TwinERGY Common Information Model

D5.1

August 2021

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Deliverable

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TWINERGY	957736	Intelligent interconnection of prosumers in positive energy communities with twins of things for digital energy markets

DELIVERABLE REFERENCE NUMBER AND TITLE

D5.1

TwinERGY Common Information Model

Revision: v1.0

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DISSEMINATION LEVEL

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Statement of Originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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Executive Summary

The present deliverable D5.1 is illustrating the TwinERGY Common Information Model (CIM) that effectively forms the structure and semantic of the data that are going to be stored and exchanged for the needs of the project.

An initial identification and extraction of the structure and the semantics of the data assets available from the TwinERGY demonstrators, combined with the potential data needs of the Modules to be implemented, serves as a basis to define the baseline concepts that the TwinERGY Common Information Model must support. An extensive study of the smart grid data modelling landscape and the selection of specific open standards, semantic models, and ontologies for their elaboration, depending on their relation to the available data assets, allows an all-around understanding of the relevant data modelling activities.

Upon performing standards gap analysis and providing specific TwinERGY CIM definition guidelines, this deliverable provides a high-level view of the actual model that currently consists of numerous concepts and fields. The TwinERGY CIM effectively captures the semantics and structure of each concept, its fields, and relations to other concepts. The mapping of the TwinERGY CIM concepts and fields to multiple standards has also been performed to ensure that the specific domain knowledge has been properly considered and directly reflected in the model.

Finally, as it is unrealistic to consider that such an information model will be inclusive of all the smart grid-pertinent data from its early beginning, particular emphasis on the processes for the CIM lifecycle assurance is given, especially regarding its consistent evolution and the way that new concepts are effectively incorporated, without disrupting the existing model, ensuring backward compatibility.

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1. Introduction

The main aim of the TwinERGY project is to introduce an innovative energy system, integrating distributed generators, storage devices, and electric vehicles, aligned with EU regulations, that will combine already existing advanced technologies into a new interoperable framework, offering new business models and consumer-centric services. To realize the open and transparent energy market for consumers, technically feasible and reliable solutions are required, based on open standards, that ensure unbundling from proprietary services and equipment, and enable vendor lock-in avoidance and easy switching between suppliers or service providers to offer a comprehensive solution to empower citizens active participation into the new EU energy market. To achieve this goal, a homogenized Common Information Model that allows for the semantic interoperability of the involved assets and that ensures seamless integration, communication, and operation on top of any Energy Management System, as well as, Smart Home systems and devices will be offered, as part of the TwinERGY Data Management Platform.

1.1 Purpose of this deliverable

This deliverable presents the results produced in the context of the activities of the TwinERGY Task T5.1 "Open Standards Review and Common Information Model Adaptation". More specifically, the main objective of D5.1 "TwinERGY Common Information Model" is to document the methodological work that has been done towards the initial release of the TwinERGY Common Information Model (CIM), that captures the basic elements underlying the TwinERGY Project.

Initial preparatory activities of D5.1, focused on the proper data landscaping of both the pilot's available data, as well as the module's data needs, to ensure that are effectively addressed from the modelling activities.

In addition, a standards' landscaping exercise was initiated, to study and evaluate the relevance of open standards, semantic models, and ontologies of the DR arena, in order to extract and target the main concepts that the TwinERGY CIM must support.

A high-level view of the CIM contents in terms of concepts and fields is provided in this deliverable, accompanied with lifecycle management processes to be followed for the proper evolution of the model.

1.2 Scope of this deliverable

The TwinERGY deliverable D5.1, titled "TwinERGY Common Information Model", aims to present the preparatory work for the definition of the core elements of the CIM, towards

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the efficient modelling of the various semantic concepts, fields, their relations, and respective mappings to DR and energy data models and standards.
To this end, this deliverable is:

- offering insights towards data requirements that emerge from the TwinERGY Use Cases data related analysis and the data landscaping activities to capture the available data in the pilot sites, as well as the data needs of the modules to be developed in the context of the project.
- presenting the landscape analysis of various relevant, established semantic standards have been selected based on their relevance to the needs of the project goals and their maturity. Brief descriptions for semantic standards and main functionalities are provided accordingly.
- ensuring a coherent and mutual understanding of the CIM concepts, foundations and implications based on a set of basic definitions and design principles.
- defining the CIM lifecycle assurance, from its initial design and creation to its evolution, by supporting updates of existing concepts and fields and allowing the integration of new ones, without compromising the already stored data.
- documenting the initial CIM contents that will become part of the TwinERGY Data Management Platform.

1.3 Structure of the document

The structure of this document is organized as follows:

- Section 2 outlines the identified data available in the pilot sites and the data needs of the TwinERGY modules as well and the landscape analysis performed in preparation of the TwinERGY CIM, including the description of relevant semantic standards that were considered as most related and appropriate to the TwinERGY planned activities.
- Section 3 provides an assessment of the analysed standards, presents a gap analysis to identify potential shortcoming of the standards based on the TwinERGY data model needs and a shortlisting of standards to be utilized in the TwinERGY CIM creation steps.
- Section 4 offers the definition and terminology of the TwinERGY CIM concepts, fields, and their relations.
- Section 5 documents the CIM lifecycle assurance approach that is followed to consistently handle any model updates that may occur during the TwinERGY project execution.
- Section 6 summarises the key aspects regarding the CIM activities and provides an outlook to the next steps.
- Annex I present in detail the CIM concepts and their associated fields.

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1.4 Abbreviation List

Acronym	Full Name
API	**Application Programming Interface(s)**
CA	**Consortium Agreement**
CIM	**Common Information Model**
D	**Deliverable**
DB	**Database**
DER	**Distributed Energy Source(s)**
DMC	**Data Monitoring Committee**
DoA	**Description of Action**
DOI	**Digital Object Identifier**
DPC	**Data Protection Coordinator**
DPO	**Data Protection Officer**
DSO	**Distribution System Operators**
Dx.y	**Deliverable x.y**
EC	**European Commission**
EFI	**Energy Flexibility Interface**
ENTSO-E	**European Network of Transmission System Operators for Electricity**
EPRI	**Electric Power Research Institute**
EU	**European Union**
EV	**Electric Vehicle(s)**
EVCC	**Electric Vehicle Communication Controller**
FAIR	**Findable, Accessible, Interoperable and Re-usable**
FAN	**FlexiblePower Alliance Network**
GA	**Grant Agreement**

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GDP	**Gross Domestic Product**
GDPR	**General Data Protection Regulation**
H2020	**Horizon 2020**
ICT	**Information and Communication Technologies**
ID	**Identifier**
IEC	**International Electrotechnical Commission**
IED	**Intelligent Electronic Device**
IoT	**Internet of things**
IPR	**Intellectual property Rights**
IPT	**Investment Planning Tool**
ISO	**International Organization for Standardization**
JSON	**JavaScript Object Notation**
KPIs	**Key Performance Indicator(s)**
LoD	**Level Of Detail**
MS	**Microsoft**
OA	**Open Access**
OCA	**Open Charge Alliance**
OCPP	**Open Charging Point Protocol**
OpenADR	**Open Automated Demand Response**
OSCP	**Open Smart Charging Protocol**
PAS	**Publicly Available Specifications**
PDF	**Portable Document Format**
PDM	**Project Data Manager**
PV	**Photovoltaics**
RES	**Renewable Energy Sources**
SAREF	**Smart Applications REFerence Ontology**
SAREF4BLDG	**SAREF for Buildings**

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SAREF4ENER	**SAREF for Energy**
SAREF4WATR	**SAREF for Water**
SCADA	**Supervisory Control And Data Acquisition**
SECC	**Supply Equipment Communication Controller**
T	**Task**
TSO	**Transmission System Operators**
Tx.y	**Task x.y**
UI	**User Interface**
USEF	**Universal Smart Energy Framework**
V2G	**Vehicle-to-Grid**
WP	**Work Package**
XML	**Extensible Markup Language**

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2. TwinERGY Common Information Model Creation Methodology

2.1 Methodology process

In order to create and ensure the implementation of a data model that addresses all the needs within the TwinERGY project, the methodology followed is presented in the figure below.

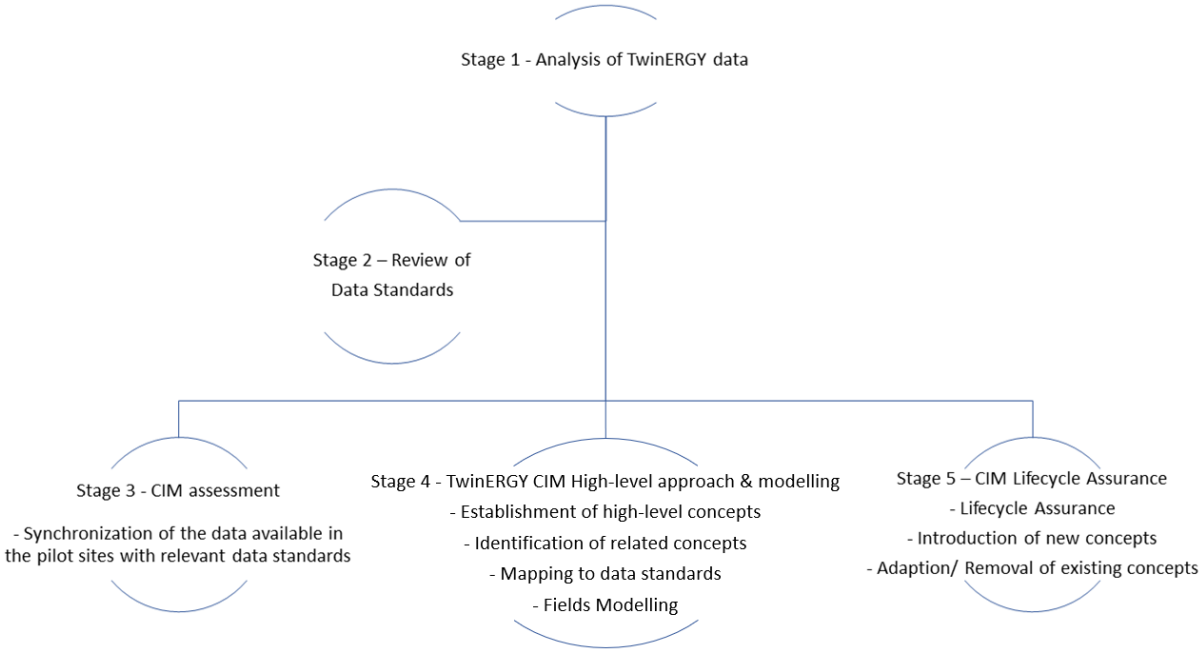

Figure 1 The TwinERGY CIM design methodology process

As depicted in Figure 1, the TwinERGY CIM design process comprises five stages which are presented in the following paragraphs.

Stage 1, including three coexisting activities:

- Analysis of the nine TwinERGY project use cases, in order to identify the scope of each use case, the potential actors involved and the relevant data needs for their implementation.
- Data collection activities in the pilot sites, aiming to capture relevant information on the current or future data sets availability in the four TwinERGY pilot sites.
- Analysis of the TwinERGY modules data needs, so to capture the data needs for the modules and Digital Twins functionality implementation

Stage 2, which includes the **review of the data standards**, ontologies and semantic models that are relevant to the TwinERGY scope. After the evaluation of a wide range of

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standards, the most appropriate ones were selected, bearing in mind their uptake, their maturity and applicability to TwinERGY. The designated standards, ontologies and semantic models are extensively elaborated in section 2.3 Review of data standards.

Stage 3, which aims to connect the available datasets in the pilot sites, that were discovered during the data collection activities that were previously presented, with the standards that are described in Stage 2 and establish those that will be integrated in the TwinERGY CIM.

Stage 4, aiming to identify the relevant high-level concepts to the TwinERGY requirements along with their relations. The concepts and all relevant aspects (fields and relations) will be mapped to explicit standards (if possible), resulting to the creation of the CIM.

Stage 5, referring to the lifecycle assurance rules that will be applied to the CIM, in order to ensure the sustainability and extensibility of the model.

2.2 Analysis of TwinERGY data

As described in the previous section, Stage 1 is the first of the five stages of the TwinERGY CIM design process. This section describes the actions taken, in order to capture the data availability and the data needs within TwinERGY. An overview of the aforementioned actions is presented in the following paragraphs.

Top-down analysis of the nine TwinERGY project use cases, aiming to identify their scope, the data needs towards their implementation and the actors/stakeholders that will facilitate the use cases implementation. The target of each use case, the potential data needs and the potential actors involved in each use case, are presented as follows.

Use Cases	Potential Data Needs	Potential actors involved
UC01-Home Energy Management	PV generation loads monitoring PV storage loads monitoring	Consumers DSO Retailer Aggregator

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Use Cases	Potential Data Needs	Potential actors involved
UC02-RES Generation in domestic and tertiary buildings	PV generation measurements PV storage measurements Storage measurements Battery measurements Heat pumps measurements EV measurements	Homeowners/ Consumers Facility managers of public buildings Facility managers of private buildings Aggregators Retailers End Users
UC03-Grid capacity enhancement utilizing e-mobility	EV batteries storage and/or discharging measurements V2G power capacity measurements Electricity bills measurements PV production measurements	EV Users Retailer, Aggregators Community/ Neighbourhood DSO
UC04-Prosumers empowerment in local energy trading markets	IoT devices data Building's data Neighbourhood/ Regional data Grid Network data DER generation data	Consumers Grid operators Aggregator DSO Prosumer Consortium Virtual Power Plant (VPP) - Operator
UC05-Enhance grid's flexibility through DER Management	DER measurements Batteries measurements, Consumption measurements network data virtual (storage) power plants Distribution Network status calculation Flexibility forecasts calculation Congestion management	Consumers DSO Aggregator/Flexibility Operator Battery storage Operator
UC06-Consumers engagement in Demand Side Management Programs utilizing feedback mechanisms	Local production data Consumption data Applied tariffs data Grid condition data	Consumers DSO Retailer

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Use Cases	Potential Data Needs	Potential actors involved
UC07-Consumer's engagement in demand response programs utilizing a socio-economic context	Local production data Local consumption data Applied Tariffs data Grid condition - related data Comfort preferences Sensor values Socio-economic variables	Consumers Community
UC08-Consumer's engagement in demand response programs utilizing personalized comfort/health-oriented services	Wearable devices data	Consumers
UC09-Consumer's engagement in demand response programs utilizing digital twins' prediction capabilities for dynamic VVPs	Weather data Energy system's data Individual building flexible loads data Electricity data DER data VPP configuration data	Consumers Community DSO Aggregator Facility Managers of Buildings Retailer

Table 1 Use cases descriptions, data needs and actors involved

TwinERGY pilot sites data collection activities, with the use of a customized template depicted in the following table. The partners involved in the activities of the TwinERGY pilots were requested to fill in the template with information related to the data sets that are, currently or will be in the future, available in each one of the pilot sites, along with their respective attributes.

