the main issue is that there is no proper method that is presented. In the next section, a comparative analysis is being led without link to any research method. As a next step, I suggest that authors present their comparative method at the beginning of this section, in order to provide with a clearer and more structured research framework. But then again, is this what the authors want to do in an open letter (having case studies and a comparative analysis)?
    - When presenting STUNNED, the 7-8 first paragrahps offer descriptive content about this project but as there is no clear research objective, it's hard for the reader to understand why this is helpful information. Authors need to guide readers a bit more.
    - Within STUNNED, you might want to be a bit more specific : where exactly? Which energy communities are involved and how?
    - I understand that you don't want to publish a research article where you present your results but at the same time, you might want to present preliminary results from STUNNED and FEDECOM to tease the readers.
- **Comparative analysis**
    - You first need to explain why you compare those two projects? Why those two and not other projects? Why 2 and not 3 or 4 or 7? How did you select those 2 projects specifically? Again, having clear objectives for this piece would help you to justifiy all these choices.
    - Links with existing literature are almost non-existent, it can not be absent and at the same time an argument that is used to value your demonstration (at the end of this analysis).
- **Conclusion**
    - You start by referring to a demonstration – which is the central issue of this piece: I miss a clear demonstration in the analysis. I miss an analysis that brings forward a sery of arguments that help demonstrate that an initial hypothesis is verified or not.
    - You have recommendations for practitioners and researchers: Are these recommendations only for them or do you also want to inform policy makers (this is not clear throughout the paper).
    - There needs to be clearer articulations between your recommendations and your comparative analysis.

Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)
Partly

Does the article adequately reference differing views and opinions?
Partly

Are all factual statements correct, and are statements and arguments made adequately supported by citations?
Partly

Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)
Yes

Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to implement guidelines or recommendations and/or constructively engage in the debate)
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Energy communities, energy governance, European politics, transition research.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 06 Jan 2026

Zia Lennard

We sincerely thank the reviewer for their careful reading of the manuscript and for their thoughtful and constructive comments. We appreciate the recognition of the relevance and timeliness of the topic, as well as the acknowledgement of the value of the FEDECOM and STUNNED project experiences. The reviewer's comments have helped us significantly improve the clarity, framing, and coherence of the Open Letter. Our responses and corresponding revisions are summarised below.

Abstract

In response to the reviewer's concern that the abstract was overly dense and insufficiently clear for an Open Letter, we have rewritten the abstract in full. The revised abstract is more concise and explicitly clarifies the nature of the contribution, namely that the paper is a practice-oriented Open Letter rather than a formal empirical analysis. We now clearly

identify the intended audience (researchers, technology providers, project developers, and policymakers) and explain that FEDECOM and STUNNED are used as illustrative examples to bridge European policy objectives, selected literature, and real-world implementation.

Introduction and problem framing

We have revised the Introduction to improve conceptual clarity and problematisation. First, we clarified the legal terminology around energy communities, explicitly referring to Renewable Energy Communities and Citizen Energy Communities as defined under EU law, and explaining how the term "energy communities" is used throughout the paper for readability. Second, we strengthened the embedding of the Open Letter within existing debates by adding explicit problem framing. A new paragraph now clearly identifies data management as a critical bottleneck for scalable and interoperable energy trading, despite increasing policy attention and technological progress. This paragraph also introduces a guiding question that frames the purpose of the Open Letter, namely how contemporary European research projects operationalise best practices in data management and what lessons can be drawn for future research, innovation, and policy design.

Role and scope of the literature review

In response to the reviewer's question regarding the appropriateness of a literature review in an Open Letter, we have added explicit justification at the beginning of the literature section. We clarify that the literature review is not intended to be exhaustive, but rather serves to contextualise recurring policy-driven and technical challenges in data management for energy exchange and trading. We further strengthened the link between the literature review and the rest of the paper by explicitly stating that it provides the analytical backdrop against which the two projects are discussed.

Case studies and comparative logic

To address concerns regarding the absence of a formal method and the rationale for selecting FEDECOM and STUNNED, we have clarified the comparative logic at the beginning of the case study section. We explicitly state that the projects are not presented as case studies in the methodological sense, but as illustrative examples drawn from the authors' direct involvement in European research and innovation projects. We explain why these two projects were selected, namely because they address similar data management challenges under common European policy constraints, while differing in scope, maturity, and architectural approach.

Within the STUNNED section, we added guiding sentences to explain how the technical description relates to the data management challenges identified in the literature, and we clarified the rationale for the selection of demonstration contexts. These additions aim to guide the reader and make the descriptive content more analytically meaningful, without overstating preliminary results.

Comparative analysis and links to literature

We have strengthened the framing of the comparative analysis by explicitly explaining why STUNNED and FEDECOM are compared and what analytical value this comparison provides. In addition, we reinforced the link between the comparative insights and existing literature by explicitly noting how the observed challenges and best practices resonate with findings reported in prior work on interoperability, data governance, and platform-based energy systems.

