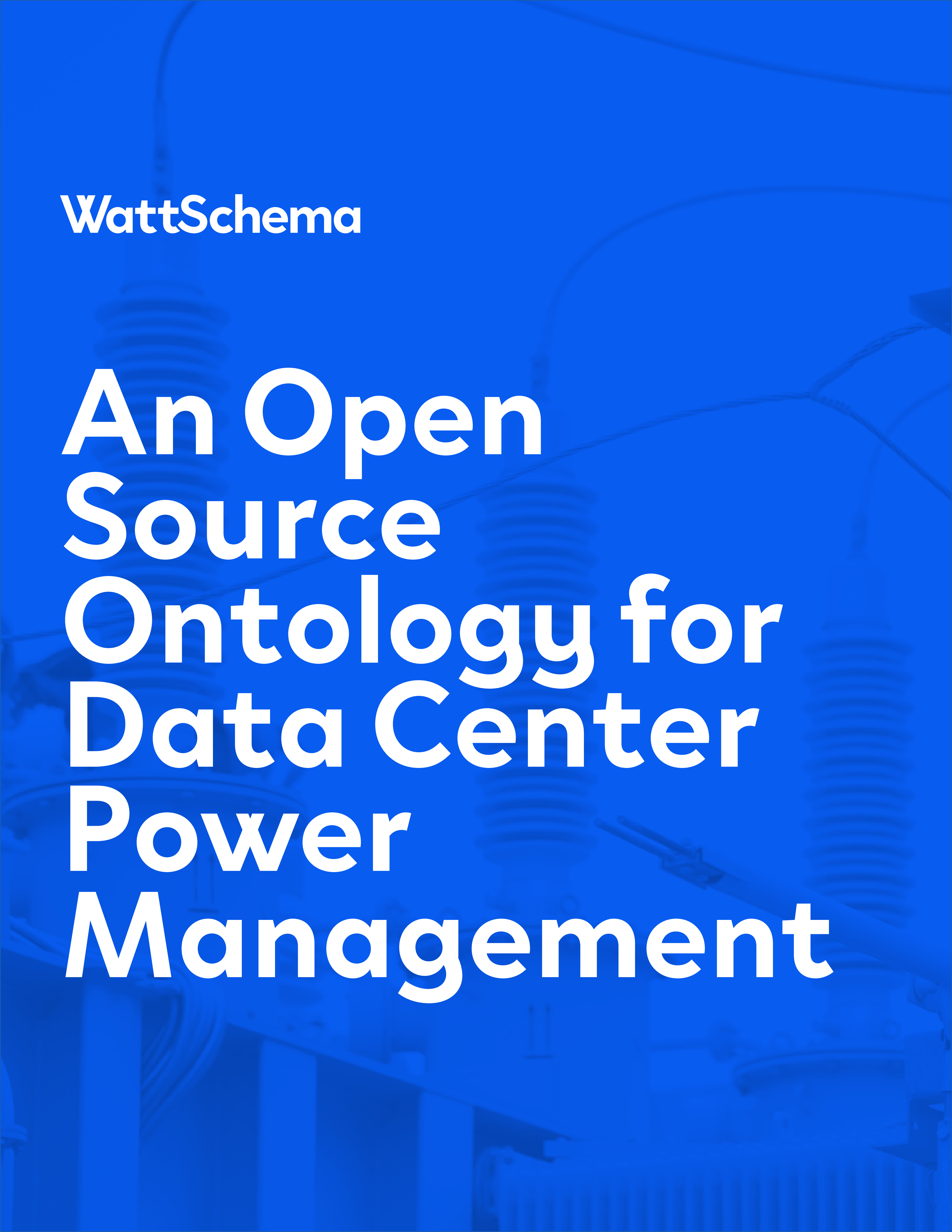


WattSchema

An Open Source Ontology for Data Center Power Management

Contents

Executive Summary

WattSchema is an open source ontology for creating digital twins of data center infrastructure.