Basic Information	**Dataset ID**	*[Unique identifier following the convention "Country_Partner#no"]*	XX_XXX_1
	Demo Case-relation or Demo Case ID	*[Unique identifier following the convention "DA_Country_Partner_DC#no"]*	DA_XX_XXX_DC1
	Data Asset Title	*The title of the data asset*	Energy imported from the Grid (kWh)
	Description	*A brief description of the data asset - At least 2-3 lines to give an overview of the data*	smart metering on residential/commercial prosumers' (customers) installations
Data Asset Features	**Volume**	*[X GBs / records / transactions per hour / day / month]*	1 record per hour
	Variety	*[Structured / Unstructured / Semi-structured]*	Structured

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	Type	*[Text / Image / Video / Audio / Other]*	text
	Format	*[csv, xml, json, other]*	csv
	Velocity	*[Real-time, Near Real-time, Batch]*	Batch
	Historical Data Availability	*[Y/N]*	N
	Temporal Coverage	*[From ... To...]*	[1-1-2020 - today]
	Spatial Coverage	*[Locations]*	XXX
	Language	*[e.g. English, Italian, German, Greek, ...]*	English
	Relevant Standards	*[List the international standards to which a data asset complies]*	n/a
	Veracity	*[Raw, Pre-processed, Processed Data asset]*	Raw
	Temporal Resolution	*[The temporal "granularity" of the data, e.g., per minute / hour / day / month]*	per hour
	Spatial Resolution	*[The spatial "granularity" of the data, e.g., at district / zone / building / area level]*	building
	Dependency / Linking to Other Sources	*[Y/N, If Y, list the other sources or codelists]*	N
Data Asset Availability	**Data Asset Owner**	*The name of the data asset owner*	XXX
	Data Asset Available from 3rd Party	*[Y/N]*	N
	Data Asset Provider	*The name of the data asset provider in TwinERGY*	XXX
	Accessibility Method	*[Through API, As downloadable file, As database extract, Other]*	As downloadable file
	Frequency of Updates	*[Real-time, Every X minutes / hours, Daily, Weekly, Monthly, Yearly, other]*	Monthly
	Update Strategy	*[Append new data / Replace existing data / other]*	New file for each period
	Documentation	*The documentation of the API or data sample (incl. the location and the name of the file in the TwinERGY repository]*	N/A
Data Asset Rights	**Privacy**	*[Confidential (not to be shared at all) / Proprietary (to be shared with appropriate licensing with the demonstrator partners) / Private (to be shared with appropriate licensing within the demonstrator & potentially to be traded with other stakeholders in TwinERGY) / Public (available to all)]*	Private
	License	*[Exact Licence that is currently applied, e.g., CC Attribution / NonCommercial-ShareAlike (CC BY-NC-SA) / Case-by-Case Bilateral Agreement]*	Case by case Bilateral Agreements
	Sharing Mode	*[Encrypted Data Sharing / Unencrypted Data Sharing / Secure Multi-party Computations*	Encrypted Data Sharing (encrypted data to be uploaded in

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		(with data always on-premise at providers' side) / Encrypted Intelligence Sharing / Unencrypted Intelligence Sharing]	the TwinERGY core platform)
	Data Asset Consumer(s)	*The list of consumers (in the demonstrator) that are interested in the specific data asset*	all
	Other Stakeholders Potentially Interested in Data Asset Use/Purchase	*[List categories of stakeholders beyond TwinERGY that are potentially interested in the specific data asset]*	DSOs, Aggregators, Retailers, ESCOs, Research Institutes
	Pricing	*[Per Transaction / Subscription / PAYG / N.A.]*	payg
	Need for Anonymization	*[Y/N depending on whether the data asset contains sensitive or personal data]*	Y
Data Analysis	**Types of analysis currently conducted on data**	*[e.g. Correlation analysis for..., Predictive analytics for...]*	N/A
Data Asset Assessment	**Accuracy**	*[Measure of correctness and precision, e.g., whether the dataset is error-free, Ranked 1 (Low) - 5 (High)]*	5
	Completeness	*[Degree to which a data asset is sufficient in scope, depth, Ranked 1 (Low) - 5 (High)]*	4
	Timeliness	*[How long a data asset remains up-to-date]*	always
	Relevance to specific demonstrator	*[How relevant a data asset is for the specific demonstrator, Ranked 1 (Low) - 5 (High)]*	5
	Relevance to other TwinERGY demonstrators / demo cases	*[How relevant a data asset is for other demonstrators, Ranked 1 (Low) - 5 (High), following the convention "D#no_DC#no_Rank X", e.g. D1_DC1_Rank 5 for a very relevant data asset for demo case 1 under demonstrator 1]*	D1_DC1_Rank 5
	Importance	*[How critical a data asset is for the demonstrator, Ranked 1 (Low) - 5 (High)]*	4
	Rationale	*[Explain the reasons for importance ranking]*	
Comments			

Table 2 The data collection template communicated to the pilot partners

Also, the pilot partners completed the data collection template and after the evaluation of the information received, an initial list of all available (and prospective) data sets in the pilot sites was formulated, embedding details such as the name of the data set, the pilot site related to the data set and a short description of the data set, as presented below.

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Pilot	Data
Bristol City (England)	Measuring and storing power grid condition data such as busbar min/max, min/man and averages voltages, RMS current and the voltage phase angle, active and reactive power per feeder
Municipality of Benetutti (Italy)	Data related to the energy imported from the grid to cover prosumers' demand needs, along with smart metering data on residential and commercial prosumers' installations
Athens (Greece)	Data related to the energy imported from the grid and sensing measurements related to Ambience and Occupancy, such as Temperature, Humidity, Lighting and Presence
Hagedorn (Germany)	Transformer station per line power, voltage, power factor measurements, solar radiation measurements at the transformer station. Smart metering data on residential and commercial prosumers' installations and power, voltage, and current measurements. Battery storage assets data spanning from battery limits to storage capacity measurements . Weather data. Public Charging Station data, including power limit measurements, the total number of charging points and connectivity nodes. RES asset data, including PV, batteries and EVs data

Table 3 Datasets' current or future availability in the pilot sites

Analysis of the TwinERGY modules data needs, with the use of tailor-made version of the template presented previously, in order to capture the data needs for the implementation of the TwinERGY modules and the Digital Twins functionality from the technical partners of the consortium, responsible for developments within TwinERGY project.

Module	Data Needs
M1 Consumer well-being module	User identification and basic data
	Environmental data
	Energy consumption and production data
	Energy prices for buying and selling
	User comfort related data
M2 & M3 Consumer and Neighborhood demand flexibility profiling Module	Electricity pricing from the Transactive Energy Market to enable optimization of DR actions and building level consumption based on dynamic pricing models
	Total electricity consumption of the building as measured at the incoming distribution panel for the building using smart metering techniques

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Module	Data Needs
	Total natural gas consumption of the building either measured or approximated based on operation of the boilers/ other gas consuming devices
	Consumption deriving from other energy sources (for example district heating systems) that are measured at the incoming meter in the building
	Measurements of the PV generation from the building's solar PV array at the inverter.
	Measurements of the current amount of energy storage in the building
	Available battery capacity within a building (if applicable)
	Available capacity to charge EV
	Measurement of instantaneous electricity demand in the building to identify the peak demand
	Measurements of the amount of electricity battery storage currently being stored within the community at any community storage devices
	Measurement of the amount battery storage capacity within the community
	Measurements of the PV generation in case of community PV array systems
	Measurements of the PV generation at the building level that is exported to the community grid for DR actions
	Any data available through the trending capabilities of the BMS (if applicable)
	Measurements of the base building loads (i.e non-flexible loads) in the building using sub-metering, disaggregation algorithms, smart plugs and any other measurement instruments or calculated as a function of total building consumption and flexible building consumption
	Measurements of flexible loads within the building achieved through the use of sub-meters, smart plugs/meters, disaggregation algorithms or otherwise
	Thermostat readings obtained from different zones within the building

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Module	Data Needs
	Humidity Readings & CO2 Readings at the zonal level within the building used to evaluate occupant comfort & wellbeing measured at a local weather station or downloaded for a reputable weather service. If on site weather station, data to be downloaded from closest weather station to site where comparable micro-climate is present
	Forecasted weather data for at least the following 24 hour time period (ideally up to 3 days ahead)
M4 Home & Tertiary realtime Energy Monitoring Module	Energy consumption of single electric appliances and single power lines
	Indoor environment monitoring Temperature [°C] Humidity [%] Pressure [Pa] CO2 [ppm] VOC [mg/m2h] Air flow [m/s]
M5 RES integration and DER management Module	Local weather forecasting data
	Smart meter data
	Local consumers data
	Grid Storage data
	Community flexibility
	Local RES asset data
	Grid/node limits
M6 Risk Management and event handling Module	Energy consumption of single electric appliances and single power lines
M7 Electric Mobility as a Service Module	Information about accounts of owners of electric vehicle, containing Name, Username, encrypted password, etc...
	Information about an electric vehicle (battery model, charging properties, V2G possibility)
	EV user's payment data, such as: payment way, payment credentials...
	Characteristics of a charging station (locations, type of chargers, Smart Meter existence, prices, Nominal Power EVSE…)
	Energy consumption (aggregated/disaggregated) (kWh)

Module	Data Needs
M8 Customer Deployment and Social Engagement Module	Energy produced (kWh)
	Energy produced /stored/forecasted for community PV/ BESS/EVCP [kWh]
M9 Transactive Energy Module	Identification data, transaction data, balances and block chain related data

Table 4 The data needs of the modules, as identified by the template

2.3 Review of data standards

As described in Stage 2 previously and accommodating what is depicted in the DoA [1] [2] the interventions that are foreseen in the pilot sites during the project's duration and the specific use cases, there are four major domains of crucial importance to the TwinERGY project and are identified as Demand Response, Energy Management, eMobility and Building Integration domains. In the following sections, an overview of the different standards, semantic models and ontologies that will be further elaborated over the TwinERGY CIM development and are highly related to the prior mentioned domains is provided.

2.3.1 Overview of relevant established semantic standards

2.3.1.1 IEC CIM: IEC 61970/61968/62325 series of standards

EPRI, the Electrical Power Research Institute has originally conceived and delivered the IEC CIM, before the latter was embraced under the auspices of the International Electrotechnical Commission, as the IEC 61970/61968/62325 series of standards. The most essential objects in an electric utility company are depicted in this set of standards IEC 61970-301[3] [4] , IEC 61968-11[5], IEC 62325-301[6]. The IEC CIM is object-oriented and is conveyed as an extensible markup language (XML) data schema, providing a definitive way for illustrating power system resources as object classes, outlining their parameters, and establishing their relationships in terms of i) inheritance, ii) association and iii) aggregation. 820 classes with more than 8500 attributes are defined in the 53 UML packages that are covered in the IEC CIM. In general, through the IEC CIM, interoperability among different systems is made feasible with the establishment of a common definition of management information for systems, networks, applications and services and the provision of appropriate mechanisms for the linkage of network applications carried out by different vendors. Transmission System Operators (TSO) use the IEC CIM so to create models of power system networks, enabling an easier and more smooth information exchange. In a more specific manner, the smooth and seamless integration of TSO energy

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management systems applications, that have been implement by different vendors amid EMS systems that have been delivered by an independent source, or among systems relevant to operations of the power system (generation or distribution management) and an EMS system, constitute the main target of the IEC 61970 series of standards.

The IEC 61968-11[5] standard has been geared towards addressing the Distribution System Operators' (DSO) requirements by designating the information exchanges between different electrical distribution systems on a utility enterprise level, focusing on the DMS functionalities. As for the IEC 62325-301[6] "CIM extensions for markets" standard, it was designed to bolster the harmonization of the deregulated electricity markets and cover the emerging need for smooth and straightforward information exchange among the stakeholders involved in the energy market. As mentioned above, IEC CIM is crucial for enabling interoperability, thus the IEC CIM was widely endorsed by a multitude of TSOs across Europe. As a matter of fact, the IEC CIM is adopted by the ENTSO-E, the European Network of Transmission System Operators for Electricity, an organization of 43 electricity transmission system operators in 36 countries across Europe.

2.3.1.2 IEC 61850

The IEC 61850 series of standards is regarded as the standards most frequently used in electrical power engineering in relation to industrial automation. The standardization of the communication protocols for intelligent electronic devices constitutes its main target. This series of standards was implemented by the IEC TC 57 WG10, in order to enable the conversion of various incompatible communication standards between the devices within a substation into a common standard, ensuring that way immaculate and consistent information exchange and of course, interoperability of devices from various vendors.

The IEC 61850 introduces semantic interpretation, as it incorporates new achievements of modern computer science and communication technology. The IEC 61850 data model is a hierarchical, function-directed object-oriented model. With the approach of object-oriented design, in IEC 61850 standard, each IED (Intelligent Electronic Device) is divided into logical devices, logical nodes and object data points. Every IED contains several logical devices for certain applications. Every logical device contains a group of logical nodes or functions. Logical nodes include all data objects they need for the function.

In the first version of the IEC 61850 (ed. 1.0) [10], the equipment of the electrical substation was the focal point, while the second version (IEC 61850 ed. 2.0) [12] comprises also real-time data collection and remote-control automation from different smart grids devices.

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2.3.1.3 IEC 62056 - Smart metering standardisation framework (DLMS / COSEM)

The IEC 62056[7] - Smart metering standardisation framework is a series of standards that specify on electricity meter data exchange. The DLMS/COSEM[8] signifies the Device Language Message Specification /Companion Specification for Energy Metering. The DLMS User Association is a non-profit organization that was founded with the purpose of developing and establishing a standard for the data exchanges of smart meters. The inclusion of DLMS UA in the IEC's technical committee 13 resulted in the adoption of the DLMS/COSEM as the IEC 62056 suite of standards. The IEC 62056 suite of standards describes the standardization framework including:

- the principles on which the standards shall be developed.
- how the existing standards shall be extended to support new use cases and to accommodate new communication technologies, while maintaining coherency.
- the aspects of interoperability and information security. It also provides guidance for selecting the suitable standards for a specific interface within the smart metering system.

2.3.1.4 SAREF

The Dutch Institute TNO has developed and delivered the Smart Applications REFerence (SAREF) [16] ontology in order to expedite and further enhance interoperability between different solutions offered by numerous providers. SAREF, in order to address the requirements set by the consumers, bestows distinct and reusable elements of the ontology. The key principles that the SAREF ontology is designed upon, are presented as follows:

- the concepts in an existing asset can be used more than once and subsequently adjusted,
- the various elements of the ontology are eligible for division and constellation, in line with the needs of the user
- further expansion of the ontology is made feasible
- the preservation of the ontology can be facile and simple; Any needs for altercations, removals, additions, or adaptations can be covered easily.

Users can conceive numerous device and technology abstraction layers and their reciprocal Application Programming Interfaces (APIs), without the condition of acquiring any exact knowledge on specific standards, through SAREF ontology. In Figure 2, a synopsis of the principal concepts and classes and their relationships, depicted in the latest version of SAREF is presented. Those relationships are established with the use of common semantics, whilst assets are allowed to use their own terminology and data models.

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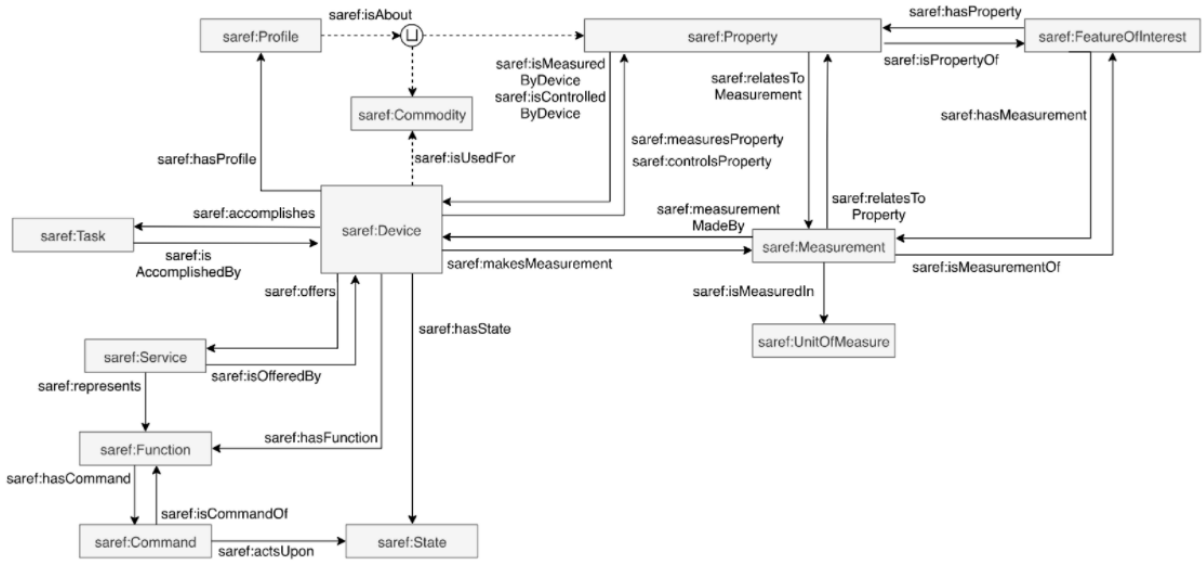

Figure 2 Synopsis of the SAREF Ontology

In order to address the needs of specific domains, such as the Energy domain, the Buildings domain, the Water domain, etc., extensions of the core SAREF ontology have been made available. The extensions considered as the most relevant to the TwinERGY project are SAREF4ENER for the energy domain and SAREF4BLDG for the Buildings domain

2.3.1.5 SAREF4BLDG

SAREF4BLDG [19], is an extension of the SAREF (Smart Applications REFerence) ontology that was created based on the Industry Foundation Classes (IFC) [20] standard (examined also in the next sections) for building information. This extension of the SAREF is limited to devices and appliances within the building domain.

SAREF4BLDG provides the mechanisms to establish, in a secure way, the exchange and the interoperability of the data communicated among various actors (architects, engineers, consultants, contractors, and product component manufacturers, among others) and the applications that are handling building information involved in the various phases of the building life cycle, spanning from construction to the demolition phase. An overview of high-level classes included in the latest version of SAREF4BLDG v1.1.2, is depicted in Figure 3.

