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Deliverable D4.1
frESCO Common Information Model

Deliverable number	D4.1
Deliverable name	frESCO Common Information Model
Lead beneficiary	Suite5
Description	The deliverable consists in the high-level domain model comprising the basic elements (semantic concepts, events, relations and respective data models etc.) underlying the frESCO Project.
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Related task(s)	Task 4.1
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ABBREVIATIONS

Abbreviation	Name
API	Application Programming Interface(s)
CA	Consortium Agreement
CIM	Common Information Model
D	Deliverable
DB	Database
DER	Distributed Energy Source(s)
DoA	Description of Action
Dx.y	Deliverable x.y
EC	European Commission
ENTSO-E	European Network of Transmission System Operators for Electricity
EPRI	Electric Power Research Institute
EU	European Union
EV	Electric Vehicle(s)
GA	Grant Agreement
GDPR	General Data Protection Regulation
H2020	Horizon 2020
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IFC	Industry Foundation Classes
IoT	Internet of things
IPR	Intellectual property Rights
JSON	JavaScript Object Notation

OCPP	Open Charging Point Protocol
OpenADR	Open Automated Demand Response
PDF	Portable Document Format
PV	Photovoltaics
RES	Renewable Energy Sources
SAREF	Smart Applications REFerence Ontology
SAREF4BLDG	SAREF for Buildings
SAREF4ENER	SAREF for Energy
T	Task
Tx.y	Task x.y
USEF	Universal Smart Energy Framework
WP	Work Package
XML	Extensible Markup Language

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EXECUTIVE SUMMARY

The current deliverable D4.1 depicts the frESCO Common Information Model (CIM), which defines the structure and semantics of the data that will be stored and shared for the project's needs. The fundamental entities that the frESCO Common Information Model must enable are defined by an initial identification and extraction of the structure and semantics of the data assets accessible from the frESCO demonstrators, together with the anticipated data requirements of the modules to be implemented.

An in-depth examination of the smart grid data modelling landscape, as well as the selection of specific open standards, semantic models, and ontologies for their elaboration based on their relationship to the available data assets, enables a comprehensive understanding of the relevant data modelling activities. This deliverable provides a high-level view of the actual data model, which currently comprises multiple entities and attributes, after providing particular instructions towards the definition of the frESCO CIM. Each entity's semantics and structure, as well as its attributes, are effectively captured by the Common Information Model. The frESCO CIM entities and attributes were also harmonized to several standards to guarantee that the relevant domain knowledge was correctly evaluated and directly reflected in the model.

1 INTRODUCTION

1.1 Purpose and target group

This deliverable contains the outcomes of frESCO Task T4.1 "Open Standards, Interoperability and Common Information Model Adaptation" activities. The major goal of D4.1 "frESCO Common Information Model" is to document the systematic effort that has been made towards the first release of the frESCO Common Information Model (CIM), which captures the fundamental data aspects of the frESCO Project. D4.1's primary preparatory activities focused on the appropriate data landscaping of both the demonstrators' available data and the modules' data requirements, in order to ensure that they are properly handled from the modelling activities.

Furthermore, a standards landscaping activity has been performed, with the aim of evaluating the importance of open standards, semantic models, and ontologies in the Building Data Management and Demand Response sectors, to extract and target the essential entities that the frESCO CIM must support. This deliverable provides a high-level view of the CIM contents in terms of entities and attributes.

1.2 Scope of the deliverable

The frESCO deliverable D4.1, titled " frESCO Common Information Model," aspires to deliver the preliminary work carried out for the definition of the core aspects of the CIM, with the objective of efficient modelling of the various semantic entities, attributes and relations. Special attention was given on harmonizing the data with Demand Response, Building Data Management and DER models and standards.

To that purpose, the following deliverable is:

- providing data requirements that emerge from the frESCO Use Cases related analysis and the data landscaping efforts to capture the available data in the demonstrators, as well as the data requirements of the modules to be implemented in the context of the frESCO project.
- offering a landscape analysis of different important, established semantic standards that have been chosen based on their relevance and maturity to the project aims. Short

summaries of the shortlisted semantic standards and their primary capabilities are presented.

- establishing a consistent and mutual knowledge of the CIM entities and attributes and foundations, defined as a set of basic points and principles of design.
- describing the initial CIM content for the frESCO Big Data Management Platform.

1.3 Structure of the deliverable

The following is the structure of this document:

Section 2 describes the procedure that was followed for the creation of the Common Information Model.

Section 3 describes the landscape analysis carried out in preparation of the frESCO CIM, which includes a description of relevant semantic standards that were deemed to be most related and appropriate to the frESCO planned activities.

Section 4 describes the identified data available (or to be available) in the demonstrators, as well as the data requirements of the frESCO modules, evaluates the standards examined and proposes a shortlist of standards to be used in the frESCO CIM creation phases. Also, in section 4, the definition and vocabulary of the frESCO CIM entities, attributes, and their relationships are also provided.

Section 5 summarizes the most important parts of the efforts carried out towards the frESCO CIM implementation and provides an outlook on the next steps.

Section 6 provides the literature references.

The CIM entities and attributes are depicted in full detail in the Annexes, in section 7.

2 FRESCO COMMON INFORMATION MODEL DESIGN PROCEDURE

The process used to build and ensure the implementation of a data model that covers the needs inside the frESCO project is shown in Figure 1.

