

# Conceptual Dataspace Architecture for District Heating Use Case

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**Abstract.** Low-temperature district heating networks require accurate demand forecasts and active load control to operate efficiently with reduced supply temperatures and high shares of renewable heat. In practice, however, district heating operators have limited access to real-time data from customer substations and buildings due to privacy concerns, data silos, and lack of interoperability. As a result, operators must apply large safety margins, leading to higher losses and reduced overall system efficiency. This paper proposes a conceptual dataspace architecture based on IDSA-compliant components, the Eclipse Dataspace Components (EDC) together with N5GEH, a FIWARE-based IoT platform. The approach enables building owners to securely share selected substation data under strict usage policies, supporting improved forecasting and demand response while maintaining full data sovereignty.

**Keywords:** Dataspace, District Heating, Eclipse Dataspace Components

## 1. Introduction

District heating (DH) is progressively evolving from high-temperature, fossil-based systems toward low-temperature networks that support renewable integration and dynamic demand response [1], [2], [3]. This transition reduces heat losses in the DH networks and enables greater use of low-grade renewable and waste heat sources.

Achieving efficient operation, however, requires secure access to high quality data from buildings, substations, weather services, and grid-connected assets [4]. In today's digital energy economy, data is a crucial asset, but its potential remains underutilized due to data siloization, interoperability issues, and security and privacy concerns [4].

District heating operators have limited visibility behind the customer substation. Consumption data, indoor temperatures, and building data remain hidden in private building management systems or proprietary cloud platforms. Building owners are often reluctant to share this data due to privacy concerns and unclear data usage rules [5], [6]. Without access to this data, operators must maintain large supply temperature and flow safety margins, making it challenging to accurately predict heat demand or optimize supply temperatures for efficient, low-carbon operation. These conservative margins directly reduce network efficiency and hinder the integration of low-grade renewable and waste heat sources.

The core technical barrier is not the absence of data, but the lack of a trusted, standardized mechanism for building owners and operators to share high-resolution operational data under clearly defined usage restrictions.

This work proposes a conceptual district heating specific dataspace, built on International Data Spaces Association, IDSA-compliant component, Eclipse Dataspace Components (EDC) (<https://github.com/eclipse-edc>). A dataspace is generally defined as a secure and standardized digital infrastructure that enables trusted data exchange and data-based services among various stakeholders [7]. This infrastructure offers a decentralized, policy enforced, interoperable data exchange where each data owners or providers retain control over their data access and usage.

## 2. Methodology

Our conceptual approach proposes a methodology with three parts: data provisioning using the N5GEH IoT platform, bilateral data exchange via the federated dataspace, and targeted data use for district heating forecasting and load control.

### 2.1 Data Provisioning with N5GEH Platform

Data providers deploy their own instance of the open-source N5GEH platform (<https://github.com/N5GEH>), a modular FIWARE-based IoT solution from our previous work and build the platform according to needs. The platform as illustrated in Figure 1 provides standardized data schemas for structured storage, standardized APIs for straightforward data access, and semantic models representing relationships between physical entities. These features ensure consistent asset representation across stakeholders, reducing integration complexity and eliminating ambiguous interpretations while improving data quality before sharing. The resulting entities are exposed through each provider's local EDC connector.

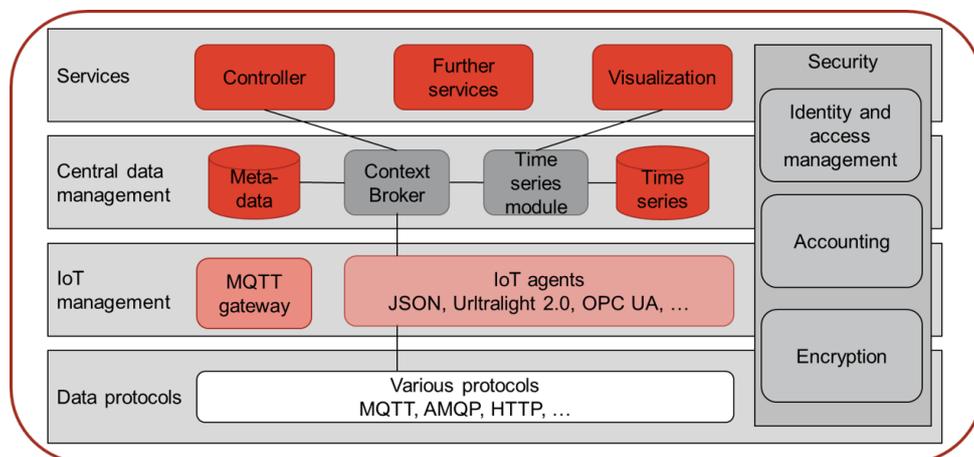


Figure 1. N5GEH Platform Architecture

### 2.2 Data Exchange

The proposed dataspace is a federated dataspace in which each participant runs its own EDC connector. Each connector has a control plane (contract negotiation, policy enforcement, metadata, identity, access rights, and transaction logging) and a data plane (secure bilateral data transfer, following the rules set by the control plane). Governance is decentralized, relying on shared trusted identity providers, standardized policy formats, and federated catalogs (Figure 2). Consumers discover assets via catalogs, negotiate contracts with explicit usage policies (purpose, duration), and upon agreement, trigger participant-to-participant data flows.