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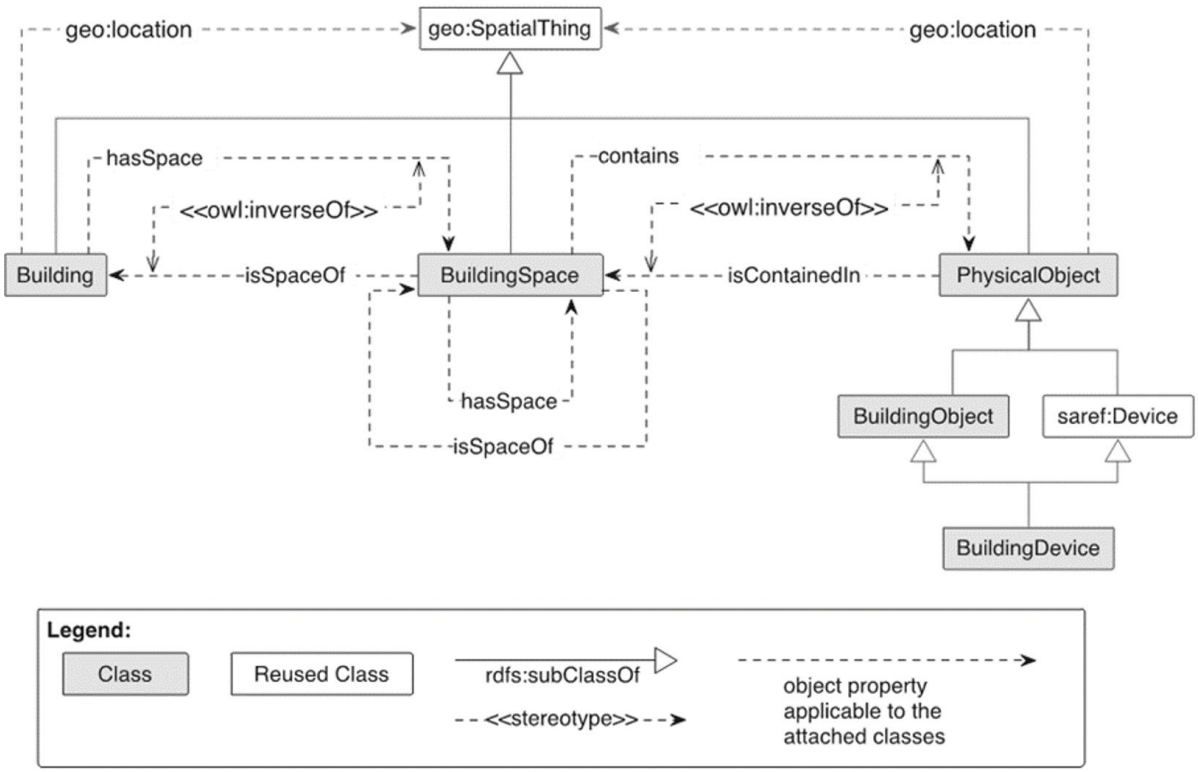

Figure 3 Overview of the SAREF4BLDG extension

SAREF4BLDG extends SAREF with 72 classes (67 defined in SAREF4BLDG and 5 reused from the SAREF and geo ontologies), 179 object properties (177 defined in SAREF4BLDG and 2 reused from the SAREF and geo ontologies), and 83 data type properties (82 defined in SAREF4BLDG and 1 reused from the SAREF ontology).

2.3.1.6 SAREF4ENER

SAREF4ENER [18] [18] is the extension of the SAREF ontology, for the energy domain, created in collaboration with Energy@Home[24] and EEBus[23] , with the target to enable the interconnection of their different data models. SAREF4ENER v1.1.2 expands the core SAREF ontology with 63 additional classes, 17 object properties and 40 data type properties. SAREF4ENER is meant to facilitate interoperability among various proprietary solutions developed by different consortia in the smart home domain (i.e., smart appliances) from manufacturers that support the EEBus or E@H data models. It is crucial to mention that SAREF4ENER focuses on demand response scenarios, in which customers can provide flexibility to the Smart Grid by handling their smart home devices by the means of using any energy management system at home or in the cloud. An overview of the SAREF4ENER's PowerProfile, PowerSequence, Slot and AlternativesGroup classes is presented in the following Figure 4.

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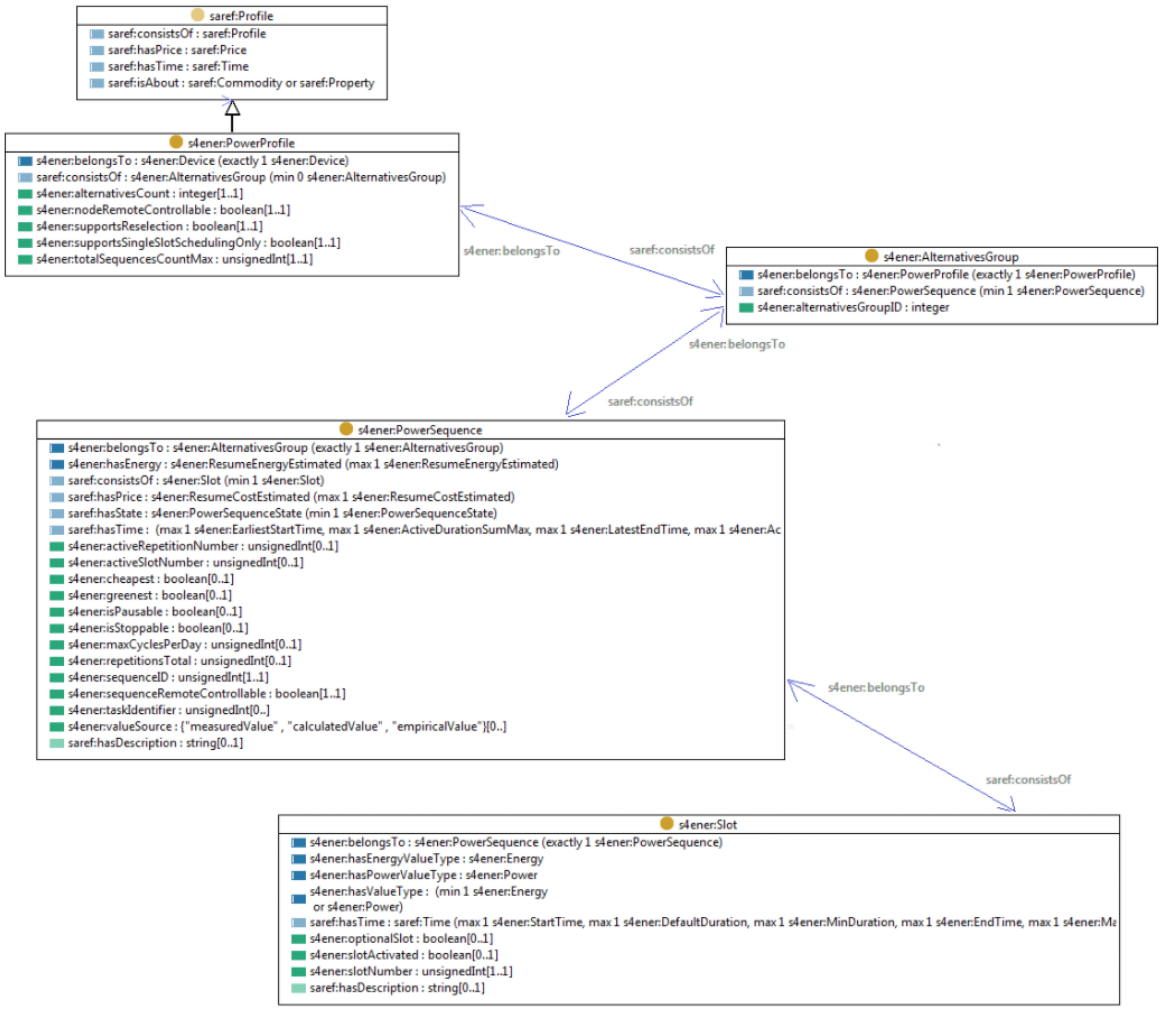

Figure 4 Overview of SAREF4ENER ontology

2.3.1.7 OpenADR

OpenADR [14] is an open, highly secure, and two-way information exchange model and global Smart Grid standard. The OpenADR , which was delivered by the OpenADR Alliance in 2010, is a well-established smart grid data model that eases the exchange of information associated to demand response (DR) programmes among electricity service providers, aggregators and consumers. The model also facilitates the management of the various distributed energy resources (DER) for flexibility providers. OpenADR is delineating the messages exchanged among different stakeholders that take part in automated demand response (Auto-DR) and DER management activities, in a uniform and most importantly, interoperable way. The objective that spurred the development of the OpenADR was the automation and the simplification DR and DER management activities. Electricity consumers are communicated with dynamic pricing and reliability signals, in order to adjust their energy usage behaviour, optimize their energy efficiency, save money, while enhancing the overall effectiveness of power distribution across the smart grid. It shall be mentioned that the IEC has recently approved the OpenADR 2.0

Profile Specification as a Publicly Available Specification (PAS), opening the way for the OpenADR to become an IEC international standard.

2.3.1.8 IFC

BuildingSMART International delivered the Industry Foundation Classes (IFC) [20] aiming to provide a digital representation of the building industry and relevant assets, offering that way the possibility for unhindered information exchange and sharing among the various stakeholders of the building industry. The updated version of the IFC, namely the IFC4, is delivered as an open specification for Building Information Modelling (BIM) data. Data specification items, concepts and terms related to the disciplines, trades and professions associated to the building industry, are included in the standard.

All the data schema and reference data that are included in the IFC standard, are depicted as EXPRESS and XML specification and as XML property and quantity definitions.

The IFC standard can be considered as a four conceptual layer standard. The layers incorporated in the IFC are presented as follows:

- Resource layer: Encompasses specific schemas with the definitions of the resources
- Core layer: Consists of the kernel schema and the core extension schema, that accommodate general entity descriptions
- Interoperability layer: Defines the entities related to general products, processes and specialization of resources
- Domain layer: Includes – as a high-level layer - the entity definitions of product specialization, processes and resources linked to a specific discipline, and can be interchanged throughout the data schema.

2.3.1.9 EFI

FAN (Flexible Power Alliance Network) has developed EFI[22], the Energy Flexibility Interface. EFI stands as a communication protocol that facilitates back-and-forth communication between smart devices and smart grids. Through the Energy Flexibility Interface, the users are presented with the possibility to manage smart devices able to communicate with smart grid technologies (smart plugs, laundry machine, etc.), in the direction of energy flexibility.

2.3.1.10 EEBUS

EEBus[23] initiative is a non-profit organization established by renowned manufacturers in the domains of eMobility, energy and smart building technologies. The main driver of this initiative is to emerge as a common language for energy, suitable for any device or

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platform, aiming to manage the information exchange, in order to organize and relocated the energy within the power grid and basically all the devices connected to it.

2.3.1.11 obXML

Focusing on establishing a common language and modelling mechanisms in order to portray and describe the behaviours of occupants, the DNAS ontology for OB standardization was formulated by IEA Annex 66. The topology of the DNAs framework has been carried out into an XML schema titled 'occupant behaviour XML' or obXML[13] schema and its objective is to connect three main elements representing Buildings, Occupants and Behaviours. Extensive emphasis is put on the study of behaviours of the occupants, based upon Drivers, Needs, Actions and Systems.

2.3.1.12 gbXML

The main purpose behind the implementation of the Green Building schema (gbXML)[9] was the enhancement of interoperability between BIM (building information models) and CAD- based architectural/engineering analysis software tools, allowing for the communication and the transfer of building information via an XML language schema, in a more straightforward way. Over 500 elements and attributes are introduced in the latest version of gbXML (v.6.01), allowing for a more detailed representation of a building's aspects.

2.3.1.13 OCPP 1.6 and 2.0.1

OCCP[21] stands for Open Charge Point Protocol and it is an initiative fronted by the Open Charge Alliance (OCA). The Open Charge Point Protocol makes standard the language, structure, and rules of data exchanges between electric vehicle charging points and central control systems. For hardware manufacturers and charging stations owners, OCPP offers a communication protocol that makes the data sharing and communication between charging points and central stations smooth and instantaneous, meeting user demand. The most used version is OCPP 1.6, that enables smart charging, the ability for the Network Operator to set restrictions like power level or time limits on an individual charger. OCPP 2.0.1offers improved smart charging capabilities, reduced data usage, and important security additions. Overall, OCPP software enables mobile apps, central management systems and EV charging stations to 'talk' to each other using the same 'language'.

2.3.1.14 OSCP 1.0

The OSCP[21] was originally designed for communicating a prediction of the local available capacity to Charging Station Operators (CPO), to enable them to fit the charging

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profiles of the electrical vehicles within the boundaries of the available capacity. Published also by OCA, the market driven Open Smart Charging Protocol (OSCP) targets the embracement and the conformity of communication protocols in the EV charging infrastructure and relevant standards through collaboration, education, testing, and certification. The OSCP protocol is mainly used for forecasting the grid capacity that will be available to other entities, focusing particularly on the business layer and the communication among the CPO and other business entities such as Distribution System Operators (DSOs). The OSCP protocol has been developed to operate in line with the OCPP and thus, offers an end-to-end communication between the DSO, a CPO and an electric vehicle charging point.

2.3.1.15 ISO 15118

The ISO/IEC 15118 is also known as "Road Vehicles – Vehicle to Grid Communication Interface". It is an international standard that comprises from several parts, namely ISO 15118-1:2013[25] , ISO 15118-2:2014[26] and ISO 15118-3:2015[27] . The optimized energy resources utilization to such an extent that electric vehicles can recharge in a more energy efficient or at least, more economical way, is addressed by the first three parts, as both use cases and technical specifications of the Vehicle-to-Grid Communication Interface are elaborated. The fourth part of the standard, defines all the tests related to network and application protocol conformance, establishing an Electric Vehicle Communication Controller (EVCC) or Supply Equipment Communication Controller (SECC).

2.3.1.16 UN/CEFACT CCTS

Through UN/CEFACT[30] Core Components Technical Specification (CCTS), an approach for further elaboration on the establishment of a universal set of semantic building blocks. The standard aims to describe currently most adopted business data types, facilitate the redesigning of the business vocabularies used nowadays and ease the creation of new ones. Thus, ensuring smooth information exchange between applications in the e-business arena is the main objective of the standard.

2.3.1.17 SSN/SOSA

The Semantic Sensor Network (SSN) and Sensor, Observation, Sample, and Actuator (SOSA) [29] deliver appropriate metadata in the direction of modelling entities, relations, and activities that may occur in the course of sensing, sampling, and actuation events. The SSN ontology defines sensors and their relevant processes, components together with the sampling procedure of properties and actuators. SSN adopts SOSA ontology for the definition of its principal classes and properties.

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2.3.2 Overview of relevant established frameworks

2.3.2.1 USEF – Universal Smart Energy Framework

USEF[15] has been established to drive the fastest, most cost-effective route to an integrated smart energy future. It delivers one common standard on which to build all smart energy products and services. The value of flexible energy use is unlocked, by making it a tradeable commodity and by delivering the market structure and associated rules and tools required to make it work effectively.

The USEF standard is meant to be a role-based model, defining the roles, the responsibilities, and the relationships among all energy market participants, so they can capitalize on demand-side participation.
Each of the identified roles and their respective responsibilities can be outlined to their exact implementation in a local market and are concisely represented as follows:

- Distribution System Operator (DSO), responsible for the optimization of the overall distribution network operation
- Balance Responsible Party (BRP), responsible for balancing supply and demand and establishing effective means towards addressing any potential network imbalances in the most cost-effective way
- Aggregator, responsible for the handling of the aggregated energy flexibility provided by the prosumers and addressing the requirements set by the Balancing Responsible Party
- Common Reference Operator (CRO), responsible for the designation of congestion points and congestions to other interested parties
- Meter Data Company, responsible for the compilation and verification of all metering data
- Active Demand and Supply, the different entities that can be communicated with suitable signals to modify the energy demand and supply
- Prosumer, the end user that not only consumes but also, produces energy

USEF was developed, maintained and audited by the USEF Foundation, a non-profit partnership of seven organizations, active in all areas of the smart energy industry: ABB, Alliander, DNV GL, Essent, IBM, ICT Automation and Stedin. In its latest version (v1.3.6), USEF framework, is regarded as the most significant standard on the regulation of the energy market trading modus operandi.

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3. Assessment and shortlisting relevant standards

3.1 Standards Gap Analysis

In order to identify and establish the standards, semantic ontologies and data models that is crucial to be incorporated in the TwinERGY CIM, a gap analysis of the standards reviewed in section 2.3 Review of data standards, is performed. This section represents the outcome of Stage 3, aiming to identify the most appropriate standards and ontologies to TwinERGY scope. The standards and ontologies designated as of high relevance to the implementation of the Common Information Model, along with their particular challenges and gaps, are depicted in Table 5.

Name	Standards Overview/ Challenges	Relevance to TwinERGY CIM
IEC CIM	Provides a definitive way for illustrating power system resources as object classes, outlining their parameters and establishing their relationships in terms of i) inheritance, association and aggregation. Interoperability among different systems is made feasible with the establishment of a common definition of management information for systems, networks, applications and services IEC CIM is applicable only to domain of the electric power system. The complexity of the IEC CIM might hinder the extraction of data with value.	The IEC CIM (IEC 61970/61968/62325) poses as one of the most extensive modelling standards related to the electric power systems, consequently the TwinERGY CIM needs to be adaptable to IEC CIM.
IEC 61850	The IEC 61850 standard is widely adopted in the electric power engineering domain, enabling communications and information exchange in a proper way. It is a standard that should be utilized in the TwinERGY CIM as its data semantics will be useful towards the mapping of the different data that will be ingested in the Core Data Management Platform.	The IEC 61850 includes all the data semantics within the protocol itself. The standard is used extensively towards ensuring seamless information exchange between different devices, something that can be proven extremely useful in respect to the needs of the TwinERGY CIM.