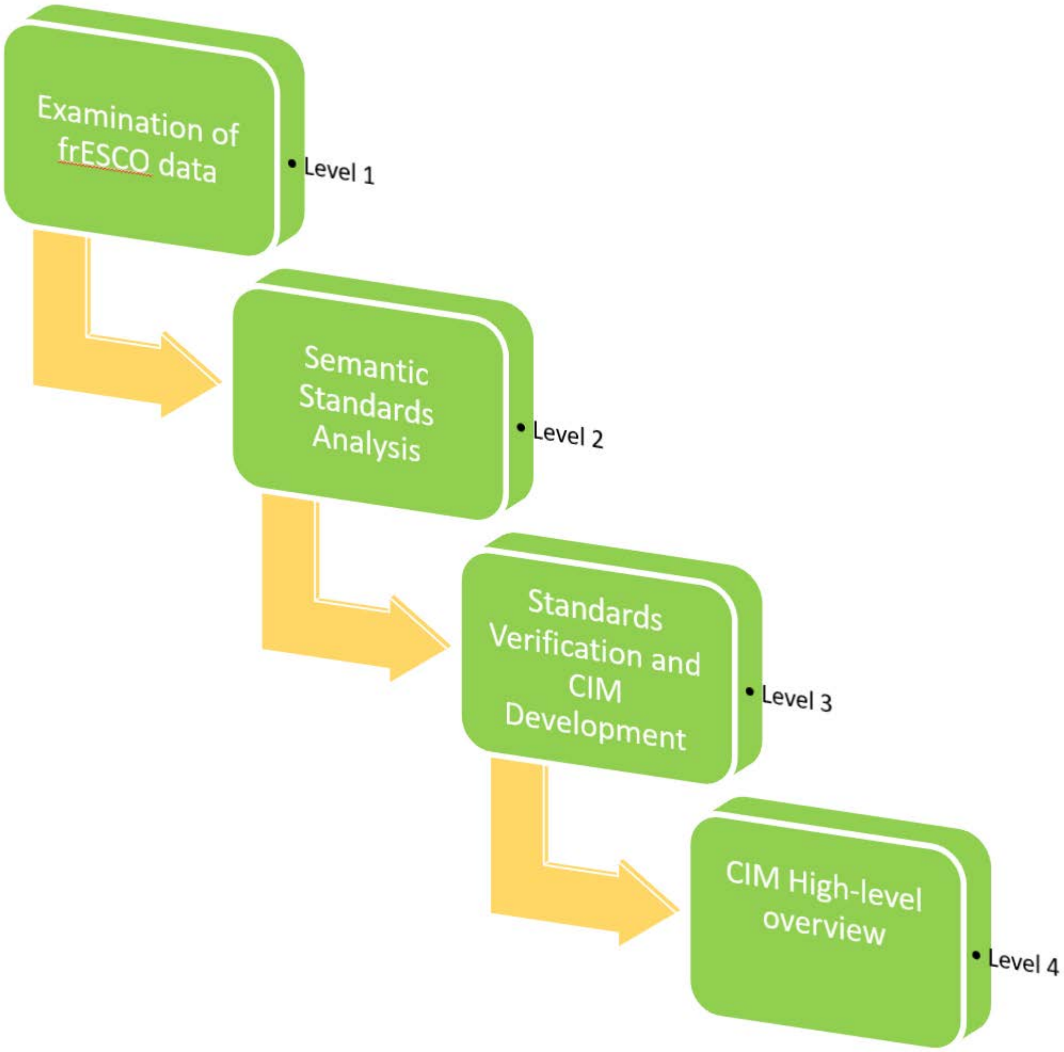

Figure 1 The procedure towards the creation of the frESCO CIM

As illustrated in the figure above, the procedure towards the creation of the frESCO CIM consists of four (4) levels which are described in the next sections.

Examination of frESCO data - Level 1, during which:

- The nine frESCO use cases are being analysed extensively, to determine the scope of each use case, the potential actors involved, and the data requirements for implementation.
- Demonstrators' data analysis, in order to identify the current and future availability of data assets in the frESCO project demo sites

- frESCO modules data analysis, in order to identify the needs, in terms of data, towards the frESCO modules implementation.

Semantic Standards Analysis - Level 2, which comprises an examination of prevalent data standards, ontologies, and semantic models to the frESCO scope. The most relevant standards were chosen after a thorough review of a wide range of standards, taking into account their market/ industry acceptance, maturity, and applicability to frESCO. In section 3.2, the designated standards, ontologies, and semantic models are thoroughly discussed.

Standards Verification and CIM Development - Level 3, which intends to connect the available datasets in the demo sites, that were discovered during the previously described data collection efforts, with the standards described in Level 2 and identify those that will be integrated in the frESCO CIM.

CIM High-level overview - Level 4, which delineates the objective to identify the high-level entities that are related to the frESCO criteria, as well as their relations. The CIM will be created by harmonizing the entities and all necessary aspects (attributes and relations) to explicit standards (where possible).

3 DATA STANDARDS EXAMINATION

3.1 frESCO Available Data Analysis

Level 1 is the first of four levels of the frESCO CIM design procedure, as detailed in the frESCO Common Information Model Design Procedure. This section outlines the steps performed to capture data availability and data requirements within the frESCO project. The paragraphs below, provide a summary of the aforementioned actions.

Top-down examination of the nine frESCO project use cases with the intention of determining their goal(s), data requirements for execution, and actors/stakeholders who will help with their implementation. The list illustrating the goal(s) of each use case, as well as the prospective data needs and actors engaged in each use case, is presented in Table 1.

