A Decentralized Approach to Sharing Energy Consumption Data of Logistics Real Estate

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Abstract

Energy consumption data in logistics properties remains fragmented across organizational silos, hindering effective comparison and benchmarking. Existing centralized platforms require stakeholders to relinquish control of their data, which conflicts with privacy requirements and commercial interests. Moreover, stakeholders lack visibility into what data others need or can offer, making it difficult to identify potential data exchange partners. We introduce the concept of Data Rooms, which enable a a group of stakeholders to identify data sharing possibilities. We present a Solid-based application that enables bidirectional sharing of building energy data. The system also supports aggregated views that expose only computed statistics without revealing underlying fine-grained building data.

Keywords

Decentralized Data Sharing, Energy Consumption Data, Logistics Real Estate

1. Introduction

Energy consumption data in logistics properties remains trapped in isolated silos, hindering access and exchange. The logistics ecosystem's complexity – with its diverse stakeholders and varied data formats – creates heterogeneity that prevents comparing and sharing energy data across properties and organizations.

Logistics properties form central hubs of logistics networks and therefore play a decisive role in the provision of logistics services. [1] With rising electricity and gas prices [2] and increasing sustainability requirements through EU taxonomies [3], energy efficiency in logistics real estate is becoming ever more relevant.

Yet substantial technical and trust barriers to sharing and comparing energy consumption data persist: The stakeholder landscape's complexity makes it difficult to access all the relevant data for a comprehensive view of energy consumption. Even within organizations, mobilizing consumption data requires extensive manual effort, and the diversity of building types and usage patterns makes meaningful comparison difficult. In addition to the technical barriers, establishing trust among stakeholders to share sensitive energy data remains a fundamental challenge, as traditional approaches lack mechanisms for identifying data sharing requirements and matching potential partners.

Existing centralized platforms fail to address the technical barriers because they require stakeholders to relinquish data control and adopt singular data models. The Solid protocol offers an alternative: stakeholders retain data sovereignty while enabling controlled sharing, aligning with both GDPR principles and the commercial realities of competitive logistics markets.

To address the trust challenges, we have developed an ontology that provides a unified data model for energy consumption data, as well as a WebApp for visualizing and sharing this data, stored on the user's Solid Pods. The WebApp provides visualizations of the energy consumption data and allows users to define access rights for real or aggregated data via an intuitive user interface. Whereas aggregated data

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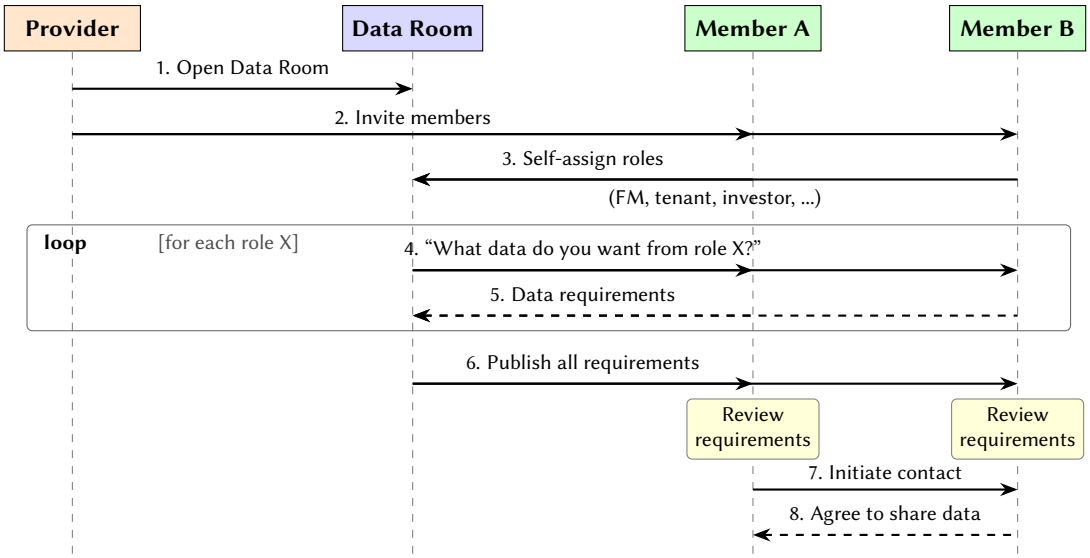