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Name	Standards Overview/ Challenges	Relevance to TwinERGY CIM
IEC 62056/ (DLMS / COSEM)	The information that can be elicited through the IEC 62056 standard refers only to metering data deriving from smart. Since interoperability stands as a prerequisite for the TwinERGY CIM , the inadequacy of semantic information that can be procured by this standard, can be a hindering factor towards addressing the needs of TwinERGY CIM needs.	The IEC 62056 specifies on electricity meter data exchange. It is quite similar to the IEC 61850 standard, in which a physical meter is established as a structure of multiple logical devices. The meter can be deployed in order to log gas, energy, water measurements, under the logical device concept. The IEC 62056 will be considered towards the TwinERGY CIM implementation, but it has to be mentioned that the inherent semantics of the standard cannot address the full spectrum of the CIM needs.
SAREF4BLDG	Extension of the SAREF ontology, emphasizing on buildings / Since it is an ontological standard, it is considered as not directly applicable. * The data model of the standard is missing: The modelling of HVAC concept with the respective fields and values The modelling of HeatPump concept with the respective fields and values The modelling of WearableDevice concept with the field and values to capture physiological data	SAREF4BLDG is an extension of SAREF ontology created on the basis of the IFC, by buildingSMART International. Its main objective is to facilitate interoperability between all stakeholders involved in the various phases of building life cycle.
SAREF4ENER	Extension of the SAREF ontology, emphasizing on energy / Since it is an ontological standard, it is considered as not directly applicable. *	SAREF4ENER is an extension of SAREF ontology created by Energy@Home and EEBus. Focuses on demand response scenarios and its main objective is to facilitate interoperability between the different solutions developed in the smart home domain.
Open ADR	The openADR standard is adopted by wide range of energy stakeholders. The standard involves various signal types referring to Demand Response implementation. The openADR standard can only facilitate the signal exchange of a potential DR event	OpenADR is an open, highly secure, and two-way information exchange model, eases the exchange of information associated to demand response (DR) programmes among electricity service providers, aggregators and consumers and enables in a an effective way, the management of the various distributed energy resources (DER) for flexibility providers
IFC	The IFC standard is mostly utilized in the design phase and maintenance of all systems that are potentially installed within a building.*	IFC standard mainly delivers information on buildings regarding their life cycle. However, the latest and the expected versions of the standard, aim to broaden its spectrum by providing data definitions on every single one of the data assets within an infrastructure. The TwinERGY CIM should examine the IFC standard, despite the fact

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Name	Standards Overview/ Challenges	Relevance to TwinERGY CIM
		that only few of the standards' concepts can be of use in the TwinERGY CIM.
EFI	Through the Energy Flexibility Interface, enables the communication between smart devices with smart grid technologies, in the direction of energy flexibility	Energy Flexibility Interface developed by FAN (Flexible Power Alliance Network). Focuses on establishing back-and-forth communication between smart devices and smart grids.
EEBUS	The EEBUS initiative focuses on the provision of a data model able to manage the information exchange, in order to organize and relocate the energy within the power grid and basically all the devices connected to it. Complementary improvements are considered crucial regarding complex buildings systems/districts. *	A common language for energy, suitable for any device or platform.
obXML	Mostly applicable for building simulation/design tools, focusing on portraying and describing occupants' behaviours.	The objective of the obXML schema is to connect three main elements representing Buildings, Occupants and Behaviours capturing the semantics of the different data deriving from the occupants, applicable to the data modelling needs of TwinERGY.
gbXML	Mostly applicable for building simulation/design tools aiming mainly to provide a detailed representation of a building's aspects.	The objective of the gbXML schema is to harmonize the occupant' behaviour in buildings in relation to energy. The modelling procedure of particular building spaces can lead to the extraction of relevant information about occupancy norms and patterns. This type of data can be used in the Common Information Model of TwinERGY, so that the data exchange/storage formats for building information can be elicited, establishing a more efficient way for the transmission of data.
OCPP 1.6 &2.0.1	Establishes the language, structure, and rules of data exchanges between electric vehicle charging points and central control systems.	OCPP offers a communication protocol that facilitates the data sharing and communication between charging points and central stations to meet user demand. The OCPP software enables mobile apps, central management systems and EV charging stations to communicate with each other under a common language.
OSCP 1.0	Targets the embracement and the conformity of communication protocols in the EV charging infrastructure and relevant standards through	Provides forecasts on the grid capacity and offers an end-to-end communication between the DSO, a CPO and an electric vehicle charging point.

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Name	Standards Overview/ Challenges	Relevance to TwinERGY CIM
	collaboration, education, testing, and certification	
ISO 15118	"Road Vehicles – Vehicle to Grid Communication Interface". Designates all the test procedures related to network and application protocol conformance, establishing an Electric Vehicle Communication Controller (EVCC) or Supply Equipment Communication Controller (SECC).	Enables the optimization of the energy resources usage in order for the Electric Vehicles to rechange in an efficient and less expensive way.
USEF	USEF framework establishes the roles in the flexibility marketplace, yet without defining the means for the exchange of flexibility. USEF is applicable once the buildings are considered as providers of flexibility.	USEF standard enables the definition of roles, responsibilities and relationships among all energy market participants. USEF framework, is regarded as the most significant standard on the regulation of the energy market trading modus operandi

Table 5 Standards/ ontologies gap analysis

*: The management and processing of big data volumes for further utilization in the execution of near real-time analytics and within applications delivering innovative services, requires effective and flexible semantic modelling mechanisms (based on data models) that remove any need for time-consuming transformations of big data to ontological formats and schemas. Consequently, appropriate modifications are required on ontological models of this kind, through a standard procedure, which, of course, will not contravene or distort the semantic concepts, attributes and features of the initial model. These modifications will ensure that the semantic data models will be well-structured and analytical, enabling their dynamic use in any big data infrastructure in any big data management infrastructure (much like to the one developed in TwinERGY) and, quite possibly, facilitate the data flows processing in real-time.

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3.2 Standards analysis summary

The objective of the analysis of the standardization landscape in section 2.3 Review of data standards, was to acknowledge and point out the most relevant standards, ontologies and data models that can be related to the identified domains and to the TwinERGY scope. The selection of the standards was made after establishing a set of criteria, such as their suitability and significance to the relevant TwinERGY activities (data collection, consumer engagement, eMobility, etc.,) as well as their maturity and usability. In the following section, a quick overview of the categorization of the different standards reviewed in relation to the domains they can support is presented.

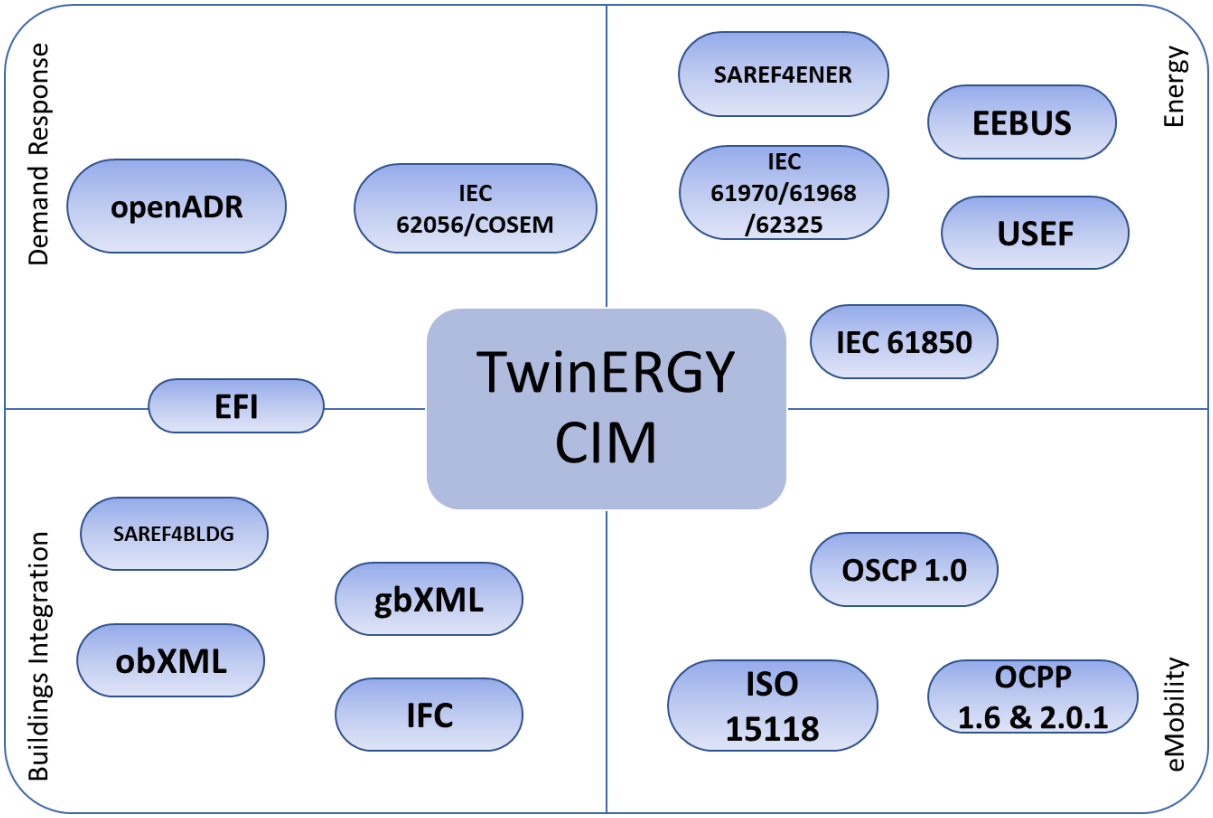

Figure 5 TwinERGY domains covered by semantic standards/ontologies

Together with the categorization presented above, we identified several preliminary challenges that need to be covered by the TwinERGY CIM as procured by the relevant analysis:

- At this stage, none of the reviewed data models can cover the TwinERGY CIM requirements in full extent by a single data model.
- Several of the standards that were reviewed previously, establish strict ontological relations. The users have to comply with the various ambiguities within the standards. In order to perform extensions in the ontology, the ontological definition will need to be revised and the integration of additional classes within the modelling ontology. This defines an unfortunate situation for the TwinERGY

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CIM, since the Common Information Model of the project is expected to be a constantly evolving model
- Enabling interoperability at the best degree possible among the different standards poses as one of the main challenges for the TwinERGY CIM. In order to ensure interoperability, the CIM shall be to adapt and cover the different levels of development in separate fields.

3.3 Common Information Model considerations

The review (section 2.3 Review of data standards) and the gap analysis (section 3.1 Standards Gap Analysis) of the relevant standards, ontologies and semantic models, which will cover in a limited or extensive degree the TwinERGY scope, led to several considerations, which can be considered as the high-level functional requirements of the TwinERGY CIM.

The main driver of the envisioned data model is to establish the means for the effective management of the data semantics that will be collected in the Core Data Management Platform and enable interoperability. Therefore, the TwinERGY CIM needs to integrate an appropriate level of semantics that will ensure interoperability, without having to follow strict ontological models to achieve this kind of implementation.

- The TwinERGY CIM is required to ensure the seamless operation of the TwinERGY CDMP, while keeping all the related semantics together with the collected data, establishing that way the TwinERGY CDMP as an open data sharing mechanism for authorized third parties.
- With the purpose of TwinERGY to be successful, it is crucial to ensure interoperability both at technical and at semantic level. The TwinERGY CIM will have multiple interactions with various data sources and systems, which will most probably comply with their exclusive data model, so it is important to provide consistent and non-ambiguous data interpretation in order to analyse the semantics accurately.
- In order for TwinERGY to be able to incorporate existing pilot site data from different data sources and data providers, advanced modelling features should be introduced in the TwinERGY CIM for the purpose of enabling interoperability (such as mapping to external data sources).
- The design of the TwinERGY model shall provide the mechanisms to allow extensibility with the introduction of appropriate extension processes and allowing model upgrades, as the TwinERGY solution is likely to evolve.
- In order to safeguard its sustainability, the TwinERGY CIM needs to be developed in such a way to approve the occasional deprecation of ambiguous concepts. This possibility can occur due to the vast volumes of data that will be collected in the platform.

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- To ensure in the most certain way the inclusion of all potential different entities and stakeholders involved in TwinERGY (directly and indirectly) along with their related attributes, the TwinERGY CIM shall avoid the compliance to a specific standard, but instead enable the integration of various data standards (and the range of features they can potentially introduce) and facilitate the possibility of combinations of them.
- The TwinERGY CIM shall use the existing standards and ontologies so that the data representations associated with relevant data collection activities can be appropriately mapped, safeguarding also that through adequate storing mechanisms, every piece of semantic information, irrespective of its potential direct use in the TwinERGY CDMP, will be used for interoperability of the CDMP.

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4. The TwinERGY Common Information Model

4.1 The foundations of the TwinERGY CIM

The Common Information Model of TwinERGY is directed towards overcoming different types of obstacles relevant to data integration and interoperability for the data deriving from the various actors that take part in the electricity domain. Processing vast volumes of raw data into something of value is the key aim of the CIM regardless of the built-in languages and formats the standards, examined in section 2.3 Review of data standards, follow. The TwinERGY CIM endeavours to accommodate aforesaid standards and elaborate more on the existing intelligence of the electricity domain.

Ab initio, the TwinERGY CIM is built upon the foundations that are described as follows:

- **Resilience:** It is essential that the TwinERGY CIM introduces the various relations of the data, so that the stakeholders (either of the TwinERGY consortium or outside of it) will have the possibility to handle and capitalize on them through the project's Core Data Management Platform (CDMP).
- **Data Frequency:** The TwinERGY CIM must ensure that the concepts that will be introduced, together with the respective fields and metadata, will be at a befitting level of granularity. Both tabular data (extracted from .csv files) and nested data are going to be ingested in the CDMP, therefore the relations among the different concepts to be introduced need to be identified and the separation of the fields (static and dynamic) that are related to a concept needs to be established.
- **User-friendliness:** Considering the possibility that the electricity data value chain stakeholders may not be familiar with the functionalities of the TwinERGY CIM, it is essential that their data, mapped in the different concepts and fields, will be manageable in a straightforward way.
- **Language-independence:** The TwinERGY CIM must be language-agnostic to the various languages that are predominantly adopted in relation to modelling purposes.
- **Scalability:** Since the CIM is considered as a constantly expandable model, it is crucial that the lifecycle assurance rules that are going to be applied, will safeguard the unhindered operation of the TwinERGY CDMP.

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4.2 CIM – relevant terminology

In order to outline the TwinERGY CIM, a set of basic terms has been identified, with the intention to establish a common understanding and perspective of terms such as Entity, Concept and Field.

- **Entity** is defined either as a tangible or an intangible object that instantiate here and now.
- **Concept** is defined as the equivalent of an entity, represented in the CIM. All concepts in the TwinERGY CIM, will be introduced and modelled based on the analysis of the standards that was performed previously
- **Field** is defined as the attributes of each concept that is modelled in the TwinERGY CIM.

It is also worth mentioning that within the TwinERGY CIM the relationships among different concepts will be depicted with the appropriate references.

4.3 TwinERGY CIM High-level view

The initial version of the TwinERGY CIM comprises 72 concepts. The fields included in those concepts sum up to 1996. The categorization of the concepts in respective areas of interest is not depicted in the TwinERGY CIM but was only conducted for the purpose of the presentation in this section.

As portrayed in Figure 6, the TwinERGY CIM incorporates appropriate concepts relevant to the

- **Stakeholders** (consisting of: Aggregator, BRP, CityBoard, DistributionSystemOperator, ESCo, PremisesAdministrator, EnergyCooperative, Prosumer, Retailer, RenewableResourcesAdministrator);
- **Structure** (consisting of: Resident, Residence, WellBeing, BuildingSite, BuildingStructure, BuildingFloor, BuildingRegion);
- the operational features of the **Network** (consisting of: ACsegment, ConnectivityJunction, ExternalNetworkSegment, PowerGrid, PowerTransformer, PowerSubstation,);
- the different types of **Equipment** (consisting of: Device, ControlAction, ControlEvent, ControlStatus, SmartAsset, SmartAssetControlAction, ElectricityMeter, Gateway, Sensor, LightingFixture, LightingFixtureControlAction, HeatPump, HeatPumpControlAction, Boiler, BoilerControlAction, DHWSystem, DHWSystemControlAction, OperationProfile, EV, EVChargingUnit, EVChargingUnitControlAction, AirCoolingSystem, AirCoolingSystemControlAction,

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BatterySystem, BatterySystemControlAction, Heater, HeaterControlAction, Ventilation, VentilationControlAction).