Use Cases	Goal	Data	Actors
UC.01: Secure data asset ingestion, handling, and storage	To enable the collection and ingestion of different modalities of data while leveraging trusted and secure data containers for data storage to ensure a high degree of trust and security on the building stakeholders' side.	Building assets energy data (real-time or data in rest/ batch data)	Residents, facility managers and owners acting as data owners and producers
UC.02: Smart equipment and building smart readiness assessment	Offer smart equipment utilization and an assessment of the readiness of a building in terms of smartness, so that service providers have a better understanding of the potential of the building to get involved in different types of services (for energy efficiency and/or flexibility provision).	Building Data Data from sensors, smart devices, clamps, smart meters	ESCOs, retailers, installers, aggregators, residents, facility managers and owners, energy communities
UC.03: Personalized informative billing	Provision of applications and interfaces made available to consumers, they will be allowed to better understand their consumption patterns, their energy wastes, and their flexibility to shift their consumption towards avoiding increased energy charges.	Data from sensors, smart devices, clamps, smart meters	Aggregators, residents, facility managers and owners
UC.04: Personalised energy analytics and recommendations for energy behaviour optimization	Provision of personalized analytics and therefore to smart recommendations for energy management in terms of efficiency based on users' energy behaviour optimization	User comfort preferences/boundaries Data from sensors, smart devices, clamps, smart meters	Residents, facility managers and owners
UC.05: Holistic self-consumption optimisation	Designing efficient energy management strategies to increase self-consumption and energy savings.	PV generation, Storage	ESCOs, facility managers and owners, prosumers, energy communities

Use Cases	Goal	Data	Actors
UC.06: Automated device control for energy efficiency optimization	Reduce energy charges and optimize the energy consumption by monitoring the comfort parameters in real-time, along with information related to the energy consumption behaviour, and acting occasionally in an automatic way on the controllable DERs	User comfort preferences/boundaries Data from sensors, smart devices, clamps, smart meters PV generation, Storage	ESCOs, facility managers and owners, residents, energy communities
UC.07: Explicit and tradable demand-side flexibility	Understand the flexibility and the potential benefits gained by offering it to balancing or ancillary services markets.	Context-aware flexibility profiles Flexibility availability, activation, remuneration Contract details	Aggregators, facility managers and owners, residents, energy communities
UC.08: Dynamic VPP formulation and on-the-fly re-configuration	Ability to configure clusters of consumers as effective and cost-efficient Virtual Power Plants and schedule their flexibility.	VPP characteristics Flexibility availability, activation, remuneration	Aggregators, DSOs, TSOs and BRPs
UC.09: Smart contract monitoring, handling and remuneration	Build for aggregators and consumers a clear understanding of the settlement and remuneration processes in relation to flexibility events (activation) or flexibility availability, based on contractual terms.	Contract details Flexibility availability, activation, remuneration	Aggregators, facility managers and owners, residents, energy communities

Table 1 The frESCO project use cases

<u>Data collection activities at the frESCO demonstrators</u>, carried out using a tailor-made template, as shown in Table 2. The partners related to the frESCO demonstrator activities were asked to fill out a template with information about the data assets that are already or will be available in each of the demonstrators, as well as their corresponding characteristics.

Basic Information	**Data asset ID (incl. number of the data asset, the demonstrator and the responsible partner)**	XX_XXX_1
	Data Asset Title (The title of the data asset)	Energy imported from the Grid (kWh)
	Description (An overview of the data asset)	smart metering on residential prosumers' installations
Data Asset Features	Volume (e.g., GBs/ records)	1 record per hour
	Type (e.g., text/ image)	text
	Format (e.g., csv, json)	csv
	Velocity (real-time, near real-time or other)	Near Real-time
	Historical Data Availability (When the data of each data asset became available)	N
	Temporal Coverage (the time that the data asset covers)	[1-1-2020 - today]
	Spatial Coverage	XXX

	(the area that the data asset covers)	
	Language (the language of the data asset contents)	English
	Relevant Standards (The semantic standards that the data asset complies with)	n/a

Table 2 The data collection template communicated to the demonstrator partners

In addition, after the completion of the data collection template by the partners involved in the frESCO demonstrator activities, a thorough analysis of the data provided has been conducted. An initial list of all available (and prospective) data assets in the demonstrators was compiled, including details such as the data asset's name, the demonstrator associated with the respective data asset, and a brief interpretation of the data asset, as shown in Table 3 .

Data	Domain, entities	Demonstrator	Description
Battery power (W) - Bungalow inverter	energy, battery, measurements	Greece	Asset applies only for battery and asset on the demonstrator site (if any). Other sites may have different setups and energy profiles, that render Battery power from the particular site irrelevant. Furthermore, the Greek pilot case is expected to simulate a diverse energy use (depending on customer number etc)
Battery charging state (enum) - Bungalow inverter	energy, battery, status	Greece	Asset applies only for battery and asset on the demonstrator site (if any). This data asset comes hand in hand with GR_VERD_1 data asset (battery power). The latter corresponds to an unsigned register, so another register (providing GR_VERD_2) is necessary to determine the status of the battery (OFF, EMPTY, DISCHAGING, CHARGING, FULL, HOLDING, TESTING)
Battery SoC (%) - Bungalow inverter	energy, battery, measurements	Greece	Asset applies only for battery and asset on the demonstrator site (if any). Other sites may have different setups and energy profiles, that render Battery power from the particular site irrelevant. Furthermore, the Greek pilot case is expected to simulate a diverse energy use (depending on customer number etc)
PV power (W) - Bungalow inverter	energy, generation, measurements	Greece	Data asset to be combined with similar installations to other sites. Asset also has a role in potential flexibility services that add to the total benefit. Applies also to Demo partners with rooftop PV production
Energy imported from the Grid (Wh) -	energy, grid, measurements	Greece	Data asset is the basis on which actual benefit from frESCO is to be measured. Asset also has a role in potential flexibility