Conclusions, audience, and recommendations

In the Conclusions section, we clarified the target audience of the recommendations by explicitly stating that they are intended not only for researchers and technology providers,

but also for policymakers involved in shaping regulatory and governance frameworks for digital energy markets. We also strengthened the articulation between the comparative analysis and the recommendations by clearly stating that the recommendations are directly derived from the comparative insights discussed earlier in the paper. Finally, we adjusted the language to avoid any ambiguity around "demonstration," emphasising that the projects illustrate and exemplify best practices rather than formally proving hypotheses. Overall, we believe these revisions substantially improve the clarity, coherence, and positioning of the Open Letter, while remaining fully aligned with its intended format and purpose. We are grateful to the reviewer for helping us sharpen the contribution and better communicate its scope and value to the research, innovation, and policy communities.

Competing Interests: No competing interests were disclosed.

Reviewer Report 25 November 2025

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Olawale M Popoola
Tshwane University of Technology, Pretoria, Gauteng, South Africa

Open Letter
Title: Advancing data management in local energy trading: European policy, state-of-the-art, and real-world practice in FEDECOM and STUNNED
Article Type: Open Letter
The Open Letter presents the role of data management in modern energy systems, focusing on policy and technical aspects, with the STUNNED and FEDECOM projects as case studies. The authors traced the challenges of data management in modern energy systems to the explosion in data volume and diversity. However, it could be improved with more details. Please see below my comments.
Introduction:
-Introduced API before abbreviating for the sake of the reader(s) who may not understand the abbreviation at a glance.
-Authors should introduce the Motivation/contribution/novelty of the work before reporting the organization of the article.

Case Studies
Under the FEDECOM, the performance metrics (KPIs) for achieving the central objectives in demonstrating the scalability and interoperability of digital platforms supporting diverse energy assets were listed to be latency and reliability of data transactions, user privacy compliance, market integration efficiency, and levels of community and prosumer participation. However, the corresponding KPIs for achieving the key objectives of on STUNNED project (which include the

integration of building EMS, DERs, and EV charging infrastructure, alongside the development of advanced analytics for system optimisation and the validation of scalable, replicable business models for flexibility services) were not captured.

Is the rationale for the Open Letter provided in sufficient detail? (Please consider whether existing challenges in the field are outlined clearly and whether the purpose of the letter is explained)
Yes

Does the article adequately reference differing views and opinions?
Yes

Are all factual statements correct, and are statements and arguments made adequately supported by citations?
Partly

Is the Open Letter written in accessible language? (Please consider whether all subject-specific terms, concepts and abbreviations are explained)
Yes

Where applicable, are recommendations and next steps explained clearly for others to follow? (Please consider whether others in the research community would be able to implement guidelines or recommendations and/or constructively engage in the debate)
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Energy and Power systems

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 06 Jan 2026

Zia Lennard

We sincerely thank the reviewer for their careful reading of the manuscript and for their constructive and supportive comments. We are grateful for the positive assessment of the relevance, accessibility, and overall contribution of the Open Letter. In response to the specific suggestions raised, we have made the following revisions:

1. **Clarification of abbreviations in the Introduction**
   We have revised the Introduction to ensure that technical abbreviations are introduced in full at first occurrence. In particular, “application programming interface (API)” is now explicitly defined before the abbreviation is used, improving accessibility for readers from diverse disciplinary backgrounds.
2. **Clear articulation of motivation, contribution, and novelty**
   To strengthen the framing of the paper, we have added a dedicated paragraph at the

end of the Introduction, immediately before the description of the article structure. This new paragraph explicitly sets out the motivation for the Open Letter, clarifies its main contributions, and highlights its novelty in linking European policy, state-of-the-art research, and real-world implementation through the STUNNED and FEDECOM projects.

3. **Explicit KPIs for the STUNNED case study**
   In Section 3.1, we have added a clear and explicit description of the key performance indicators used to assess progress in the STUNNED project. These KPIs are directly aligned with the project's core objectives, including flexibility activation, forecasting and optimisation performance, data exchange reliability and latency, participation of buildings and prosumers, and the validation of flexibility-related business models. This ensures symmetry with the KPI treatment already provided for FEDECOM and strengthens the comparative value of the case studies.
4. **Improved clarity and actionability of recommendations**
   In the Conclusions and Recommendations section, we have added a clarifying sentence explicitly stating that the proposed recommendations are intended to be directly actionable by future European research projects. This reinforces the practical relevance of the guidance provided and clarifies how the research community can build upon the insights presented.

We appreciate the reviewer's confirmation that the rationale, referencing of perspectives, and overall accessibility of the Open Letter are sound. The reviewer's suggestions have helped us improve clarity, balance, and completeness, and we thank them again for their valuable input.

Competing Interests: No competing interests were disclosed.