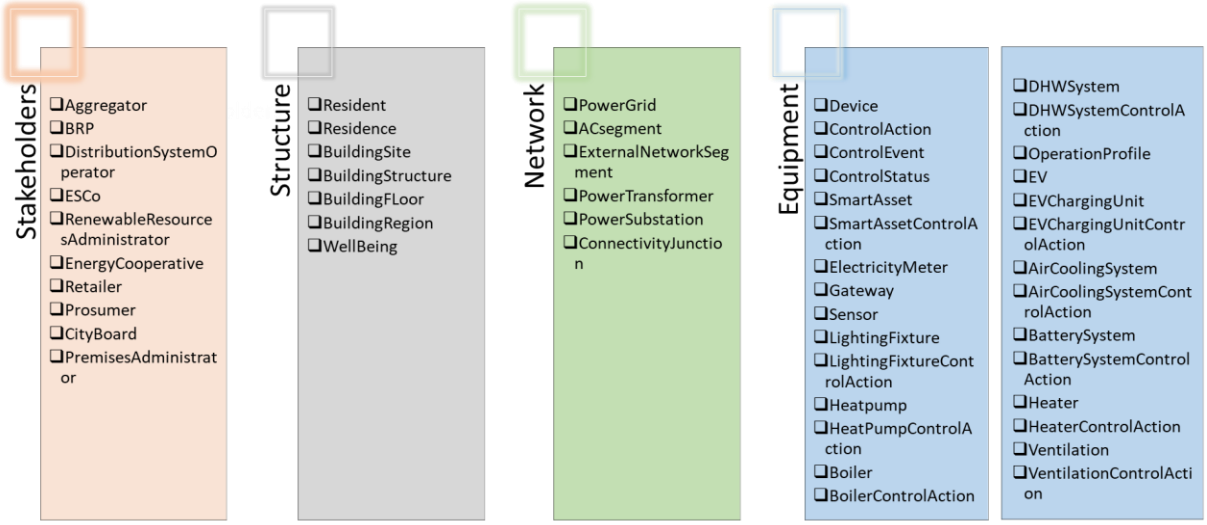

Figure 6 Part I of the introduced concepts in the TwinERGY CIM

Additionally, the CIM incorporates concepts relevant to

- **Measurements** of each and every type of equipment (consisting of: Measurement, GenerationMeasurement, StorageMeasurement, DemandMeasurement, SensingMeasurement, Weather Measurement).
- **Power Plants** (consisting of: VPP, Photovoltaic, RenewableResources, WeatherStation);
- **Events** (consisting of: Event, NetworkIncident, NetworkIncidentLog, Outage, OutageLog),
- and **General** concepts (consisting of: ContactPoint, Locale, Address, Status, Term), depicted in Figure 7.

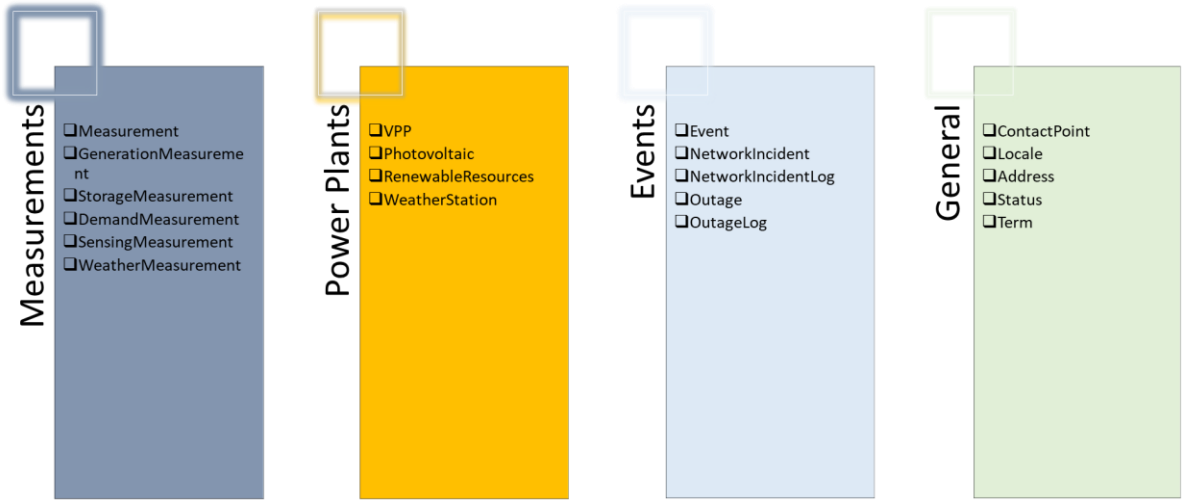

Figure 7 Part II of the introduced concepts in the TwinERGY CIM

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Also, the CIM of the TwinERGY project is foreseen to be a continuously evolving data model. To this point, apart from the initial version of the Common Information Model and the concepts introduced, presented in the previous paragraphs, we identified several areas of interest on top of the existing eight. The concepts and their relations are identified and will be incorporated accordingly, in order to address any future needs of the TwinERGY CIM. In Figure 8, an overview of potential categories with regard to the areas of interest of TwinERGY, along with relevant concepts, is presented.

Figure 8 Overview of potential concepts to be introduced in the next version of the TwinERGY CIM

In the next, Table 6 presents all concepts already introduced in the TwinERGY CIM together with their relations and the respective standards (if any) that were utilised to facilitate their modelling process.

Concept	Related Concepts	Fields (incl. Related)	Standard(s) Used
ACsegment	ConnectivityJunction, DistributionSystemOperator, GenerationMeasurement, Locale, Measurement, PerformanceIndicator*, PowerGrid, PowerSubstation, Term	36 (9*)	IEC CIM
Address	Locale, Status, Term	24 (3)	UN/CEFACT CCTS
Aggregator	Address, AggregatorPortfolio*, ContactPoint, Contract*, DREvent*, DRReport*, FlexibilityOffer*, FlexibilityOption*, FlexibilityOrder*, FlexibilitySettlement*, Locale, Market*, Status, VPP	22 (14*)	-
AirCoolingSystem	AirCoolingSystemControlAction, AggregatorPortfolio*, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, ControlEvent, ControlStatus, DemandMeasurement, DRevent*, Flexibility*,	49 (15*)	SAREF4BLDG

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Concept	Related Concepts	Fields (incl. Related)	Standard(s) Used
	Measurement, OperationProfile, PerformanceIndicator*, Prosumer		
AirCoolingSystemControlAction	AirCoolingSystem, ControlEvent, ControlStatus, DemandMeasurement, DREvent*, DRReport*, Flexibility*, Measurement, Term	24 (9*)	-
BatterySystem	AggregatorPortfolio*, BatterySystemControlAction, ControlEvent, ControlStatus, Flexibility*, Locale, Measurement, PerformanceIndicator*, Prosumer, Status, StorageMeasurement	41 (11*)	IEC CIM, SAREF4ENER
BatterySystemControlAction	Aggregator, BatterySystem, ControlEvent, ControlStatus, DREvent*, DRReport*, Flexibility*, FlexibilityOffer*, FlexibilitySettlement*, Prosumer, StorageMeasurement, Term	22 (12*)	IEC CIM
Boiler	AggregatorPortfolio*, BoilerControlAction, BuildingRegion, BuildingSite, BuildingStructure, ControlEvent, ControlStatus, DemandMeasurement, Flexibility*, Locale, Measurement, OperationProfile, PerformanceIndicator*, Prosumer, Status, Term	47 (16*)	SAREF4BLDG
BoilerControlAction	Aggregator, Boiler, Contract*, ControlEvent, ControlStatus, DemandMeasurement, DREvent*, DRReport*, Flexibility*, FlexibilityOffer*, FlexibilitySettlement*, Prosumer, Term	23 (13*)	-
BRP	Address, ContactPoint, Locale, FlexibilityOffer*, FlexibilityOption*, FlexibilityOrder*, FlexibilitySettlement*, Market*, RetailerPortfolio*, Status	18(10*)	-
BuildingFloor	BuildingRegion, BuildingSite, BuildingStructure, DemandMeasurement, Device, Measurement, Residence, Resident, Prosumer	24 (9)	IFC
BuildingRegion	AirCoolingSystem, Boiler, BuildingFloor, BuildingSite, BuildingStructure, Device, DemandMeasurement, DHWSystem, Gateway, Heater, LightingFixture, Measurement, Residence, Resident, PerformanceIndicator*, PremisesAdministrator, Prosumer, SensingMeasurement, Sensor, SmartAsset, Ventilation, WellBeing	32 (22*)	IFC
BuildingSite	AirCoolingSystem, BatterySystem, Boiler, BuildingFloor, BuildingRegion, BuildingStructure, DemandMeasurement, Device, DHWSystem, EVChargingUnit, Gateway, GenerationMeasurement, Heater, LightingDevice, Measurement, Residence, Resident, Photovoltaic, PremisesAdministrator, Prosumer, Retailer, SensingMeasurement, Sensor, SmartAsset, StorageMeasurement, Ventilation, WellBeing	43 (27)	IFC
BuildingStructure	Address, BatterySystem, BuildingFloor, BuildingRegion, BuildingSite, DemandMeasurement, EVChargingUnit, GenerationMeasurement, Locale, Measurement, PerformanceIndicator*, Photovoltaic, PowerGrid, PremisesAdministrator, Prosumer, Residence, Resident, Retailer, SensingMeasurement, Sensor, StorageMeasurement, WeatherMeasurement	58 (22*)	IFC

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Concept	Related Concepts	Fields (incl. Related)	Standard(s) Used
CityBoard	Address, BuildingStructure, ContactPoint, Locale, Status	12 (5)	-
ConnectivityJunction	ACsegment, DistributionSystemOperator, Locale, Measurement, PowerGrid, PowerSubstation, PowerTransformer, Term	17 (8)	IEC CIM
ContactPoint	Address, Status, Term	16 (3)	UN/CEFACT CCTS
DemandMeasurement	ACsegment, Aggregator, AggregatorPortfolio*, AirCoolingSystem, BatterySystem, Boiler, BuildingStructure, Device, DistributionSystemOperator, EV, Heater, LightingFixture, Locale, Market*, Measurement, PowerGrid, PowerSubstation, Prosumer, Retailer, RetailerPortfolio*, SmartAsset, Status, Term, Ventilation	55 (24*)	IEC CIM
Device	DemandMeasurement, Device, DeviceControlEvent, Flexibility*, GenerationMeasurement, Locale, Measurement, OperationProfile, PerformanceIndicator*, PowerSubstation, Prosumer, SensingMeasurement, StorageMeasurement, Term	34 (14*)	IEC CIM, SAREF4ENER
DeviceControlAction	Device, DeviceControlStatus, Term	15 (3)	SAREF4ENER
DeviceControlEvent	AirCoolingSystem, AirCoolingSystemControlAction, BatterySystem, BatterySystemControlAction, Boiler, BoilerControlAction, Device, DeviceControlAction, DeviceControlStatus, DHWSystem, DHWSystemControlAction, EVChargingUnit, EVChargingUnitControlAction, HeatPump, HeatPumpControlAction, LightingFixture, LightingFixtureControlAction, Term, Ventilation, VentilationControlAction	27 (20)	SAREF4ENER
DeviceControlStatus	AirCoolingSystem, AirCoolingSystemControlAction, BatterySystem, BatterySystemControlAction, Boiler, BoilerControlAction, Device, DeviceControlAction, DeviceControlStatus, DemandMeasurement, DHWSystem, DHWSystemControlAction, EVChargingUnit, EVChargingUnitControlAction, HeatPump, HeatPumpControlAction, LightingFixture, LightingFixtureControlAction, Term, Ventilation, VentilationControlAction	30 (21)	SAREF4ENER
DHWSystem	AggregatorPortfolio*, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, DemandMeasurement, DeviceControlEvent, DeviceControlStatus, DREvent*, DHWSystemControlAction, DRReport*, Flexibility*, Measurement, OperationProfile, PerformanceIndicator*, Prosumer	29 (16*)	-
DHWSystemControlAction	DREvent*, DRReport*, DeviceControlEvent, DeviceControlStatus, DHWSystem, DemandMeasurement, Flexibility*, Measurement	18 (8*)	-
DistributionSystemOperator	Address, ContactPoint, Contract*, Market*, PowerGrid, Locale, FlexibilitySettlement*	14 (7*)	-
ElectricityMeter	BuildingStructure, DistributionSystemOperator, DemandMeasurement, GenerationMeasurement, Retailer, Photovoltaic	16 (6)	IEC CIM

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Concept	Related Concepts	Fields (incl. Related)	Standard(s) Used
EnergyCooperative	Aggregator, BuildingStructure, BatterySystem, DistributionSystemOperator, DemandMeasurement, GenerationMeasurement, StorageMeasurement, EVChargingUnit, Flexibility*, PowerGrid, Locale, Measurement, Photovoltaic, Prosumer, RenewableResources, Retailer, Status, PowerSubstation	27 (18*)	-
ESCo	Address, ContactPoint, Locale, Status	12 (4)	-
EV	AggregatorPortfolio*, BatterySystem, DemandMeasurement, StorageMeasurement, EVChargingUnit, Flexibility*, PerformanceIndicator*, Measurement, Prosumer, SensingMeasurements, Sensor, Status, Term	27 (13*)	-
EVChargingUnit	ACsegment, BuildingStructure, ContactPoint, EVChargingUnitControlAction, Locale, PerformanceIndicator*, PowerSubstation, Prosumer, Status, Term	18 (10*)	IEC CIM
EVChargingUnitControlAction	DemandMeasurement, DREvent*, DRReport*, DeviceControlEvent, DeviceControlStatus, EVChargingUnit, Measurement	19 (7*)	IEC CIM
Event	Locale, Status, Term	14 (3)	UN/ CEFACT CCTS
ExternalNetworkSegment	ACsegment, ConnectivityJunction, PowerGrid, PowerSubstation	23 (4)	IEC CIM
Gateway	BuildingRegion, BuildingSite, BuildingStructure, Sensor, SmartAsset	14 (5)	SSN
GenerationMeasurement	ACsegment, Aggregator, AggregatorPortfolio*, BuildingStructure, DistributionSystemOperator, Locale, Market*, Photovoltaic, PowerGrid, PowerSubstation, Prosumer, RenewableResources, RenewableEnergySourceAdministrator, Retailer, RetailerPortfolio*, Status, Term	154 (17*)	IEC CIM
Heater	AggregatorPortfolio*, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, DemandMeasurement, Flexibility*, PerformanceIndicator*, Measurement, OperationProfile, Prosumer, HeaterControlAction, Status	36 (13*)	SAREF4BLDG
HeaterControlAction	AggregatorPortfolio*, OperationProfile, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, DemandMeasurement, Flexibility*, PerformanceIndicator*, Measurement, Prosumer, HeaterControlAction, Status	24 (13*)	-
HeatPump	AggregatorPortfolio*, OperationProfile, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, DemandMeasurement, DeviceControlEvent, DeviceControlStatus, DREvent*, DRReport*, Flexibility*, HeatPumpControlAction, Measurement, PerformanceIndicator*, Prosumer	35 (16*)	-
HeatPumpControlAction	DemandMeasurement, DeviceControlEvent, DeviceControlStatus, DREvent*, DRReport*, Flexibility*, HeatPump, Measurement	19 (8*)	-

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Concept	Related Concepts	Fields (incl. Related)	Standard(s) Used
LightingFixture	AggregatorPortfolio*, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, DemandMeasurement, Flexibility*, LightingFixtureControlAction, Measurement, OperationProfile, PerformanceIndicator*, PremisesAdministrator, Prosumer	34(13*)	SAREF4BLDG
LightingFixtureControlAction	DemandMeasurement, DeviceControlEvent, DeviceControlStatus, DREvent*, DRReport*, Flexibility*, LightingFixture, Measurement, Term	22 (9*)	-
Locale	Address, Term, WeatherStation	36 (3)	UN/ CEFACT CCTS
Measurement	AirCoolingSystem, BatterySystem, Boiler, Device, DHWSystem, EV, HeatPump, Heater, LightingFixture, PowerTransformer, Photovoltaic, Sensor, SmartAsset, Term, Ventilation, VPP	25 (16)	SAREF, SSN
NetworkIncident	ContactPoint, Locale, Outage, Photovoltaic, RenewableResources, Status, Term	22 (7)	IEC CIM
NetworkIncidentLog	Locale, NetworkIncident, OutageLog, PerformanceIndicator*, Photovoltaic, RenewableResources, Status,	13 (7*)	-
OperationProfile	AirCoolingSystem, Boiler, DemandMeasurement, Device, DHWSystem, Heater, LightingFixture, SmartAsset, Term, Ventilation, WellBeing	23 (11)	SAREF4ENER
Outage	ACsegment, ContactPoint, Locale, NetworkIncident, OutageLog, Photovoltaic, PowerSubstation, RenewableResources, Status, Term	35 (10)	IEC CIM
OutageLog	ContactPoint, DistributionSystemOperator, Locale, NetworkIncidentLog, Outage, PerformanceIndicator*, Photovoltaic, PowerSubstation, Prosumer, RenewableResources, Status, Term	19 (12*)	IEC CIM
Photovoltaic	ACsegment, Flexibility*, GenerationMeasurement, Locale, Measurement, PerformanceIndicator*, PowerGrid, PowerSubstation, Prosumer, RenewableResources, RenewableResourcesAdministrator, Sensor, Status, Term	42 (14*)	IEC CIM
PowerGrid	ACsegment, DistributionSystemOperator, DemandMeasurement, Flexibility*, GenerationMeasurement, Locale, NetworkIncidentLog, OutageLog, PerformanceIndicator*, PowerSubstation, RenewableResources, Term	23 (12*)	IEC CIM
PowerSubstation	ACsegment, GenerationMeasurement, Locale, Measurement, PerformanceIndicator*, PowerTransformer, Sensor, Status, Term	18 (9*)	IEC CIM
PowerTransformer	ConnectivityJunction, Measurement, PowerSubstation, Sensor, Status, Term	40 (6)	IEC CIM
PremisesAdministrator	Address, BuildingStructure, ContactPoint, Locale, Status	13 (5)	-
Prosumer	Address, AirCoolingSystem, BatterySystem, Boiler, ContactPoint, Contract*, DemandMeasurement, Device, DHWSystem, EV, GenerationMeasurement, Heater, HeatPump, Market*, LightingFixture, Photovoltaic,	36 (21*)	USEF