Data	Domain, entities	Demonstrator	Description
Bungalow smart meter			services that add to the total benefit. Actual savings can be thus measured.
Energy exported to the Grid (Wh) - Bungalow smart meter	energy, grid, measurements	Greece	Data asset is the basis on which actual benefit from frESCO is to be measured. Asset also has a role in potential flexibility services that add to the total benefit. Applies also to Demo partners with rooftop PV production.
Illuminance, occupancy, relative humidity, temperature	Sensing data, measurements	Greece	Data asset is the basis for acquiring explicit information for each apartment concerning conditions and occupancy
Active and reactive power production at Treskavac 1 Power plant (PV)	energy, generation, measurements	Croatia	This data asset is important in the framework of VPP configuration for the Croatian demo in order to increase self-consumption on the island of KRK and reaching carbon neutrality.
Active and reactive power production at Treskavac 2 Power plant (PV)	energy, generation, measurements	Croatia	This data asset is important in the framework of VPP configuration for the Croatian demo in order to increase self-consumption on the island of KRK and reaching carbon neutrality.

Table 3 Data assets availability in the demonstrators

It is worth mentioning that for the moment, only the Greek and the Croatian demonstrators provided the necessary feedback on their data assets availability. The feedback that is expected from the Spanish and French demonstrators, which is currently delayed due to buildings being changed, will be evaluated and incorporated accordingly when available, in the updated versions of the frESCO CIM, which will be made available in D4.6 (M20) and in D4.7 (M32) respectively. In those deliverables, updates for the Greek and the Croatian demonstrators will also be considered.

Analysis of the data requirements for the frESCO modules, using a customized version of the previously presented template, in order to capture the data requirements for the implementation of the frESCO modules from the consortium's technical partners responsible for technological advancements over the timespan of the frESCO project. The results of this exercise are presented in Table 4.

Module	Data	Domain, entities	Description
Advanced Performance Monitoring/ Forecasting Module for Generation/ Storage/ Demand Assets	Building Energy generation (kWh)	Building, generation, measurements,	Energy generation (preferably hourly) at dwelling level. This will include PV (If other sources were considered, include different variables related to PV, wind, fuel…etc).
	Building Energy consumption (kWh)	Building, consumption, measurements	Energy consumption (preferably hourly) at dwelling level (mainly metering data). This will include all loads (manageable and not manageable; lighting, EV, HVAC, DHW…etc.,)
	External Ambient Temperature (ºC)	Sensing data, measurements	Ambient temperature. This will affect curve demands of users.
	Irradiation (W/m2)	Sensing data, measurements	Irradiation Measurement. Preferably these measurements will be related to direct irradiation on panels. If not…use horizontal irradiation. If there are not real measurements, this information should be collected from APIS meteorological websites
	HVAC set-point (°C)	HVAC, Status	setpoint indoor temperature defined by dwelling users. This will define the comfort needs of users and will affect curve demands forecasts.
	DHW set-point (°C)	DHW, Status	setpoint water temperature (tank water) defined by dwelling users. This will define the comfort needs of users and will affect curve demands forecasts.
	Indoor temperature (ºC)	Sensing data, measurements	Temperature inside dwelling. The difference from setpoint will affectcurve demands forecasts.
	DHW tank water temperature (°C)	DHW, measurements	Water Temperature in dwelling (tank water). The difference from setpoint will affect curve demands forecasts.

Module	Data	Domain, entities	Description
Advanced Performance Monitoring/ Forecasting Module for Generation/ Storage/ Demand Assets	HVAC Energy consumption (kWh)	HVAC, consumption, measurements	Energy demand of domestic Heating, Ventilation, Air Conditioning systems at dwelling level. If there is independent heat pump, include it as an additional variable (not aggregated in HVAC) It could be useful.
	DHW energy consumption (kWh)	DHW, consumption, measurements	energy demand of domestic hot water system at dwelling level
	EV energy consumption (kWh)	EV, consumption, measurements	energy demand of Electrical vehicle system at dwelling level
	Battery power (charge or discharge, kW)	Battery, status	battery charging/discharging energy flow.
	PV: nominal power, number of modules, modules datasheet…	PV, properties	Static properties
	HVAC: nominal power output, efficiency	HVAC, properties	Static properties
	DHW: water tank volume capacity, nominal power output	DHW, properties	Static properties
	EV (ev_capacity, ev_charge_rate, ev_soc_max, ev_soc_min)	EV, properties	Static properties
	battery (battery_capacity, battery_charge_rate, battery_soc_max, battery_soc_min)	Battery, properties	Static properties
Energy Management Analytics and Self-Consumption Optimization Tool for ESCOs	PV Energy generation (kW)	PV generation, measurements	PV generation at dwelling level
	Building Energy consumption (kW)	Building, consumption, measurements	Energy consumption at dwelling level
	Battery power (charge or discharge, kW)	Battery, status	battery charging/discharging energy flow.
	Energy demand from grid (kW)	Grid, demand, measurements	The energy demand of the dwelling from the grid
	Indoor Temperature (oC)	Sensing data, measurements	Temperature inside dwelling. The difference from setpoint will affect curve demands forecasts.
	Weather data	Sensing data, measurements	Weather data at the dwelling
	HVAC Energy consumption (kW)	HVAC, consumption, measurements	Energy demand of domestic Heating, Ventilation, Air Conditioning systems at dwelling level.