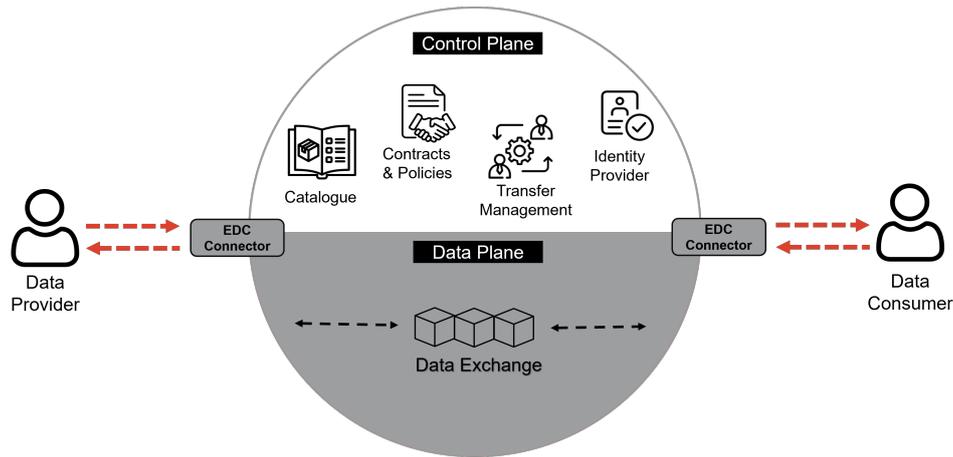


Figure 2. Dataspace architecture

### 2.3 Use Case: Heat Demand Forecasting and Load Control

The dataspace target heat demand forecasting and active load control, enabling district heating operators to reduce supply temperature safety margins and improve forecast accuracy.

Buildings serve as the primary data providing entities, with owners retaining full control over their data. Each building exposes multiple data streams via its local EDC connector: supply and return temperatures, flow rates, and valve positions from the substation, along indoor temperatures, radiator measurements, and room or apartment level heat consumption patterns from in-building systems such as intelligent thermostatic valves or energy management systems.

The district heating operator, as the main data consumer, directly receives these time-resolved building level datasets under strict usage policies. This access allows training of heat load predictor models, supporting accurate district wide forecasting and targeted control signals (e.g., adjustments to substation valves or thermostatic valves in individual buildings).

Throughout the workflow, policies explicitly restrict data usage to forecasting and load control, with defined retention periods and deletion obligations. Figure 3 illustrates the workflow, showing three example buildings sharing data via EDC connectors to the final consumer.

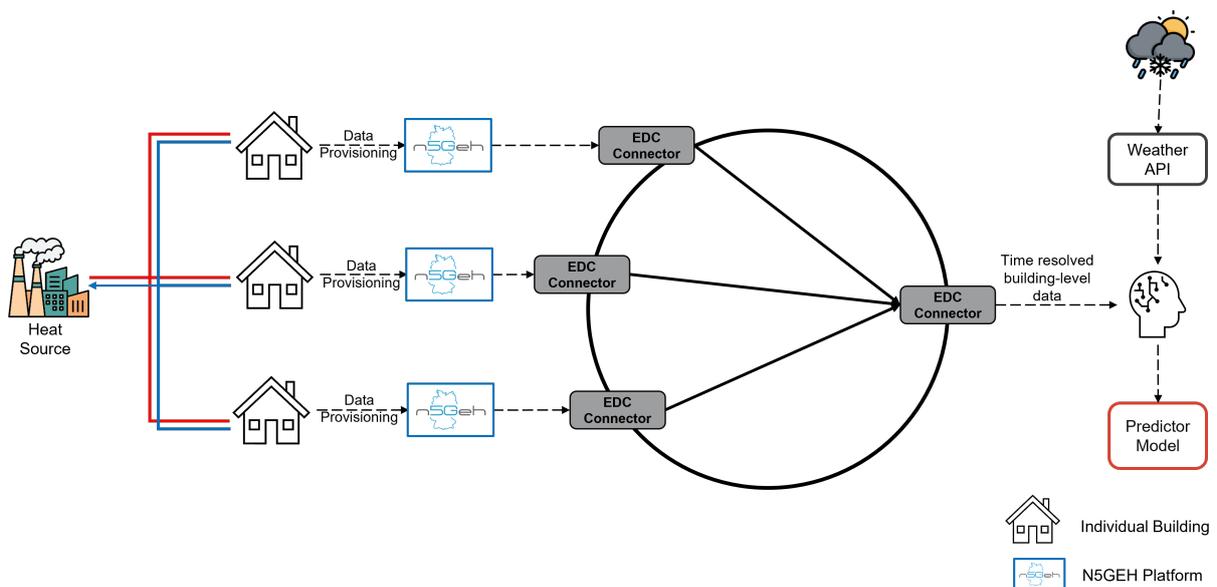


Figure 3. Workflow for heat demand forecasting: data flow from data providers to consumer

### 3. Conclusion

The proposed dataspace architecture, integrating the N5GEH IoT platform for local data provisioning with a federated EDC-based exchange layer, enables secure and sovereign sharing of building level data in district heating systems. With improved access to building level data and consumption patterns, operators can design better flexibility schemes for load control. This allows operators to reduce supply temperature safety margins, lowering heat losses and enabling greater integration of low-grade renewable sources. Building owners also retain full sovereignty over their raw data via strict usage policies, while benefiting from enhanced system efficiency and potential flexibility incentives.

Overall, this DH-focused dataspace demonstrates how standardized, decentralized data sharing can directly address operational challenges and lay the foundation for scalable digital services and future market mechanisms.

### Data availability statement

No data were created or analyzed in this study.

### Author contributions

Julianah Odeyemi: Conceptualization; writing - original draft preparation. Junsong Du: Conceptualization; review and editing. Rita Streblov: Conceptualization; review and editing; Supervision; Funding Acquisition. Dirk Müller: Supervision; Funding Acquisition.

### Competing interests

The authors declare that they have no competing interests.

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