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Concept	Related Concepts	Fields (incl. Related)	Standard(s) Used
	RenewableResources, SmartAsset, StorageMeasurement, Term, Ventilation		
RenewableResources	ACsegment, Flexibility*, GenerationMeasurement, Locale, Measurement, PerformanceIndicator*, Photovoltaic, PowerGrid, PowerSubstation, Prosumer, RenewableResourcesAdministrator, Sensor, Status, StorageMeasurement, Term	22 (15*)	IEC CIM
RenewableResourcesAdministrator	Address, ContactPoint, FlexibilityOffer*, FlexibilityOption*, FlexibityOrder*, FlexibilitySettlement*, Locale, Market*, Photovoltaic, RenewableResources, Status	19 (11*)	-
Residence	BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure	17 (4)	IFC
Resident	BuildingStructure, WellBeing	16 (2)	-
Retailer	Address, BRP, ContactPoint, FlexibilityOffer*, FlexibilityOption*, FlexibilityOrder*, FlexibilitySettlement*, Locale, Market*, RenewableResourcesAdministrator, RetailerPortfolio*, Status	20 (12*)	-
SensingMeasurement	AirCoolingSystem, BatterySystem, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, Gateway, LightingFixture, Measurement, Sensor, Status, Term	34 (12)	SSN
Sensor	BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, Gateway, Measurement, Photovoltaic, PowerSubstation, PowerTransformer, RenewableResources, SensingMeasurement, WeatherStation	22 (12)	SAREF, SSN
SmartAsset	AggregatorPortfolio*, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, DemandMeasurement, Gateway, PerformanceIndicator*, Prosumer, Status, SmartAssetControlAction	23 (11*)	SAREF4BLDG
SmartAssetControlAction	DemandMeasurement, DeviceControlEvent, DeviceControlStatus, DREvent*, DRReport*, Flexibility*, SmartAsset, Term	17 (8*)	-
Status	Device, Term	19 (2)	UN/ CEFACT CCTS
StorageMeasurement	BatterySystem, EV, Locale, Status, Term	29 (5)	IEC CIM
Term	DemandMeasurement, GenerationMeasurement, PerformanceIndicator*, Status, StorageMeasurement	32 (5*)	UN/ CEFACT CCTS
Ventilation	AggregatorPortfolio*, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, DemandMeasurement, Flexibility*, Measurement, OperationProfile, PerformanceIndicator*, Prosumer, VentilationControlAction, Status	30 (13*)	SAREF4BLDG
VentilationControlAction	DemandMeasurement, DeviceControlEvent, DeviceControlStatus, DREvent*, DRReport*, Flexibility*, Measurement, Ventilation	18 (8*)	-

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Concept	Related Concepts	Fields (incl. Related)	Standard(s) Used
VPP	Aggregator, DistributionSystemOperator, Locale, Market*, PerformanceIndicator*, Prosumer, Term	15 (7*)	IEC CIM
Weather Measurement	Locale, Term, WeatherStation	31 (3)	-
WeatherStation	Locale, Photovoltaic, RenewableResources, Sensor, Term, WeatherMeasurement	13 (6)	-
WellBeing	BuildingRegion, BuildingSite, Residence, Resident, SensingMeasurement, Sensor, Status, Term	33 (8)	-

Table 6 Concepts overview in the TwinERGY CIM

*: Identified concepts and relations that will be integrated accordingly to the Common Information Model, in order to cover any future needs of TwinERGY.

All concepts depicted in Table 6, their fields and relations will be available for further elaboration in the Annexes Section.

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5. CIM Lifecycle Assurance

Concluding with Stage 5 of the 2.1 Methodology process, appropriate lifecycle assurance rules need to be established, to ensure the sustainability and extensibility of the Common Information Model. Despite how meticulously the methodology for the TwinERGY CIM has been followed, several core principals have been identified, to ensure the sustainability and extensibility of the model and are described in the following sections.

5.1 Introduction of new concepts/fields

The TwinERGY CIM is designed to be a constantly and continuously evolving data model. Therefore, it is important to be able to adapt to the ingestion of updated data from the TwinERGY pilot sites or to the identification of new-found data needs from technical partners of the consortium, responsible for the modules' implementation, enabling appropriate mechanisms to cope with them in an efficient way.

Also, any stakeholder that will be granted access to the TwinERGY CDMP, will be offered the possibility of suggesting potential additions to the existing concepts/ fields of the TwinERGY CIM.

5.2 Adaptations of available concepts/fields

The TwinERGY CIM manager is in charge of the assessment process of the proposed changes by the different stakeholders and for keeping track of the standardisation landscape, in the case that new standards or semantic ontologies become available. The CIM manager has the authority to either accept or deny any change suggestion relevant to the data model. Any change that may occur within the CIM will lead to minor or major versions of the TwinERGY Common Information Model.

5.3 Removal of available concepts/fields

Ensuring backwards compatibility between updated and previous versions of the TwinERGY CIM is a prerequisite, in respect to the consistency of the data that have been already stored in the TwinERGY CDMP. Therefore, complete removal of existing concepts/ fields is not permitted. Instead, it will be possible to tag concepts/ fields as deprecated, thus preventing their future usage, whilst safeguarding the validity of the datasets already stored in the TwinERGY Core Data Management Platform.

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6. Conclusions

This deliverable, D5.1 "TwinERGY Common Information Model", focused on a methodological approach to define the TwinERGY CIM in the context of the Task T5.1 "Open Standards Review and Common Information Model Adaptation".

The CIM design was supported by an exhaustive analysis of the data needs of the TwinERGY pilots and the TwinERGY modules, combined with a widespread study of the widely adopted data standards related to the data exchanges between the project stakeholders for the needs of the project. As part of this exercise, applicable data standards (e.g. IEC, SAREF, USEF, OpenADR) have been shortlisted in terms of alignment to the TwinERGY needs, and have been thus selected as the base to shape the TwinERGY CIM.

Creating a "common language" for all data to be collected, enables both syntactic and semantic interoperability, supports the sharing and spreading of knowledge among the different organizations, and enables the utilisation of data from heterogeneous systems of different domains and interconnecting their services. In this context, this deliverable offers an initial definition of the TwinERGY CIM, that consists of 72 concepts and 1996 fields and efficiently describes the semantics and structure of each concept, its fields, and relations to other concepts. A matching of defined TwinERGY CIM concepts and fields to 18 standards has been also performed, encapsulating domain knowledge during the definition of the model.

In TwinERGY, the Common Information Model is essentially viewed as a "living" model that will be continuously change and grow based on the needs of the project. Following a strictly controlled CIM lifecycle assurance approach to introduce any new or changed data needs, the consistency of the already ingested data is safeguarded and the TwinERGY platform's stability is maintained.

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ANNEXES

All the TwinERGY CIM concepts, the fields identified and the relations with other concepts are depicted in detail, in the following tables.
The identified concepts and relations that will be integrated accordingly to the Common Information Model, in order to cover any future needs of TwinERGY, are accompanied by an asterisk (*)

Concept: ACsegment

Fields (27)	capacity, cableType, conductorDiameter, coreDiameter, id, impedance, layersCount, length, name, nominalCurrent, nominalCurrentMax, nominalFrequency, nominalVoltage, operatingCurrentMax, operatingVoltageMax, reactance, resistance, shortCircuitTemperature, shuntConductance, shuntSusceptance, status, type, transformersCount, zeroReactance, zeroResistance, zeroShuntConductance, zeroShuntSusceptance
Related Concepts (9*)	relatedConnectivityJunction, relatedDistributionSystemOperator, relatedGenerationMeasurement, relatedLocale, relatedMeasurement, relatedPerformanceIndicator*, relatedPowerGrid, relatedPowerSubstation, relatedTerm

Concept: Address

Fields (21)	addressLine, apartmentID, buildingName, buildingNumber, cityCode, cityName, continentName, countryCode, countryName, description, districtName, floorNumber, id, name, plotID, postalCode, postOfficeBox, region, status, streetName, type
Related Concepts (3)	relatedLocale, relatedStatus, relatedTerm

Concept: Aggregator

Fields (8)	brandName, departmentName, description, id, legalClassificationCode, legalName, name, type
Related Concepts (14*)	relatedAddress, relatedAggregatorPortfolio*, relatedContactPoint, relatedContract*, relatedDREvent*, relatedDRReport*, relatedFlexibilityOffer*, relatedFlexibilityOption*, relatedFlexibilityOrder*, relatedFlexibilitySettlement*, relatedLocale, relatedMarket*, relatedStatus, relatedVPP

Concept: AirCoolingSystem

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Fields (34)	airflowRate, brandName, code, coolingCapacity, coolingMedium, description, europeanSeasonalEnergyEfficiencyRatio, externalSurfaceArea, heatingCapacity, id, internalRefrigerantVolume, internalSurfaceArea, internalWaterVolume, manufacturerName, maximumCapacity, minimumCapacity, model, name, nominalCapacity, nominalCoolingLoad, nominalHeatingLoad, nominalHeatTransferArea, nominalHeatTransferCoefficient, nominalNoiseLevel, nominalPartLoadMax, nominalPartLoadMin, nominalPartLoadRatio, nominalVoltage, performanceCoefficient, refrigerantClass, refrigerantName, seasonalEnergyEfficiencyRatio, serialNumber, type
Related Concepts (15*)	relatedAirCoolingSystemControlAction, relatedAggregatorPortfolio*, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedControlEvent, relatedControlStatus, relatedDemandMeasurement, relatedDRevent*, relatedFlexibility*, relatedMeasurement, relatedOperationProfile, relatedPerformanceIndicator*, relatedProsumer

Concept: AirCoolingSystemControlAction

Fields (15)	coolingSetpoint, createdDateTime, description, fanDirection, fanSpeed, heatingSetpoint, id, modeSetting, name, powerSwitch, reportedDateTime, temperatureSetpoint, timerIndicator, type, updatedDateTime
Related Concepts (9*)	relatedAirCoolingSystem, relatedControlEvent, relatedControlStatus, relatedDemandMeasurement, relatedDREvent*, relatedDRReport*, relatedFlexibility*, relatedMeasurement, relatedTerm

Concept: BatterySystem

Fields (30)	autonomy, brandName, cellsInParallelCount, cellsInSeriesCount, chargeVoltage, code, cutOffVoltage, cycleLife, depthOfDischarge, description, dischargeRate, duration, id, manufacturerName, maxCapacity, maxChargeCurrent, maxChargeRate, maxDischargeCurrent minChargeStatus, model, name, nominalCapacity, nominalEnergyDelivered, nominalVoltage, ratedCapacity, remainingUsefulLife, roundTripEfficiency, serialNumber, throughput, type
Related Concepts (11*)	relatedAggregatorPortfolio*, relatedBatterySystemControlAction, relatedControlEvent, relatedControlStatus, relatedFlexibility*, relatedLocale, relatedMeasurement, relatedPerformanceIndicator*, relatedProsumer, relatedStatus, relatedStorageMeasurement

Concept: BatterySystemControlAction

Fields (10)	chargingSwitch, createdDateTime, description, dischargingSwitch, id, name, reportedDateTime, stateOfChargeIndicator, type, updatedDateTime
Related Concepts (12)	relatedAggregator, relatedBatterySystem, relatedControlEvent, relatedControlStatus, relatedDREvent*, relatedDRReport*, relatedFlexibility*, relatedFlexibilityOffer*, relatedFlexibilitySettlement*, relatedProsumer, relatedStorageMeasurement, relatedTerm

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Concept: Boiler

Fields (31)	brandName, code, description, energySource, flowMode, heatingLoad, heatingSurfaceArea, id, manufacturerName, model, name, nominalCapacity, nominalEnergyConsumption, nominalEnergyConsumptionRate, nominalPartLoadRatio, nominalPower, nominalThermalEfficiency, operatingMode, outletTemperatureMax, outletTemperatureMin, outletTemperatureRange, parasiticElectricConsumption, parasiticElectricLoad, pressureRating, serialNumber, storageCapacityAvailability, type, waterInletTemperatureMax, waterInletTemperatureMin, waterInletTemperatureRange, waterStorageCapacity
Related Concepts (16*)	relatedAggregatorPortfolio*, relatedBoilerControlAction, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedControlEvent, relatedControlStatus, relatedDemandMeasurement, relatedFlexibility*, relatedLocale, relatedMeasurement, relatedOperationProfile, relatedPerformanceIndicator*, relatedProsumer, relatedStatus, relatedTerm

Concept: BoilerControlAction

Fields (10)	createdDateTime, description, id, name, powerSwitch, reportedDateTime, temperatureSetpoint, timerIndicator, type, updatedDateTime
Related Concepts (13*)	relatedAggregator, relatedBoiler, relatedContract*, relatedControlEvent, relatedControlStatus, relatedDemandMeasurement, relatedDREvent*, relatedDRReport*, relatedFlexibility*, relatedFlexibilityOffer*, relatedFlexibilitySettlement*, relatedProsumer, relatedTerm

Concept: BRP

Fields (8)	brandName, departmentName, description, id, legalClassificationCode, legalName, name, type
Related Concepts (10*)	relatedAddress, relatedContactPoint, relatedLocale, relatedFlexibilityOffer*, relatedFlexibilityOption*, relatedFlexibilityOrder*, relatedFlexibilitySettlement*, relatedMarket*, relatedRetailerPortfolio*, Status

Concept: BuildingFloor

Fields (15)	actualGrossArea, actualNetArea, description, documentationFiles, elevation, grossHeight, id, maxOccupants, minOccupants, name, netHeight, plannedGrossArea, plannedNetArea, storeyNumber, zonesCount
Related Concepts (9)	relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedDemandMeasurement, relatedDevice, relatedMeasurement, relatedResidence, relatedResident, relatedProsumer

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Concept: BuildingRegion

Fields (10)	actualGrossArea, actualNetArea, documentation, id, name, plannedGrossArea, plannedNetArea, spacesCount, storeyNumber, type
Related Concepts (22*)	relatedAirCoolingSystem, relatedBoiler, relatedBuildingFloor, relatedBuildingSite, relatedBuildingStructure, relatedDevice, relatedDemandMeasurement, relatedDHWSystem, relatedGateway, relatedHeater, relatedLightingFixture, relatedMeasurement, relatedResidence, relatedResident, relatedPerformanceIndicator*, relatedPremisesAdministrator, relatedProsumer, relatedSensingMeasurement, relatedSensor, relatedSmartAsset, relatedVentilation, relatedWellBeing

Concept: BuildingSite

Fields (16)	description, documentation, documentationFiles, elevation, elevationWithFlooring, energyPerformanceCertificationClass, finishCeilingHeight, finishFloorHeight, grossFloorArea, id, name, netFloorArea, occupancyType, smartReadinessAssessmentClass, spaceHeight, type
Related Concepts (27)	relatedAirCoolingSystem, relatedBatterySystem, relatedBoiler, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingStructure, relatedDemandMeasurement, relatedDevice, relatedDHWSystem, relatedEVChargingUnit, relatedGateway, relatedGenerationMeasurement, relatedHeater, relatedLightingDevice, relatedMeasurement, relatedResidence, relatedResident, relatedPhotovoltaic, relatedPremisesAdministrator, relatedProsumer, relatedRetailer, relatedSensingMeasurement, relatedSensor, relatedSmartAsset, relatedStorageMeasurement, relatedVentilation, relatedWellBeing