Module	Data	Domain, entities	Description
Energy Management Analytics and Self-Consumption Optimization Tool for ESCOs	DHW Energy consumption (kW)	DHW, consumption, measurements	energy demand of domestic hot water system at dwelling level
	static properties HVAC: nominal power output, efficiency	HVAC, properties	Static properties
	static properties DHW: water tank volume capacity, nominal power output	DHW, properties	Static properties
Advanced Flexibility Analytics and Optimal VPP configuration tool for Consumer-Centric Demand Response Optimization	PV Energy generation (kW)	PV generation, measurements	PV generation at dwelling level
	Building Energy consumption (kWh)	Building, consumption, measurements	Energy consumption at dwelling level
	Building Energy storage (kW)	Building, storage, measurements	Building energy storage
	Weather data	Sensing data, measurements	Weather data at the dwelling
	static properties of EV (ev_capacity, ev_charge_rate, ev_soc_max, ev_soc_min)	EV, properties	Static properties
	static properties of battery (battery_capacity, battery_charge_rate, battery_soc_max, battery_soc_min)	Battery, properties	Static properties
Personalized Energy Analytics and Human-Centric Automation tool for residential buildings, including smart readiness certification features	PV Energy generation (kW)	PV generation, measurements	PV generation at dwelling level
	Building Energy consumption (kW)	Building, consumption, measurements	Energy consumption at dwelling level
	Devices consumption (kW)	Consumption, measurements	Energy consumption of devices
	Battery power (charge or discharge, kW)	Battery, status	battery charging/discharging energy flow.
	Battery SOC (%)	Battery, status	battery state of charge
	Energy demand from grid (kW)	Grid, demand, measurements	The energy demand of the dwelling from the grid
	Indoor Temperature (oC)	Sensing data, measurements	Temperature inside dwelling. The difference from setpoint will affect curve demands forecasts.
	Weather data	Sensing data, measurements	Weather data at the dwelling
	HVAC Energy consumption (kW)	HVAC, consumption, measurements	Energy demand of domestic Heating, Ventilation, Air Conditioning systems at dwelling level.
	DHW Energy consumption (kW)	DHW, consumption, measurements	energy demand of domestic hot water system at dwelling level

Module	Data	Domain, entities	Description
Personalized Energy Analytics and Human-Centric Automation tool for residential buildings, including smart readiness certification features	static properties HVAC: nominal power output, efficiency	HVAC, properties	Static properties
	additional static properties HVAC: thermal resistance (°C/kW), thermal capacity (kWh/°C)	HVAC, properties	Static properties
	static properties DHW: water tank volume capacity, nominal power output	DHW, properties	Static properties
	additional static properties DHW: efficiency, thermal resistance (°C/kW), thermal capacity (kWh/°C)	DHW, properties	Static properties
	static properties of EV (ev_capacity, ev_charge_rate, ev_soc_max, ev_soc_min)	EV, properties	Static properties
	static properties of battery (battery_capacity , battery_charge_rate, battery_soc_max, battery_soc_min)	Battery, properties	Static properties
	Maximum power imported from grid allowed (power contracted, kW)	Grid, properties	The allowed power that can be imported from the grid
	HVAC set-point (°C)	HVAC, status	The set point of the HVAC
	HVAC actuator (binary)	HVAC, status	The status of the HVAC
	DHW set point (°C)	DHW, Status	The set point of the DHW
	DHW tank water temperature (°C)	DHW, Status	The temperature set for the DHW
	DHW actuator (binary)	DHW, Status	The status of the DHW
	Indoor CO2 sensors (ppm)	Sensing data, measurements	The indoor CO2 measurements
	Presence sensors (binary)	Sensing data, measurements	The presence value
	Doors and windows open/closed sensors (binary)	Sensing data, measurements	The status of the windows
	Light on/off sensors (binary)	Sensing data, measurements	The status of lights
	Light on/off actuators (binary)	Sensing data, measurements	The status of lights
	Electricity prices (€ or HRK)	Market	The price of electricity
Blockchain-enabled Smart Contract Monitoring, Handling, Settlement and Remuneration	*Contract duration, amount of nominal power to be delivered, ISPs and duration, etc.)	Contract	Contract terms/parameters
	PV Energy generation (kW)	PV generation, measurements	PV generation, measurements
	Building Energy consumption (kW)	Building, consumption, measurements	Energy consumption at dwelling level
	HVAC Energy consumption (kWh)	HVAC, consumption, measurements	Energy demand of domestic Heating, Ventilation, Air Conditioning systems at dwelling level.

Module	Data	Domain, entities	Description
Blockchain-enabled Smart Contract Monitoring, Handling, Settlement and Remuneration	DHW energy consumption (kWh)	DHW, consumption, measurements	energy demand of domestic hot water system at dwelling level
	Short Term forecasting	Energy Measurements	Forecasting of various values in short term

Table 4 The identified data needs of the modules

*: Related contract information to be made available.