WattSchema builds on and extends ASHRAE Standard 223 and is complementary to other standards such as the Brick Schema and Real Estatea Core. WattSchema enables applications including simulation and modeling, data exchange between vendors, construction firms, and operators, and emerging agentic AI-driven operations capabilities.

Modern data centers are an order of magnitude larger than their predecessors from just a few years earlier. This scale requires digital representations of data center infrastructure, especially the power and cooling infrastructure, as well as standard operating procedures that govern them.

We provide WattSchema as an Resource Description Framework (RDF)-based ontology, a Microsoft Fabric IQ ontology, as well as an OPC Unified Architecture (OPC UA) Companion Specification, and plan to provide alignments to upcoming IFC 5.0 BIM standards in the future. WattSchema is developed by a community of software developers, equipment providers, and data center operators, and invites additional collaborators to participate in managing and evolving the standard.

THE CHALLENGE:

Infrastructure At A New Scale

Data center energy management is no longer a static monitoring problem. Modern facilities increasingly operate as tightly coupled electrical and thermal systems, with operational complexity driven by scale, redundancy requirements, and integration with external energy systems.

Today's data centers commonly include:

- **Multiple utility interconnections and on-site generation**
- **Redundant and meshed power distribution paths**
- **High-density cooling systems with tightly coupled electrical and thermal behavior**
- **Operational strategies that span IT load, facilities infrastructure, and grid interaction**

At this scale, traditional artifacts such as single-line diagrams, commissioning documents, vendor submittals, and point lists become fragmented, inconsistent representations of a single underlying system. They are difficult to keep synchronized, difficult to interpret programmatically, and nearly impossible to reason over holistically.

As a result, many organizations lack a machine-interpretable source of truth that describes:

- **What equipment exists, down to specific models, stock keeping units (SKUs), and firmware revisions**
- **How that equipment is electrically and thermally connected**
- **What each component measures or controls**
- **What operational constraints, dependencies, and redundancy strategies apply**

Without such a representation, higher-level capabilities such as simulation, optimization, automation, and AI-driven operations are forced to reconstruct system understanding repeatedly, often inconsistently and incompletely.

02

Digital Twins Require Shared Semantics

Digital twins are often framed in terms of geometry, telemetry, or simulation models. While these components are necessary, they are insufficient on their own. A useful digital twin must also encode **semantic understanding:** what things are, how they relate, and what roles they play in operation.

For example:

- **A power meter is not merely a time series; it measures a specific electrical quantity at a defined location within a power topology.**
- **A uninterruptible power supply (UPS) does not simply "feed loads"; it participates in a redundancy, isolation, and failover strategy.**
- **A chiller is not just an asset; it provides cooling capacity to a defined set of loads under specific control logic and constraints.**

These distinctions matter because they determine how data can be interpreted, what actions are safe or meaningful, and how systems should respond under abnormal conditions.

In the absence of a shared semantic model, every system such as the building management systems, energy management platforms, analytics tools, and AI agents must infer this meaning independently. This leads to duplicated effort, inconsistent interpretations, and brittle integrations.

WattSchema addresses this gap by providing a **shared semantic foundation** for data center power and cooling infrastructure. By making structure and intent explicit, WattSchema allows systems to reason about relationships rather than just consume telemetry, enabling consistent interpretation across vendors, tools, and lifecycle stages.

As data centers adopt AI-driven optimization and increasingly autonomous operational strategies, this shared semantic layer moves from a convenience to a prerequisite.

03

SCOPE & COVERAGE:

Modeling the Full Energy Ecosystem

WattSchema is designed to model the systems that directly determine how a data center consumes, produces, and manages energy. While its foundation lies in traditional facility infrastructure, its scope reflects the rapidly changing energy landscape in which data centers now operate.

BEYOND THE UTILITY FEED:

3.1 On-Site and Behind-the-Meter Resources

Historically, data center power models focused on utility service entrances, switchgear, uninterruptible power supply (UPS) systems, and downstream distribution. Today, that boundary is expanding.