Figure 1: Sequence diagram of the Data Room process: the Provider opens the Data Room and invites members. Members then self-assign roles before they are asked by the Provider which data they would like to receive from each role. The collected requirements are published, enabling members to identify matching partners and initiate data sharing agreements.

is computed based on the user's preferences and shared as a snapshot without provenance information, individual building data can be shared directly from the owner's Pod with fine-grained access control. Additionally, to address the trust challenges, we have developed a process we coined *Data Rooms*. Data Rooms enable stakeholders to identify and formalize data sharing requirements, allowing the stakeholders to discover potential partners for data exchange.

2. Scenario

A central concept of our approach is the Data Room. Data Rooms are demarcated virtual areas with clearly defined access conditions, controlled by a *Provider*. Only approved participants are permitted to enter, based on explicit authorization. Within a Data Room, stakeholders can negotiate and formalize data sharing agreements, ensuring that trust and consent are established before any data is exchanged.

We deliberately chose the term Data Room, as these spaces are conceptualized as protected and restricted areas. A Data Room is opened by a Provider – typically a neutral party such as an industry association (e.g., Bundesvereinigung Logistik) or a project consortium – who invites members and can remove them from the Data Room. Each member assigns themselves one or more roles reflecting their position in the logistics ecosystem. In the logistics domain, these roles are users, owners, and facility managers (FM) as well as developers, financiers, brokers, energy suppliers, and benchmark service providers (BSPs). Then, the Provider asks each member which data they would like to receive from each role. This role-based elicitation produces a comprehensive map of data exchange pairs. The collected exchange pairs are then published to all participants, allowing participants to identify potential partners and to initiate contact.

For each stakeholder, different real estate data is relevant for their purposes. While users, owners, and FMs are primarily interested in specific consumption data for reporting and calculation purposes, developers, financiers, brokers, energy suppliers, and BSPs rely on data for property comparisons, accurate energy reporting, and consumption optimization.

To capture these interests and requirements, the project team opened a Data Room and invited stakeholders from across the logistics real estate sector. Table 1 and Table 2 provide examples of the data exchange pairs that emerged from the elicitation process. In these tables, each row represents a data exchange where the party on the left acts as the *Data Provider* and the party on the right as the

Table 1
Overview of stakeholder data exchange pairs involving the facility manager (FM).

Data flow	Data points	Granularity	Periodicity
FM → Broker	Consumption data (for energy performance certificate)	Consumption types*	annually
Broker → FM	User for new properties (as sales support)	Total property	once
FM → Tenant	Consumption data	Consumption types*, as granular as possible	At least monthly, ideally every 15 minutes
	Blind loads	Total property	once
	Peak loads	Consumer types†	As detailed as possible
Tenant → FM	Consumption data	Total consumption per user	monthly
	Building specifics‡	Number, size, location	annually

*Electricity, water, and gas. †lighting, intralogistics, etc. ‡area, age, shift regime, etc.

Table 2
Overview of stakeholder data exchange pairs between investor and benchmark service provider (BSP). The BSP takes building specifics and consumption data and then provides the calculated consumption per m^2.

Data flow	Data points	Granularity	Periodicity
Investors → BSP	Building specifics‡	Total property	once
	Consumption data	Consumption types*	annually
BSP → Investors	Min/max/median consumption per m^2 per property	Consumption types*	annually

*Electricity, water, and gas. ‡area, age, shift regime, etc.

Data Requester. The arrow (→) indicates the direction of data flow from provider to requester. Table 1 shows data exchange pairs involving the FM role, including exchanges with brokers (e.g., consumption data for energy performance certificates) and tenants (e.g., detailed consumption breakdowns including blind and peak loads). Table 2 illustrates data exchange pairs between an investor and a BSP, where the investor shares building specifics and consumption data, and the BSP computes and shares back aggregated consumption per m^2.