3.2 Review of semantic standards

There are three (3) major domains of critical importance to the frESCO project, namely Building Data Management, Demand Response, Other DERs. These domains can accommodate what is depicted in the DoA [1] , the actions that are foreseen in the demonstrators during the project's time span, and the respective use cases. As described in chapter 2, a thorough analysis of the standards that are most applicable to the frESCO project scope has been performed, and in the following subsections an overview of the aforementioned analysis is provided.

3.2.1.1 OpenADR

OpenADR [3] is a global Smart Grid standard and an open, highly secure, two-way information exchange model. The OpenADR is a well-established smart grid data model that facilitates the interchange of information related to demand response (DR) programs among energy service providers, aggregators, and customers, and was delivered by the OpenADR Alliance in 2010. The model also makes it easier for flexibility providers to manage their numerous distributed energy resources (DER). OpenADR unifies and, most significantly, interoperates the messages exchanged among various stakeholders involved in automated demand response (Auto-DR) and demand response management operations.

Dynamic pricing and reliability signals are transmitted to electricity consumers, in order to alter their energy usage behaviour, improve their energy efficiency, and save money while improving the overall efficacy of power distribution across the smart grid. The OpenADR 2.0 Profile Specification was recently certified as a Publicly Available Specification (PAS) by the IEC, paving the road for the OpenADR to become an IEC worldwide standard.

3.2.1.2 obXML

The DNAS ontology for OB standardization was developed by IEA Annex 66 with the goal of developing a consistent vocabulary and modelling methods to display and describe occupant behaviour. The DNAs framework's topology has been translated into an XML format called 'occupant behaviour XML,' or obXML [4], with the goal of connecting three key parts representing Buildings, Occupants, and Behaviours. The study of occupant behaviour, based on Drivers, Needs, Actions, and Systems, receives a lot of attention.

3.2.1.3 SAREF

The Dutch Institute TNO has developed and delivered the Smart Applications REFerence (SAREF) [5] [6] 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.

Extensions of the fundamental SAREF ontology have been made available to satisfy the demands of certain domains, such as the Energy domain, the Buildings domain, the Water domain, and so on. SAREF4ENER for the energy domain and SAREF4BLDG for the buildings domain are the extensions most relevant to the frESCO project.

3.2.1.4 SAREF4BLDG

SAREF4BLDG [7] is an extension of the SAREF (Smart Applications REFerence) ontology for building information, which was built based on the Industry Foundation Classes (IFC) standard (discussed further in the following sections). This SAREF extension is only applicable to devices and appliances in the building domain. SAREF4BLDG provides the mechanisms for establishing secure data exchange and interoperability among various actors (architects, engineers, consultants, contractors, and product component manufacturers, among others) and applications that handle building information throughout the building life cycle (from the initial phase of construction to the potential demolition).

SAREF4BLDG adds 72 classes (67 introduced in SAREF4BLDG and 5 reused from the SAREF and geo ontologies), 179 object attributes (177 introduced in SAREF4BLDG and 2 reused from the SAREF and geo ontologies), and 83 data type attributes to SAREF (82 introduced in SAREF4BLDG and 1 reused from the SAREF ontology).

3.2.1.5 SAREF4ENER

SAREF4ENER [8] is a SAREF ontology extension for the energy domain. EEBus [9] and Energy@Home [10] partnered towards the development of the ontology, in order to allow the connectivity of their various data models. SAREF4ENER v1.1.2 adds 63 new classes, 17 new object attributes, and 40 new data type properties to the basic SAREF ontology. SAREF4ENER is intended to improve interoperability between proprietary solutions produced by various consortia in the smart home sector (i.e., smart appliances) from manufacturers who support the EEBus or E@H data models.

It's important to note that SAREF4ENER focuses on demand response situations, in which consumers can provide the Smart Grid with flexibility, by managing their smart home devices with any energy management system, either at home or in the cloud.

3.2.1.6 OCPP 1.6 & 2.0.1

The Open Charge Alliance spearheads the OCCP initiative, which stands for Open Charge Point Protocol (OCA). The Open Charge Point Protocol standardizes the vocabulary, structure, and regulations for data exchanges between charging stations and central control systems for electric vehicles. OCPP [11] provides a communication protocol for device producers and charging station operators, empowering unhindered and prompt communication between charging points and central stations, matching customer demand. The most widely used version is OCPP 1.6, appropriate for smart charging, which allows the Network Operator to place constraints on individual chargers such as power level or time limits. OCPP 2.0.1 improves smart charging, reduces data usage, and adds essential security features. Overall, OCPP software allows mobile apps, central management systems, and electric vehicle charging stations to communicate using the same 'language.'

3.2.1.7 USEF

USEF [12] was founded to pave the way for the most efficient and cost-effective transition to a smart energy future. It establishes a single, universal standard on which all smart energy products and services can be built. By making flexible energy usage a tradeable commodity and providing the market structure, regulations, and tools needed to make it operate, the value of flexible energy use is unleashed.

The USEF standard is intended to be a role-based model that defines the duties, responsibilities, and connections among all energy market participants so that demand-side involvement can be maximized. Each of the identified roles and their corresponding tasks can be briefly expressed as follows:

- Balancing Responsible Party (BRP), responsible for balancing supply and demand and providing effective means of correcting any possible network imbalances in the most cost-effective manner.
- Distribution System Operator (DSO), responsible for optimizing the overall distribution network operation.
- Aggregator, in charge of managing the aggregated energy flexibility given by prosumers and meeting the Balancing Responsible Party's needs.
- Common Reference Operator (CRO), handling the assignment of congestion locations and congestions to other interested parties.
- Meter Data Company, in charge of compiling and verifying all metering data.