New data center developments increasingly incorporate:

- **On-site generation (diesel, natural gas, fuel cells, and emerging technologies)**
- **Solar photovoltaic (PV) and other distributed energy resources**
- **Battery energy storage systems (BESS)**
- **Microgrid configurations capable of islanded or grid-interactive operation**
- **Demand response and load-shedding capabilities**

These systems are no longer peripheral. In many regions, grid interconnection delays and transmission constraints have made **behind-the-meter generation and storage key enablers of site development.** At the same time, regulators and utilities are asking large data center operators to reduce grid impact, participate in demand response programs, and demonstrate more flexible load behavior.

SCOPE & COVERAGE:

Modeling the Full Energy Ecosystem

3.1

BEYOND THE UTILITY FEED:

On-Site and Behind-the-Meter Resources

(Continued)

WattSchema explicitly models these resources and their relationships to core facility loads, allowing digital twins to represent not just how power is distributed, but how it is sourced, shifted, and managed over time. This richer representation supports advanced forms of **scenario analysis and capacity planning** and the ability to evaluate "what-if" operational and infrastructure configurations, such as:

- **How additional on-site generation changes available IT load capacity**
- **How storage duration affects ride-through and peak-shaving strategies**
- **How different redundancy strategies impact both reliability and grid dependency**

By encoding these relationships semantically, WattSchema allows planning, optimization, and AI-driven systems to reason over infrastructure configurations in a structured way rather than relying solely on external spreadsheets or bespoke simulation models.

Several contributors to WattSchema bring deep expertise in photovoltaic systems, distributed generation, and backup power architectures, helping ensure that these behind-the-meter capabilities are modeled with the same rigor as traditional electrical distribution.

3.2 Core Infrastructure Domains

In addition to distributed energy resources, WattSchema covers the primary domains required to describe data center power and cooling systems:

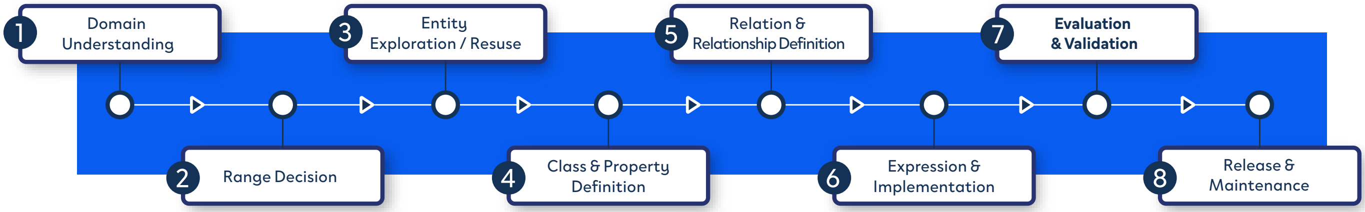
- **Utility service and interconnection points**
- **Medium- and low-voltage electrical distribution**
- **UPS systems and power conditioning equipment**
- **Cooling plants, chilled water systems, and heat rejection**
- **Sensors, meters, and control points**
- **Operational groupings such as redundancy blocks and capacity zones**

Together, these domains form the semantic backbone of a data center energy digital twin.

04

Design Principles of WattSchema

WattSchema's structure reflects practical experience deploying semantic models in operational environments. The following principles guide its design and evolution.



4.1 Explicit Relationships Over Implicit Conventions

Many legacy models rely on naming conventions, drawings, or vendor-specific hierarchies to imply system structure. WattSchema instead models relationships directly: electrical connectivity, thermal supply paths, containment, measurement, and control associations are all first-class elements. This enables automated validation, topology traversal, and reasoning about dependencies, redundancy, and failure domains.

4.2 Validation as a First-Class Capability

WattSchema is designed to work alongside constraint frameworks such as Shapes Constraint Language (SHACL), allowing stakeholders to formally define what constitutes a complete or valid model for a given use case.