3. Implementation

The scenarios in Sect. 2 impose three key requirements: (1) a data model flexible enough to represent the diverse data points, granularities, and periodicities demanded by different stakeholder pairs; (2) fine-grained access control that allows selective sharing and revocation; and (3) a mechanism for sharing aggregated statistics without exposing underlying building data.

Following the Solid principles of separating identity, data, and application, the WebApp operates as a pure client-side application that communicates directly with Solid Pods without requiring a central backend. All user data resides exclusively in the users' personal Solid Pods. Data sharing is only configured after trust has been established in a Data Room: the implementation assumes that stakeholders have already agreed on the terms of data exchange beforehand.

3.1. Data Model

Each building is represented as a Turtle file within the user's Pod containing static metadata such as type, location, area, and year of construction (see https://granergize-homer.solidcommunity.net/private/granergize/buildings/2.ttl for an example). The data model builds upon established ontologies – including RealEstateCore for building classifications and Schema.org for organizational entities – and introduces domain-specific terms via our GRANERGIZE vocabulary (`gra:`). Crucially, a building's

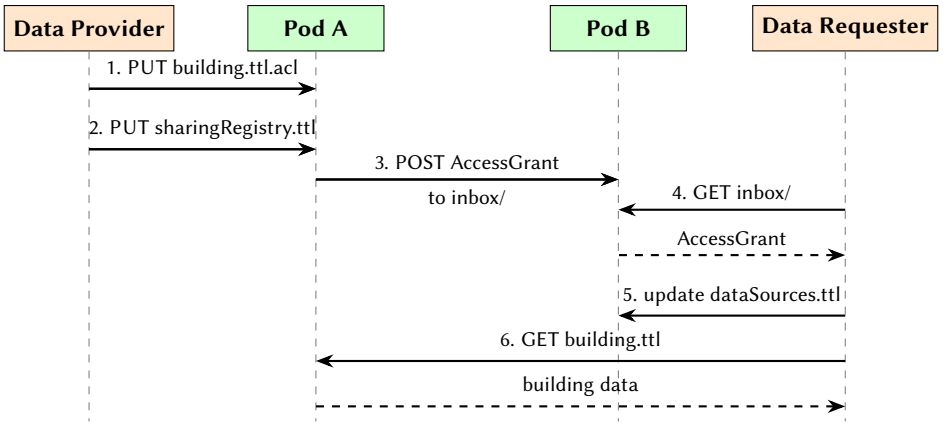


Figure 2: Sequence diagram of the data sharing process: the Data Provider grants access by updating the ACL and sending a notification; the Data Requester processes the notification and can then fetch the shared data.

energy measurement data is stored in separate datasets per year, linked from the building file. This separation allows sharing building metadata independently of detailed energy data, supporting the fine-grained access control required by Data Providers.

3.2. Data Sharing and Access Control

Once stakeholders have reached mutual consent within a Data Room, data sharing is implemented using the Web Access Control (WAC) specification [4]. When the Data Provider grants access, the application appends an `acl:Authorization` block to the resource's `.acl` file, specifying the recipient's WebID and the granted access mode. Building metadata and energy data reside in separate files, each with its own ACL, so the provider can share metadata without exposing detailed measurements.

The sharing workflow follows the Solid Application Interoperability (INTEROP) specification [5] for notifying Data Requesters about granted access. Figure 2 illustrates the sharing process. The Data Provider initiates sharing through the web interface by selecting a building and entering the recipient's WebID. Upon confirmation, the application executes three operations on the Data Provider's Pod (steps 1–3 in the figure): it updates the resource's ACL file to grant read permission, records the sharing action in `sharingRegistry.ttl`, and posts an `interop:AccessGrant` notification to the recipient's inbox. When the recipient's application polls the inbox (steps 4–5), it discovers the grant and adds the shared building URI to its local `dataSources.ttl`, after which it can fetch the data directly from the provider's Pod (step 6).