  Active Demand and Supply, comprising different organizations that can communicate with each other using appropriate signals to adjust energy demand and supply.
- Prosumers, the end users that both provide and consume energy.

3.2.1.8 IFC

BuildingSMART International created the Industry Foundation Classes (IFC) with the objective of creating a digital representation of the building industry and key assets, enabling for unrestricted information interchange, and sharing across industry leaders. The IFC4, which is an enhanced version of the IFC, is used as an open specification for BIM data. The standard covers data specification items, concepts, and applicable language for the construction industry's disciplines, trade, and specializations. EXPRESS and XML standards, as well as XML property and quantity definitions, are used to express the IFC standard's data structure and reference data. The IFC [13] standard is structured as a four-layer conceptual model.

3.2.1.9 IEC CIM

The IEC CIM was first created and supplied by EPRI, the Electrical Power Research Institute, before being adopted by the International Electrotechnical Commission as the IEC series of standards 61970/61968/62325. This set of standards, IEC 61970-301 [14], IEC 61968-11 [15], and IEC 62325-301 [16], depicts the most important objects in an electric utility company. The IEC CIM is an object-oriented data schema that is conveyed as an extensible markup language (XML) data schema. It provides a definitive way to depict power system resources as object classes, outline their parameters, and establish their relationships in terms of i) inheritance, ii) association, and iii) aggregation.

In the 53 UML packages covered by the IEC CIM, there are 820 classes with over 8500 attributes. In principle, the IEC CIM enables interoperability across different systems by establishing a common definition of management information for systems, networks, applications, and services, as well as providing appropriate mechanisms for network application linkage carried out by different manufacturers. The IEC CIM is used by Transmission System Operators (TSO) to develop models of power system networks, allowing for faster and more efficient information transmission. In more detail, the smooth and seamless integration of TSO energy management system applications implemented by different vendors with EMS systems delivered by an independent source, or between systems relevant to power system operations (generation or distribution management) and an EMS system, is the primary goal of the IEC 61970 series of standards.

The IEC 61968-11 standard was developed to meet the needs of Distribution System Operators (DSOs) by defining the information exchanges across various electrical distribution systems on a utility enterprise level, with a focus on DMS functions.

The IEC 62325-301 "CIM extensions for markets" standard was created to help deregulated electricity markets become more harmonized and to address the growing requirement for smooth and transparent information sharing among market participants. As previously stated, the IEC CIM is critical for facilitating interoperability, and as a result, the IEC CIM has been widely endorsed by a variety of TSOs around Europe. In reality, the European Network of Transmission System Operators for Electrical (ENTSO-E) [3], an organization of 43 electricity transmission system operators from 36 nations across Europe, has embraced the IEC CIM.

4 THE FRESCO CIM

4.1 Standards Evaluation

4.1.1 Synopsis

The purpose of the standardization landscape study in section 3.2, was to identify and highlight the most appropriate standards, ontologies, and data models in regard to the domains (Building Data Management, Demand Response, Other DERs) identified and of course, to the frESCO scope. The standards were chosen based on a set of criteria covering their applicability and significance to important frESCO activities (data collecting, energy efficiency, eMobility, and so on), as well as their maturity and applicability. A brief synopsis of the categorization of the different standards studied, in relation to the domains they can support is depicted in Figure 2.