Concept: BuildingStructure

Fields (36)	actualGrossArea, actualNetArea, bimFile, constructionEndDate, constructionMethod, constructionStartDate, coolingWetBulb, description, documentation, eavesHeight, elevationOfRefHeight, elevationOfTerrain, energyPerformanceCertificationClass, fireProtectionClass, grossFloorArea, heatingDesignDateTime, heatingDryBulb, heatingWetBulb, id, landmarkIndicator, lastRefurbishmentDate, name, netFloorArea, occupancyType, permanentIndicator, plannedGrossArea, plannedNetArea, planningControlStatus, smartReadinessAssessmentClass, sprinklerProtectionAutomaticIndicator, sprinklerProtectionStatus, storeysCount, subType, totalHeight, type, zonesCount
Related Concepts (22*)	relatedAddress, relatedBatterySystem, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedDemandMeasurement, relatedEVChargingUnit, relatedGenerationMeasurement, relatedLocale, relatedMeasurement, relatedPerformanceIndicator*, relatedPhotovoltaic, relatedPowerGrid, relatedPremisesAdministrator, relatedProsumer, relatedResidence, relatedResident, relatedRetailer, relatedSensingMeasurement, relatedSensor, relatedStorageMeasurement, relatedWeatherMeasurement

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Concept: CityBoard

Fields (7)	departmentName, description, id, legalClassificationCode, legalName, name, type
Related Concepts (5)	relatedAddress, relatedBuildingStructure, relatedContactPoint, relatedLocale, relatedStatus

Concept: ConnectivityJunction

Fields (9)	connectionID, groundID, id, name, nodeType, nominalActivePower, nominalReactivePower, nominalVoltage, phaseType
Related Concepts (8)	relatedACsegment, relatedDistributionSystemOperator, relatedLocale, relatedMeasurement, relatedPowerGrid, relatedPowerSubstation, relatedPowerTransformer, relatedTerm

Concept: ContactPoint

Fields (13)	departmentName, description, eMailAddress, familyName, faxNumber, givenName, jobTitle, landline, mobileNumber, name, role, title, type
Related Concepts (3)	relatedAddress, relatedStatus, relatedTerm

Concept: DemandMeasurement

Fields (31)	airConditioningSystemLoad, baseLoad, batteryLoad, boilerLoad, createdDateTime, dayAheadDemand, demandFactor, description, deviceLoad, diversifiedLoad, diversityFactor, electricVehicleLoad, forecastDateTime, forecastLoad, gridLoad, id, load, lightingDeviceLoad, loadFactor, loadProfileHourly, name, observedDateTime, peakLoad, smartApplianceLoad, spaceHeatingDeviceLoad, totalConsumptionHourly, totalConsumption, updatedDateTime, unmetLoad, utilizationFactor, ventilationSystemLoad
Related Concepts (24*)	relatedACsegment, relatedAggregator, relatedAggregatorPortfolio*, relatedAirCoolingSystem, relatedBatterySystem, relatedBoiler, relatedBuildingStructure, relatedDevice, relatedDistributionSystemOperator, relatedEV, relatedHeater, relatedLightingFixture, relatedLocale, relatedMarket*, relatedMeasurement, relatedPowerGrid, relatedPowerSubstation, relatedProsumer, relatedRetailer, relatedRetailerPortfolio*, relatedSmartAsset, relatedStatus, relatedTerm, relatedVentilation

Concept: Device

Fields (20)	brandName, code, description, deviceName, hardwareRevision, manufacturerLabel, manufacturerName, model, nodeID, nominalPower, powerSkewness, powerSource, powerStandardDeviation, powerMax, powerMin, serialNumber, softwareRevision, type, vendorCode, vendorName

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Related Concepts (14*)	relatedDemandMeasurement, relatedDevice, relatedDeviceControlEvent, relatedFlexibility*, relatedGenerationMeasurement, relatedLocale, relatedMeasurement, relatedOperationProfile, relatedPerformanceIndicator*, relatedPowerSubstation, relatedProsumer, relatedSensingMeasurement, relatedStorageMeasurement, relatedTerm

Concept: DeviceControlAction

Fields (12)	capacityPercent, consumeActionDescription, createdDateTime, description, id, name, operationModeChange, produceActionDescription, reportedDateTime, setpoint, type, updatedDateTime
Related Concepts (3)	relatedDevice, relatedDeviceControlStatus, relatedTerm

Concept: DeviceControlEvent

Fields (7)	createdDateTime, id, occurenceDateTime, occurenceDescription, reportedDateTime, type, updatedDateTime
Related Concepts (20)	relatedAirCoolingSystem, relatedAirCoolingSystemControlAction, relatedBatterySystem, relatedBatterySystemControlAction, relatedBoiler, relatedBoilerControlAction, relatedDevice, relatedDeviceControlAction, relatedDeviceControlStatus, relatedDHWSystem, relatedDHWSystemControlAction, relatedEVChargingUnit, relatedEVChargingUnitControlAction, relatedHeatPump, relatedHeatPumpControlAction, relatedLightingFixture, relatedLightingFixtureControlAction, relatedTerm, relatedVentilation, relatedVentilationControlAction

Concept: DeviceControlStatus

Fields (9)	createdDateTime, consumeLoadControlStatus, description, id, name, produceLoadControlStatus, reportedDateTime, type, updatedDateTime
Related Concepts (21)	relatedAirCoolingSystem, relatedAirCoolingSystemControlAction, relatedBatterySystem, relatedBatterySystemControlAction, relatedBoiler, relatedBoilerControlAction, relatedDevice, relatedDeviceControlAction, relatedDeviceControlStatus, relatedDemandMeasurement, relatedDHWSystem, relatedDHWSystemControlAction, relatedEVChargingUnit, relatedEVChargingUnitControlAction, relatedHeatPump, relatedHeatPumpControlAction, relatedLightingFixture, relatedLightingFixtureControlAction, relatedTerm, relatedVentilation, relatedVentilationControlAction

Concept: DHWSystem

Fields (13)	brandName, code, description, id, manufacturerName, model, name, nominalPerformanceEffciency, nominalPower, serialNumber, title, type, volume

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Related Concepts (16*)	relatedAggregatorPortfolio*, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedDemandMeasurement, relatedDeviceControlEvent, relatedDeviceControlStatus, relatedDREvent*, relatedDHWSystemControlAction, relatedDRReport*, relatedFlexibility*, relatedMeasurement, relatedOperationProfile, relatedPerformanceIndicator*, relatedProsumer

Concept: DomesticHotWaterSystemControlAction

Fields (10)	createdDateTime, description, id, name, powerSwitch, reportedDateTime, temperatureSetpoint, timerIndicator, type, updatedDateTime
Related Concepts (8*)	relatedDREvent*, relatedDRReport*, relatedDeviceControlEvent, relatedDeviceControlStatus, relatedDHWSystem, relatedDemandMeasurement, relatedFlexibility*, relatedMeasurement

Concept: DistributionSystemOperator

Fields (7)	brandName, departmentName, description, id, legalName, name, type
Related Concepts (7*)	relatedAddress, relatedContactPoint, relatedContract*, relatedMarket*, relatedPowerGrid, relatedLocale, relatedFlexibilitySettlement*

Concept: ElectricityMeter

Fields (10)	acquiredDateTime, brandName, code, description, id, manufacturerName, model, name, serialNumber, type
Related Concepts (6)	relatedBuildingStructure, relatedDistributionSystemOperator, relatedDemandMeasurement, relatedGenerationMeasurement, relatedRetailer, relatedPhotovoltaic

Concept: EnergyCooperative

Fields (9)	brandName, description, id, legalClassificationCode, legalName, members, membersCount, name, type
Related Concepts (18*)	Aggregator, BuildingStructure, BatterySystem, DistributionSystemOperator, DemandMeasurement, GenerationMeasurement, StorageMeasurement, EVChargingUnit, Flexibility*, PowerGrid, Locale, Measurement, Photovoltaic, Prosumer, RenewableResources, Retailer, Status, PowerSubstation

Concept: ESCo

Fields (8)	brandName, departmentName, description, id, legalClassificationCode, legalName, name, type

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Related Concepts (4)	relatedAddress, relatedContactPoint, relatedLocale, relatedStatus

Concept: EV

Fields (14)	brandName, code, description, efficiency, id, manufacturerName, name, nominalDrivingRange, nominalVoltage, releaseDateTime, serialNumber, type, typicalRechargeTime, upstreamEmissions
Related Concepts (13*)	relatedAggregatorPortfolio*, relatedBatterySystem, relatedDemandMeasurement, relatedStorageMeasurement, relatedEVChargingUnit, relatedFlexibility*, relatedPerformanceIndicator*, relatedMeasurement, relatedProsumer, relatedSensingMeasurements, relatedSensor, relatedStatus, relatedTerm

Concept: EVChargingUnit

Fields (8)	chargingMode, effectiveChargingPower, effectiveCurrent, id, maxChargingPower, maxCurrent, name, type
Related Concepts (10*)	relatedACsegment, relatedBuildingStructure, relatedContactPoint, relatedEVChargingUnitControlAction, relatedLocale, relatedPerformanceIndicator*, relatedPowerSubstation, relatedProsumer, relatedStatus, relatedTerm

Concept: EVChargingUnitControlAction

Fields (12)	chargingModeSwitch, chargingPowerClass, chargingTime, createdDateTime, description, id, name, powerSwitch, reportedDateTime, timeIndicator, type, updatedDateTime
Related Concepts (7*)	DemandMeasurement, DREvent*, DRReport*, DeviceControlEvent, DeviceControlStatus, EVChargingUnit, Measurement

Concept: Event

Fields (11)	createdDateTIme, description, id, modificationReason, name, occurenceDateTime, priority, remarks, testIndicator, type, updatedDateTime
Related Concepts (3)	relatedLocale, relatedStatus, relatedTerm

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Concept: ExternalNetworkSegment

Fields (19)	activePower¸ id, maximumPower, maximumReactivePower, maxInitialSymmetricalCurrent, maxZeroSequenceResistanceToZeroSequenceReactanceRatio, maxPositiveSequenceResistanceToPositiveSequenceReactanceRatio, maxZeroSequenceImpedanceToPositiveSequenceImpedanceRatio, minimumActivePower, minimumReactivePower, minInitialSymmetricalCurrent, minZeroSequenceResistanceToZeroSequenceReactanceRatio, minPositiveSequenceResistanceToPositiveSequenceReactanceRatio, minZeroSequenceImpedanceToPositiveSequenceImpedanceRatio, name, powerFrequencyBias, reactivePower, referencePriority, voltageFactor
Related Concepts (4)	relatedACsegment, relatedConnectivityJunction, relatedPowerGrid, relatedPowerSubstation

Concept: Gateway

Fields (9)	brandName, code, description, id, manufacturerName, model, name, serialNumber, type
Related Concepts (5)	relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedSensor, relatedSmartAsset

Concept: GenerationMeasurement

Fields (137)	activeEnergyExport. activeEnergyExportBiomass, activeEnergyExportCoal, activeEnergyExportFossilFuel, Actual Energy from Fossil Fuel. activeEnergyExportGeothermal, activeEnergyExportHydroPower, activeEnergyExportNuclear, activeEnergyExportPetroleum, activeEnergyExportPhotovoltaic, activeEnergyExportRenewable, activeEnergyExportSolar, activeEnergyExportSolarThermal, activeEnergyExportWind, activePower, apparentPower, availabilityFactor, availabilityFactorBiomass, availabilityFactorCoal, availabilityFactorFossilFuel, availabilityFactorGas, availabilityFactorGeothermal, availabilityFactorHydroPower, availabilityFactorNuclear, availabilityFactorPetroleum, availabilityFactorPhotovoltaic, availabilityFactorRenewable, availabilityFactorSolar, availabilityFactorSolarThermal, availabilityFactorWind, averageCurrent, averageVoltage, createdDateTime, description, equivalentAvailabilityFactor, forecastDateTime, frequency, grossGeneration, grossGenerationBiomass, grossGenerationCoal, grossGenerationFossilFuel, grossGenerationGas, grossGenerationGeothermal, grossGenerationHydroPower, grossGenerationNuclear, grossGenerationPetroleum, grossGenerationPhotovoltaic, grossGenerationRenewable, grossGenerationSolar, grossGenerationSolarThermal, grossGenerationWind, id, instantaneousCurrent, instantaneousPower, instantaneousVoltage, name, netCapacityFactor, netCapacityFactorBiomass, netCapacityFactorCoal, netCapacityFactorFossilFuel, netCapacityFactorGas, netCapacityFactorGeothermal, netCapacityFactorHydroPower, netCapacityFactorNuclear, netCapacityFactorPetroleum, netCapacityFactorPhotovoltaic, netCapacityFactorRenewable, netCapacityFactorSolar, netCapacityFactorSolarThermal, netCapacityFactorWind, netGeneration, netGenerationBiomass, netGenerationCoal, netGenerationFossilFuel, netGenerationGas, netGenerationGeothermal, netGenerationHydroPower, netGenerationNuclear, netGenerationPetroleum, netGenerationPhotovoltaic, netGenerationRenewable, netGenerationSolar,

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	netGenerationSolarThermal, netGenerationWind, observedDateTime, peakCurrent, peakToPeakCurrent, peakToPeakVoltage, peakVoltage, powerFactor, reactiveEnergyExport, reactiveEnergyExportBiomass, reactiveEnergyExportCoal, reactiveEnergyExportFossilFuel, reactiveEnergyExportGas, reactiveEnergyExportGeothermal, reactiveEnergyExportHydroPower, reactiveEnergyExportNuclear, reactiveEnergyExportPetroleum, reactiveEnergyExportPhotovoltaic, reactiveEnergyExportRenewable, reactiveEnergyExportSolar, reactiveEnergyExportSolarThermal, reactiveEnergyExportWind, reactivePower, rmsCurrent, rmsVoltage, totalEnergyExport, totalEnergyExportBiomass, totalEnergyExportCoal, totalEnergyExportFossilFuel, totalEnergyExportGas, totalEnergyExportGeothermal, totalEnergyExportHydroPower, totalEnergyExportNuclear, totalEnergyExportPetroleum, totalEnergyExportPhotovoltaic, totalEnergyExportRenewable, totalEnergyExportSolar, totalEnergyExportSolarThermal, totalEnergyExportWind, totalEnergyImport, totalPrimaryEnergySupply, totalPrimaryEnergySupplyBiomass, totalPrimaryEnergySupplyCoal, totalPrimaryEnergySupplyFossilFuel, totalPrimaryEnergySupplyGas, totalPrimaryEnergySupplyGeothermal, totalPrimaryEnergySupplyHydroPower, totalPrimaryEnergySupplyNuclear, totalPrimaryEnergySupplyPetroleum, totalPrimaryEnergySupplyPhotovoltaic, totalPrimaryEnergySupplyRenewable, totalPrimaryEnergySupplySolar, totalPrimaryEnergySupplySolarThermal, totalPrimaryEnergySupplyWind, totalUptimePercentage, updatedDateTime
Related Concepts (17*)	relatedACsegment, relatedAggregator, relatedAggregatorPortfolio*, relatedBuildingStructure, relatedDistributionSystemOperator, relatedLocale, relatedMarket*, relatedPhotovoltaic, relatedPowerGrid, relatedPowerSubstation, relatedProsumer, relatedRenewableResources, relatedRenewableEnergySourceAdministrator, relatedRetailer, relatedRetailerPortfolio*, relatedStatus, relatedTerm

Concept: Heater

Fields (23)	bodyMass, brandName, code, description, energySource, heatTransferDimension, heatTransferMedium, id, manufacturerName, model, name, nominalPower, nominalVoltage, outputCapacity, panelsCount, placementType, sectionsCount, serialNumber, temperatureClassification, thermalEfficiency, thermalMass, type, typicalEnergyConsumption
Related Concepts (13*)	relatedAggregatorPortfolio*, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedDemandMeasurement, relatedFlexibility*, relatedPerformanceIndicator*, relatedMeasurement, relatedOperationProfile, relatedProsumer, relatedHeaterControlAction, relatedStatus

Concept: HeaterControlAction

Fields (11)	createdDateTime, description, heatingSetpoint, id, name, powerSwitch, reportedDateTime, temperatureSetpoint, timerIndicator, type, updatedDateTime
Related Concepts (13*)	AggregatorPortfolio*, OperationProfile, BuildingFloor, BuildingRegion, BuildingSite, BuildingStructure, DemandMeasurement, Flexibility*, PerformanceIndicator*, Measurement, Prosumer, HeaterControlAction, Status

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Concept: HeatPump

Fields (19)	airflowRate, brandName, code, description, energyEfficiencyRatio, heatingCapacity, id, manufacturerName, maximumCapacity, minimumCapacity, model, name, nominalCapacity, nominalHeatingLoad, nominalHeatTransferCoefficient, nominalVoltage, performanceCoefficient, serialNumber, type
Related Concepts (16*)	relatedAggregatorPortfolio*, relatedOperationProfile, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedDemandMeasurement, relatedDeviceControlEvent, relatedDeviceControlStatus, relatedDREvent*, relatedDRReport*, relatedFlexibility*, relatedHeatPumpControlAction, relatedMeasurement, relatedPerformanceIndicator*, relatedProsumer