This supports:

- **Design and commissioning validation**
- **Model exchange between engineering firms and operators**
- **Continuous conformance checking as systems evolve**

4.3 Interoperable by Design

WattSchema is not intended to exist in isolation. Rather than redefining foundational concepts, WattSchema builds on existing standards, most notably ASHRAE 223, extending them where necessary to capture data center-specific architectures.

The same conceptual entities such as equipment, connections, measurements, and roles are reused across representations, reducing the need for fragile one-off mappings and making it easier for tools in different domains to share a common understanding of infrastructure.

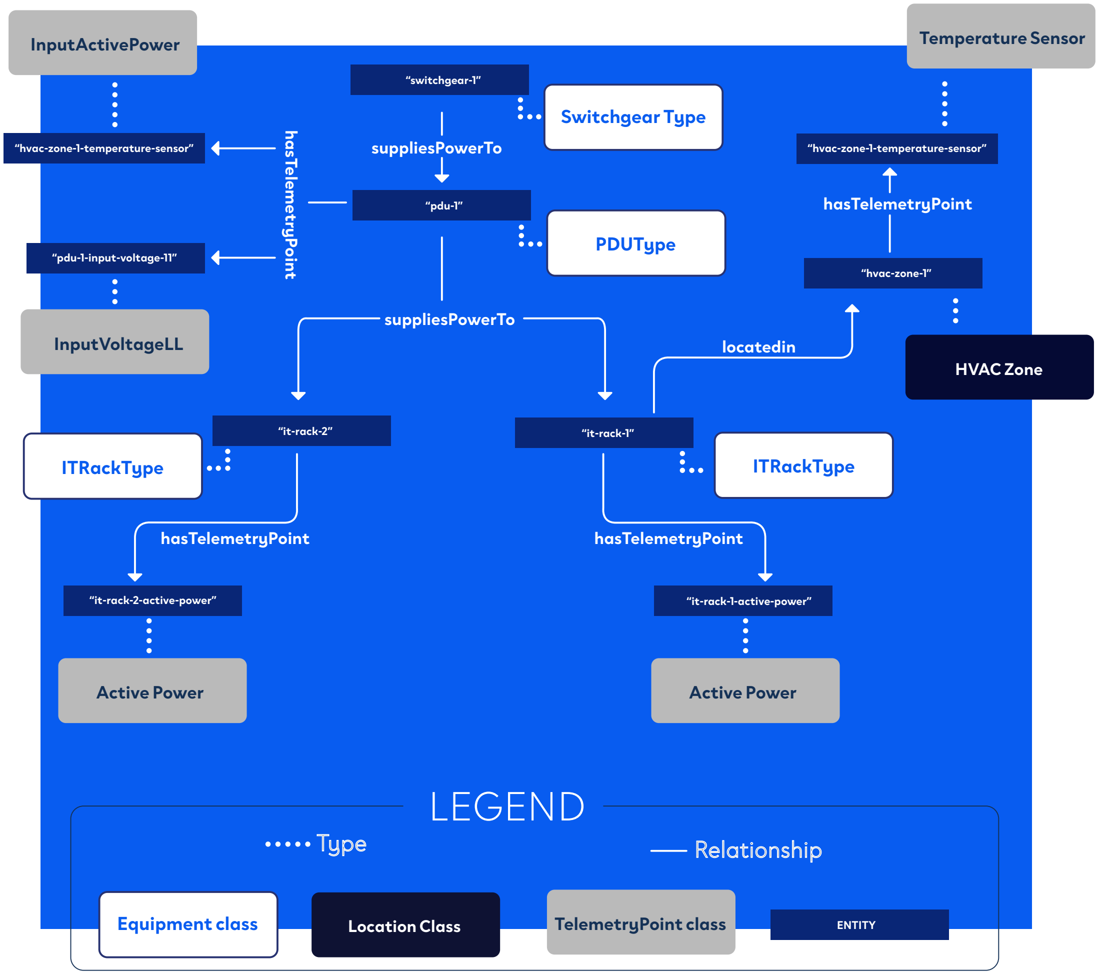
05

Relationship to Existing Ecosystems

WattSchema is intentionally positioned as a complement to, not a replacement for, existing semantic efforts:

- **ASHRAE 223 provides the foundational semantics for physical systems and observed phenomena.**
- **Brick Schema offers a mature vocabulary for building equipment and points, widely adopted in building automation contexts.**
- **RealEstateCore addresses portfolio- and asset-level concerns above individual facilities.**

WattSchema focuses on the **power and cooling semantics unique to data centers**, while remaining interoperable in linked-data environments.