Revocation removes the recipient's authorization from the ACL; subsequent access attempts return HTTP 403, prompting automatic cleanup of the recipient's `dataSources.ttl`.

3.3. Sharing Aggregated Data

While sharing individual building data enables direct collaboration between pairs such as the FM and tenant, the investor – BSP scenario (Table 2) demonstrates a different need: computing aggregated statistics across multiple properties without exposing the individual buildings. Our WebApp addresses this through aggregated views – snapshots containing only computed values.

An aggregated view is defined by three parameters: a set of source buildings, an aggregation function (`sum`, `average`, `minimum`, or `maximum`), and a selection of energy metrics. Figure 3 shows the user interface for creating a view, and Listing 1 shows the resulting Turtle definition stored in the owner's Pod. Note, that the view definition itself – including the source building URIs – is never shared. Only the computed snapshot, containing aggregated values without provenance information, is made accessible to recipients.

When the owner creates or refreshes a view, the application fetches energy data from each source building, applies the selected aggregation function, and stores the result as a separate snapshot file.

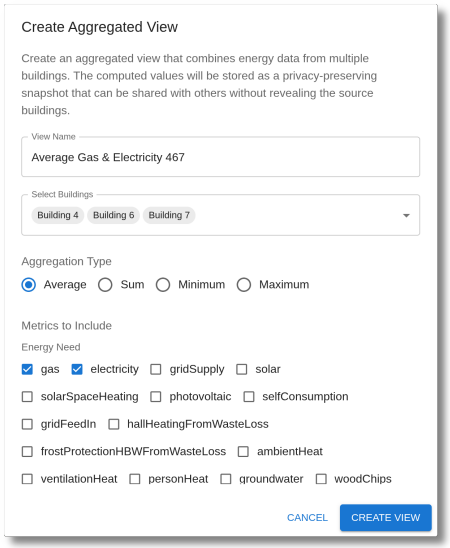


Figure 3: Create Aggregated View Dialog

```
<#view-1770048602886-f5n4sea> a
    gra:AggregatedViewDefinition ;
  gra:viewId "view-1770048602886-f5n4sea" ;
  gra:viewName "Average Gas and Electricity 467" ;
  gra:aggregationType "average" ;
  gra:createdAt
    "2026-02-02T16:10:02.886Z"^^xsd:dateTime ;
  gra:includesBuilding
    <../private/granergize/buildings/4.ttl>,
    <../private/granergize/buildings/2.ttl>,
    <../private/granergize/buildings/6.ttl> ;
  gra:includesMetric "gas", "electricity" ;
  gra:lastComputedAt
    "2026-02-02T16:10:04.064Z"^^xsd:dateTime .
```

Listing 1: View Definition Example

Sharing and revoking access to aggregated views follows the same WAC-based pattern as individual buildings. Because snapshots are materialized, shared values reflect the state at the time of last refresh; owners can update by triggering a manual recomputation.

4. Conclusion

Energy consumption data in the logistics sector remains fragmented across organizational boundaries, preventing effective benchmarking and collaboration. Centralized platforms require stakeholders to surrender data control, conflicting with privacy requirements and competitive interests.

This paper introduces the concept of Data Rooms – a structured process for stakeholders to identify and formalize data sharing requirements, establishing trust and enabling partner discovery before any data is exchanged. Additionally, a Solid-based Web application that addresses these challenges through decentralized data sharing while preserving data sovereignty. The implementation demonstrates how WAC for fine-grained permissions and the INTEROP specification for access notifications can solve real-world data-sharing problems without centralized data custody. The aggregated views feature extends the sharing model to support statistical summaries without exposing individual building details.

A key area for future development is integrating Data Room functionality directly into the WebApp, enabling stakeholders to discover potential partners, and manage data sharing agreements within the application. Additional future work includes integrating automated access request workflows, data integration pipelines, and supporting additional aggregation functions such as weighted averages based on building size. We also plan to evaluate the system's usability with logistics stakeholders in a field study.

5. Generative AI Declaration

Generative artificial intelligence was not used in this work.

6. Acknowledgements

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