Concept: HeatPumpControlAction

Fields (11)	createdDateTime, description, heatingSetpoint, id, name, powerSwitch, reportedDateTime, temperatureSetpoint, timerIndicator, type, updatedDateTime
Related Concepts (8*)	relatedDemandMeasurement, relatedDeviceControlEvent, relatedDeviceControlStatus, relatedDREvent*, relatedDRReport*, relatedFlexibility*, relatedHeatPump, relatedMeasurement

Concept: LightingFixture

Fields (21)	brandName, code, colorAppearance, colorRenderingIndex, colorTemperature, contributedLuminousFlux, description, id, lampBallastType, lampCompensationType, lampMaintenanceFactor, manufacturerName, model, name, nominalPower, numberOfDimmingScales, serialNumber, spectrumMax, spectrumMin, spectrumRange, type
Related Concepts (13*)	relatedAggregatorPortfolio*, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedDemandMeasurement, relatedFlexibility*, relatedLightingFixtureControlAction, relatedMeasurement, relatedOperationProfile, relatedPerformanceIndicator*, relatedPremisesAdministrator, relatedProsumer

Concept: LightingFixtureControlAction

Fields (13)	colorSetting, colorTemperatureSetting, createdDateTime, description, dimmingLevel, id, modeSetting, name, powerSwitch, reportedDateTime, timerIndicator, type, updatedDateTime
Related Concepts (9*)	relatedDemandMeasurement, relatedDeviceControlEvent, relatedDeviceControlStatus, relatedDREvent*, relatedDRReport*, relatedFlexibility*, relatedLightingFixture, relatedMeasurement, relatedTerm

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Concept: Locale

Fields (33)	addressLine, altitude, apartmentNumber, areaSize, buildingName, buildingNumber, buildingType, cityCode, cityName, citySubDivisionName, continentName, countryCode, countryName, departmentName, description, directions, districtName, floorNumber, id, latitude, latitudeDirectionIndicator, longitude, longitudeDirectionIndicator, municipalityName, name, polygonPoint, postalCode, radius, roomNumber, streetName, systemID, type, villageName
Related Concepts (3)	relatedAddress, relatedTerm, relatedWeatherStation

Concept: Measurement

Fields (9)	createdDateTime, description, id, measuredDateTime, measurementUnit, name, reportedDateTime, scale, value
Related Concepts (16)	relatedAirCoolingSystem, relatedBatterySystem, relatedBoiler, relatedDevice, relatedDHWSystem, relatedEV, relatedHeatPump, relatedHeater, relatedLightingFixture, relatedPowerTransformer, relatedPhotovoltaic, relatedSensor, relatedSmartAsset, relatedTerm, relatedVentilation, relatedVPP

Concept: NetworkIncident

Fields (15)	actualRestorationTime, cause, description, effect, estimatedRestorationTime, forecastDateTime, id, name, workNotes, occurenceDateTime, priority, status, subType, totalFailureCount, type
Related Concepts (7)	relatedContactPoint, relatedLocale, relatedOutage, relatedPhotovoltaic, relatedRenewableResources, relatedStatus, relatedTerm

Concept: NetworkIncidentLog

Fields (6)	createdDateTime, id, name, totalFailureCount, type, updatedDateTime
Related Concepts (7*)	relatedLocale, relatedNetworkIncident, relatedOutageLog, relatedPerformanceIndicator*, relatedPhotovoltaic, relatedRenewableResources, relatedStatus

Concept: OperationProfile

Fields (12)	activatedDateTime, configuration, createdDateTime, description, id, name, remoteControlIndicator, reselectionSupportIndicator, singleSlotSchedulingIndicator, status, totalSequencesCount, updatedDateTime

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Related Concepts (11)	relatedAirCoolingSystem, relatedBoiler, relatedDemandMeasurement, relatedDevice, relatedDHWSystem, relatedHeater, relatedLightingFixture, relatedSmartAsset, relatedTerm, relatedVentilation, relatedWellBeing

Concept: Outage

Fields (25)	actualDowntime, actualMaintenanceTime, actualRestorationDateTime, actualRestorationTime, cause, comments, description, downtimeRange, duration, effect, estimatedRestorationDateTime, estimatedRestorationTime, extensiveDamageIndicator, id, name, workNotes, occurenceDateTime, peopleAffectedCount, plannedDowntime, plannedMaintenanceTime, plannedIndicator, priority, status, subType, type
Related Concepts (10)	relatedACsegment, relatedContactPoint, relatedLocale, relatedNetworkIncident, relatedOutageLog, relatedPhotovoltaic, relatedPowerSubstation, relatedRenewableResources, relatedStatus, relatedTerm

Concept: OutageLog

Fields (7)	createdDateTime, customerAverageInterruptionDuration, customerAverageInterruptionFrequency, systemAverageInterruptionDuration, totalDowntime, totalOutagesCount, updatedDateTime
Related Concepts (12*)	relatedContactPoint, relatedDistributionSystemOperator, relatedLocale, relatedNetworkIncidentLog, relatedOutage, relatedPerformanceIndicator*, relatedPhotovoltaic, relatedPowerSubstation, relatedProsumer, relatedRenewableResources, relatedStatus, relatedTerm

Concept: Photovoltaic

Fields (28)	brandName, capitalCost, code, deratingFactor, description, efficiency, id, levelisedCostOfElectricity, lifetime, manufacturerName, manufacturerName, maxPowerPoint, maxPowerPointCurrent, maxPowerPointVoltage, model, name, nominalCapacity, nominalVoltage, openCircuitVoltage, operatingCost, panelsCount, powerTolerance, replacementCost, serialNumber, shortCircuitCurrent, temperatureCoefficient, temperatureCoefficientPercent, type
Related Concepts (14*)	relatedACsegment, relatedFlexibility*, relatedGenerationMeasurement, relatedLocale, relatedMeasurement, relatedPerformanceIndicator*, relatedPowerGrid, relatedPowerSubstation, relatedProsumer, relatedRenewableResources, relatedRenewableResourcesAdministrator, relatedSensor, relatedStatus, relatedTerm

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Concept: PowerGrid

Fields (11)	description, firmCapacity, id, name, nominalCapacity, nominalFrequency, operatingReserve, operatingReservePercent, spinningReserve, spinningReservePercent, type
Related Concepts (12*)	relatedACsegment, relatedDistributionSystemOperator, relatedDemandMeasurement, relatedFlexibility*, relatedGenerationMeasurement, relatedLocale, relatedNetworkIncidentLog, relatedOutageLog, relatedPerformanceIndicator*, relatedPowerSubstation, relatedRenewableResources, relatedTerm

Concept: PowerSubstation

Fields (9)	code, description, id, name, networkTopology, scadaDiagram, type, voltageLevel, visualImages
Related Concepts (9*)	relatedACsegment, relatedGenerationMeasurement, relatedLocale, relatedMeasurement, relatedPerformanceIndicator*, relatedPowerTransformer, relatedSensor, relatedStatus, relatedTerm

Concept: PowerTransformer

Fields (34)	code, conductance, conductorSize, conductorType, connectionType, copperLoss, description, duty, allDayEfficiency, id, ironLoss, fullLoadEfficiency, fullLoadLoss, impedance, impedancePercent, maximumEfficiency, nominalApparentPower, name, nominalFrequency, reactance, reactancePercent, resistance, resistancePercent, susceptance, type, windingPrimary, windingReactancePrimary, windingResistancePrimary, windingVoltagePrimary, windingSecondary, windingReactanceSecondary, windingResistanceSecondary, windingVoltageSecondary, averageWindingTemperatureRise
Related Concepts (6)	relatedConnectivityJunction, relatedMeasurement, relatedPowerSubstation, relatedSensor, relatedStatus, relatedTerm

Concept: PremisesAdministrator

Fields (8)	brandName, departmentName, description, id, legalClassificationCode, legalName, name, type
Related Concepts (5)	relatedAddress, relatedBuildingStructure, relatedContactPoint, relatedLocale, relatedStatus

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Concept: Prosumer

Fields (15)	age, birthDateTime, category, description, familyName, gender, givenName, id, lifestyle, maidenName, middleName, name, nationality, profession, title
Related Concepts (21*)	relatedAddress, relatedAirCoolingSystem, relatedBatterySystem, relatedBoiler, relatedContactPoint, relatedContract*, relatedDemandMeasurement, relatedDevice, relatedDHWSystem, relatedEV, relatedGenerationMeasurement, relatedHeater, relatedHeatPump, relatedMarket*, relatedLightingFixture, relatedPhotovoltaic, relatedRenewableResources, relatedSmartAsset, relatedStorageMeasurement, relatedTerm, relatedVentilation

Concept: RenewableResources

Fields (7)	code, id, name, additionalCapacity, existingCapacity, levelizedCostOfEnergy, type
Related Concepts (15*)	relatedACsegment, relatedFlexibility*, relatedGenerationMeasurement, relatedLocale, relatedMeasurement, relatedPerformanceIndicator*, relatedPhotovoltaic, relatedPowerGrid, relatedPowerSubstation, relatedProsumer, relatedRenewableResourcesAdministrator, relatedSensor, relatedStatus, relatedStorageMeasurement, relatedTerm

Concept: RenewableResourcesAdministrator

Fields (8)	brandName, departmentName, description, id, legalClassificationCode, legalName, name, type
Related Concepts (11*)	relatedAddress, relatedContactPoint, relatedFlexibilityOffer*, relatedFlexibilityOption*, relatedFlexibityOrder*, relatedFlexibilitySettlement*, relatedLocale, relatedMarket*, relatedPhotovoltaic, relatedRenewableResources, relatedStatus

Concept: Residence

Fields (13)	areaPerOccupant, code, description, id, maxOccupantsCount, minOccupantsCount, name, occupancyTimePerDay, occupancyTimePerWeekDay, occupancyTimePerWeekendDay, occupantsCount, occupantsPeakCount, type
Related Concepts (4)	relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure

Concept: Resident

Fields (14)	age, birthDateTime, category, description, familyName, gender, givenName, id, lifestyle, maidenName, middleName, name, nationality, profession, title
Related Concepts (2)	relatedBuildingStructure, relatedWellBeing

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Concept: Retailer

Fields (8)	brandName, departmentName, description, id, legalClassificationCode, legalName, name, type
Related Concepts (12*)	relatedAddress, relatedBRP, relatedContactPoint, relatedFlexibilityOffer*, relatedFlexibilityOption*, relatedFlexibilityOrder*, relatedFlexibilitySettlement*, relatedLocale, relatedMarket*, relatedRenewableResourcesAdministrator, relatedRetailerPortfolio*, relatedStatus

Concept: SensingMeasurement

Fields (22)	acousticPressure, airQualityIndex, batteryCoolantIntakeTemperature, batteryCoolantOutputTemperature, createdDateTime, forecastMaxTemperature, forecastMinTemperature, forecastTemperature, forecastTemperatureRange, maxTemperature, meanTemperature, minTemperature, noiseLevel, occurenceDateTime, observedDateTime, observedLuminance, observedSoundPower, observedSoundPowerLevel, observedTemperature, temperatureAlarm, temperatureChangeRate, vocConcentration
Related Concepts (12)	relatedAirCoolingSystem, relatedBatterySystem, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedGateway, relatedLightingFixture, relatedMeasurement, relatedSensor, relatedStatus, relatedTerm

Concept: Sensor

Fields (10)	accuracy, brandName, code, description, id, manufacturerName, model, name, serialNumber, type
Related Concepts (14)	relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedGateway, relatedMeasurement, relatedPhotovoltaic, relatedPowerSubstation, relatedPowerTransformer, relatedRenewableResources, relatedSensingMeasurement, relatedWeatherStation

Concept: SmartAsset

Fields (12)	brandName, code, description, id, manufacturerName, model, name, nominalVoltage, serialNumber, stateOfCharge, type, typicalEnergyConsumption
Related Concepts (11*)	relatedAggregatorPortfolio*, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedDemandMeasurement, relatedGateway, relatedPerformanceIndicator*, relatedProsumer, relatedStatus, relatedSmartAssetControlAction

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Concept: SmartAssetControlAction

Fields (9)	createdDateTime, description, id, name, powerSwitch, reportedDateTime, timerIndicator, type, updatedDateTime
Related Concepts (8*)	relatedDemandMeasurement, relatedDeviceControlEvent, relatedDeviceControlStatus, relatedDREvent*, relatedDRReport*, relatedFlexibility*, relatedSmartAsset, relatedTerm

Concept: Status

Fields (17)	conditionCode, conditionIndicator, currentStatus, description, id, manualOverride, name, overchargedStatusIndicator, referenceDateTime reason, reasonCode, remarks, statusCount, statusDateTime, testResult, type, underchargedStatusIndicator
Related Concepts (2)	relatedDevice, relatedTerm

Concept: StorageMeasurement

Fields (24)	actualEnergyStored, batteryLoad, chargeSetpoint, chargeStatus, createdDateTime, description, electricVehicleLoad, energyDeliveredSinceLastCharge, energyObtainedFromStorage, forecastDateTime, id, name, numberofCycles, observedDateTime, operationTimeSinceLastCharge, remainingUsefulLife, stateOfCharge, stateOfHealth, stateOfSafety, targetEnergyStored, throughput, totalEnergyDelivered, totalOperationTime, updatedDateTime
Related Concepts (5)	relatedBatterySystem, relatedEV, relatedLocaLe, relatedStatus, relatedTerm

Concept: Term

Fields (27)	defaultDuration, description, durationAbsoluteUncertainty, durationPercentUncertainty, earliestStartDateTime, elapsedDuration, endDateTime, id, latestEndDateTime, maxDuration, minDuration, name, optionalIndicator, pauseTime, referenceDateTime, referenceDay, referenceDayNumber, referenceMonth referenceMonthNumber, referenceYear, referenceWeekNumber, seasonCode, sequenceNumeric, startDateTime, type, weekdayIndicator, weekendIndicator
Related Concepts (5*)	relatedDemandMeasurement, relatedGenerationMeasurement, relatedPerformanceIndicator*, relatedStatus, relatedStorageMeasurement

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Concept: Ventilation

Fields (17)	brandName, code, defrostIndicator, description, heatTransferType, id, manufacturerName, model, name, operationTemperatureMax, operationTemperatureMin, primaryAirFlowRateMax, primaryAirFlowRateMin, secondaryAirFlowRateMax, secondaryAirFlowRateMin, serialNumber, type
Related Concepts (13*)	relatedAggregatorPortfolio*, relatedBuildingFloor, relatedBuildingRegion, relatedBuildingSite, relatedBuildingStructure, relatedDemandMeasurement, relatedFlexibility*, relatedMeasurement, relatedOperationProfile, relatedPerformanceIndicator*, relatedProsumer, relatedVentilationControlAction, relatedStatus

Concept: VentilationControlAction

Fields (10)	createdDateTime, description, fanSpeed, id, name, powerSwitch, reportedDateTime, timerIndicator, type, updatedDateTime
Related Concepts (8*)	relatedDemandMeasurement, relatedDeviceControlEvent, relatedDeviceControlStatus, relatedDREvent*, relatedDRReport*, relatedFlexibility*, relatedMeasurement, relatedVentilation

Concept: VPP

Fields (8)	capacity, description, energySource, id, name, powerSourcesCount, scalability, type
Related Concepts (7*)	relatedAggregator, relatedDistributionSystemOperator, relatedLocale, relatedMarket*, relatedPerformanceIndicator*, relatedProsumer, relatedTerm

Concept: WeatherMeasurement

Fields (28)	absoluteHumidity, atmosphericPressure, cloudiness, conditionDetails, conditionIntensity, conditionStatus, description, id, measuredDateTime, precipitationProbability, precipitationRate, proximity, realFeelTemperature, relativeHumidity, reportedDateTime, seaLevelPressureMax, seaLevelPressureMean, seaLevelPressureMin, temperature, temperatureMax, temperatureMin, turbulenceIntensity, uvIndex, visibilityMax, visibilityMean, visibilityMin, windDirection, windspeed
Related Concepts (3)	relatedLocale, relevantTerm, relatedWeatherStation

Concept: WeatherStation

Fields (7)	accuracy, id, description, manufacturerName, model, name, type
Related Concepts (6)	relatedLocale, relatedPhotovoltaic, relatedRenewableResources, relatedSensor, relatedTerm, relatedWeatherMeasurement,

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Concept: WellBeirng

Fields (25)	description, id, acousticValueMax, acousticValueMin, createdDateTime, feedback, IAQValueMax, IAQValueMin, name, occurenceDateTime, optimalAcousticValue, optimalIAQValue, optimalThermalValue, optimalVisualValue, optimalAcousticRange, optimalIAQRange, optimalThermalRange, optimalVisualRange, preference, satisfactionIndicator, thermalValueMax, thermalValueMin, visualValueMax, visualValueMin, type
Related Concepts (8)	relatedBuildingRegion, relatedBuildingSite, relatedResidence, relatedResident, relatedSensingMeasurement, relatedSensor, relatedStatus, relatedTerm

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