06

Multiple Representations, One Conceptual Model

WattSchema is delivered through multiple technical representations to support adoption across Information Technology (IT), Operational Technology (OT), and analytics domains. While these technologies differ in syntax and tooling, they are intentionally aligned at the conceptual level.

WattSchema is like a superhero story told both as a comic book and a movie. The medium is different, but the characters, relationships, and story beats are the same. Someone familiar with one version can easily follow the other.

6.1 RDF Ontology

The canonical representation of WattSchema is an RDF-based ontology expressed in Turtle (.ttl) format. This form supports:

- **Semantic reasoning and inference**
- **Formal validation**
- **Linked data integration with other ontologies**

It serves as the reference model from which other representations are derived.

6.2 WattSchema and Microsoft Fabric IQ

Microsoft Fabric has recently released Fabric IQ as a semantic foundation for enterprise AI, enabling consistent meaning across data assets, analytics, and AI agents.

WattSchema aligns naturally with this approach. The Fabric IQ representation of WattSchema:

- **Reuses the same core concepts as the RDF ontology**
- **Adapts them to Fabric's analytics and AI workflows**
- **Enables AI systems to reason about infrastructure context, not just raw data**

By mapping WattSchema concepts into Fabric IQ, organizations can integrate data center infrastructure semantics directly into enterprise analytics and agentic AI systems, without requiring those systems to understand RDF or semantic web tooling.

The result is **semantic continuity**: the same conceptual model supports both operational infrastructure modeling and enterprise-scale AI.

06

Multiple Representations, One Conceptual Model

6.3 WattSchema as an OPC UA Companion Specification

To support industrial automation and control systems, WattSchema is also expressed as an **OPC UA Companion Specification**, aligned with the practices of the OPC Foundation.

The OPC UA representation:

- **Uses OPC UA's object, variable, and type system**
- **Is designed for real-time, operational environments**
- **Integrates naturally with programmable logic controllers (PLCs), supervisory control and data acquisition (SCADA), and control platforms**

While the technical encoding differs from RDF or Fabric IQ, the **conceptual model is the same**. Equipment types, relationships, and semantics correspond directly, enabling consistent interpretation across IT and OT boundaries.

This alignment reduces translation friction between analytics platforms and control systems, supporting closed-loop optimization and automation scenarios.

07

Interoperability Through Concept Reuse

By reusing the same concepts across RDF, Fabric IQ, and OPC UA, WattSchema enables:

- **Easier data exchange between vendors and operators**
- **Consistent semantics across design, construction, and operations**
- **AI systems that can reason across traditionally siloed domains**

Rather than forcing convergence on a single technology stack, WattSchema allows each domain to use the tools best suited to it, while sharing a common semantic foundation.

08

Governance and Community

WattSchema is developed as an open-source project with transparent governance. Contributions are welcomed from data center operators, equipment manufacturers, software and analytics providers, standards organizations and researchers, and any other interested party.

The ontology is available on GitHub and is released under a Berkeley Software Distribution (BSD) open-source license.

APPENDIX A

Glossary

ASHRAE Standard 223

A standard defining machine-readable semantic models for physical systems using technologies like RDF, SHACL, and SPARQL. It provides a foundational graph-based semantic framework for interoperable, automated systems.

Battery Energy Storage System (BESS)

A system that stores electrical energy in batteries for use in backup power, load shifting, peak shaving, or grid-support functions.

Behind-the-Meter Resources

Energy resources located on the customer side of a utility meter, such as solar PV, BESS, and on site generators. These resources contribute to local generation, resiliency, and grid-interactive operations.

Brick Schem

An open schema for representing building equipment, sensors, actuators, and telemetry points. It defines relationships like hasPoint and isPartOf to support structured, interoperable building data.

Chiller

Cooling equipment that removes heat from the chilled-water loop serving data center cooling loads, operating under defined control logic and thermal constraints.

Digital Twin

A virtual representation of a physical system that uses real-time and historical data to model and reflect the system's behavior, conditions, and performance.

Distributed Energy Resources (DERs)

Small-scale energy generation or storage technologies—such as solar PV, fuel cells, or batteries—located close to the load they serve.

Fabric IQ (Microsoft Fabric IQ)

Microsoft Fabric's semantic layer designed to unify meaning across datasets, analytics, and AI workflows. WattSchema can map into Fabric IQ to support AI-driven infrastructure understanding.

Firmware Revision

The specific version of embedded software running on equipment, relevant for tracking configuration, compatibility, and operational behavior.

Medium- and Low-Voltage Distribution

Electrical distribution tiers within a data center. Medium voltage typically includes utility interconnection and major switchgear, while low voltage powers downstream equipment such as IT racks.

Microgrid

A localized electrical system capable of operating either connected to or independent from the main grid, often incorporating DERs, controls, and islanding capability.

Ontology

A structured system for defining concepts, relationships, and categories so that software systems can interpret and reason about information.

OPC Unified Architecture (OPC UA)

A communication standard used in industrial automation, enabling structured, secure, and interoperable information exchange between control systems. WattSchema provides an OPC UA Companion Specification version for OT integration.

Power Meter

A device that measures specific electrical quantities at defined points within a power topology, providing context-rich telemetry for operations and modeling.

APPENDIX A

Glossary

Redundancy Strategy
An operational approach ensuring continuous service by duplicating critical components or paths (e.g., N+1, 2N). Essential for data center reliability and fault tolerance.

Resource Description Framework (RDF)
A graph-based semantic data model used to represent entities, relationships, and properties in a machine-readable format. WattSchema's canonical form is an RDF ontology in Turtle (.ttl) format.

Semantic Understanding
The ability of systems to interpret the meaning, relationships, and contextual roles of entities—enabling correct reasoning, automation, and safe decision-making.

SHACL (Shapes Constraint Language)
A framework for validating RDF graphs to ensure semantic models meet defined completeness and correctness requirements (e.g., validating commissioning or vendor model exchanges).

Single-Line Diagram
A simplified electrical schematic showing components and connections in a power system. Traditionally used for design but often insufficient for semantic or machine-readable modeling.

Solar Photovoltaic (PV)
On-site renewable energy generation technology converting sunlight into electricity, increasingly common in data center energy ecosystems.

Uninterruptible Power Supply (UPS)
A system composed of converters, switches, and stored energy (e.g., batteries) designed to maintain continuous power to loads during utility interruptions.

WattSchema
An open-source ontology for modeling data center power and cooling systems. Built on ASHRAE 223 and aligned with standards such as Brick and RealEstateCore, it enables simulation, automation, reasoning, and AI-driven operations across IT and OT environments.

Utility Interconnection
The point at which a data center connects electrically to the external grid, including service entrances, transformers, and associated protection equipment.

Validation (Model Validation)
Processes ensuring that a semantic model is complete, correct, and consistent with design requirements. Enabled in WattSchema through SHACL-based constraints.

APPENDIX B

Resources

WattSchema
https://wattschema.org/

GitHub
https://github.com/wattschema

Email
info@wattschema.org

ASHRAE Standard 223
https://docs.open223.info/

Brick Schema
https://brickschema.org/

Real Estate Core
https://dev.realestatecore.io/ontology/

Fabric IQ (Microsoft Fabric IQ)
https://blog.fabric.microsoft.com/en-us/blog/introducing-fabric-iq-the-semantic-foundation-for-enterprise-ai