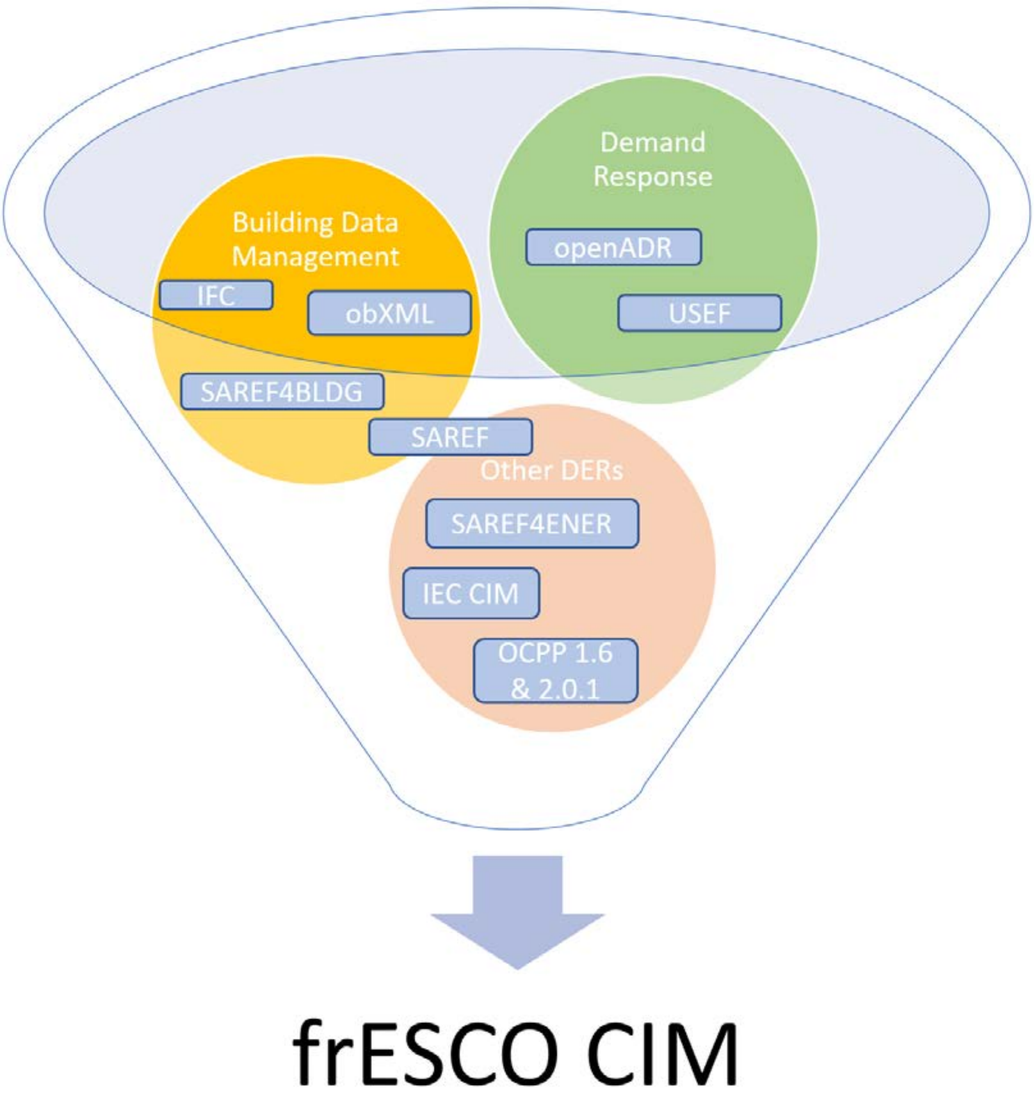

Figure 2 The semantic standards/ontologies which cover the identified frESCO domains

In addition to the above classification, several additional preliminary difficulties that the frESCO CIM must address were identified by the relevant analysis. At this time, none of the data models under consideration can fully meet the frESCO CIM requirements.

4.1.2 CIM Key Principles

The evaluation of applicable standards, ontologies, and semantic models (section 3.2), which will address the frESCO scope to a limited or comprehensive degree, resulted in several considerations that can be regarded as the frESCO CIM's high-level functional requirements.

The major objective of the proposed data model is to create a framework for managing the data semantics that will be collected in the frESCO Big Data Management Platform and ensuring interoperability. As a result, the frESCO CIM shall incorporate an appropriate level of semantics to assure interoperability, without having to adhere to rigorous ontological models in order to do so.

- The frESCO CIM is essential to ensure that the Big Data Management Platform runs smoothly while maintaining all related semantics together with the harvested data, effectively establishing the frESCO Platform as an open data exchange mechanism for entitled third parties.
- It is critical to establish compatibility at both the technical and semantic levels in order for frESCO to succeed. Because the frESCO CIM will interact with a variety of data sources and systems, all of which will most likely adhere to their own data model, it is critical to provide consistent and non-ambiguous data interpretation in order to accurately analyse the semantics.
- As the frESCO solution is expected to evolve, the design of the frESCO model must include mechanisms to anticipate its extensibility whenever new needs are expressed by the frESCO modules or the demo sites.
- To confirm the involvement of all potential different actors/stakeholders associated with frESCO (explicitly or implicitly), as well as their characteristics, the frESCO CIM is critical to avoid compliance with a specific standard, allowing instead the incorporation of various data standards (and the combination of features they can potentially introduce) and fostering the possibility of configurations of them.

- The frESCO CIM will make use of existing standards and ontologies in order to harmonize the data representations associated with relevant data collection activities, while also ensuring that, through appropriate storing mechanisms, every piece of semantic information, regardless of its potential direct use in the frESCO Platform, will be used for establishing the Big Data Management Platform interoperability.

Having in mind the considerations that were elaborated above, the Common Information Model of frESCO was developed under some very specific foundations, starting with the need to be as resilient as possible. The different data relationships have to be properly introduced, so that stakeholders (both within and outside the frESCO consortium) may manage and leverage them using the project's integrated Platform. Another key aspect towards the development of the CIM is that the entities introduced, as well as the attributes and information associated with them, are of sufficient granularity. Also, considering the possibility that the stakeholders in the energy data value chain are unfamiliar with the frESCO CIM's characteristics, it's vital that their data, which is harmonized in a variety of entities and attributes, is easily configured. When it comes to the numerous languages that are typically used for modelling, the frESCO CIM must be language agnostic. Finally, the lifecycle assurance criteria that will be applied must ensure that the frESCO integrated Platform can operate without interruption because the CIM is supposed to be an ever-expanding model.

4.2 The cornerstone of the CIM and relevant Terminology

The frESCO Common Information Model aims to overcome a variety of challenges related to data integration and interoperability for data derived from the numerous entities involved in the electricity sector. The CIM's main goal is to turn large amounts of raw data into something useful, regardless of the built-in languages and formats that the standards, which are discussed in chapter 3 (Data Standards Examination), support. The frESCO CIM aims to accommodate the aforementioned standards and expand on the existing electricity intelligence.

A set of basic terminology has been identified in order to explain the frESCO CIM, with the goal of establishing a shared understanding and perspective of terms such as System, Entity and Attribute.

- A tangible and intangible, logical (asset, meter, utility pole) or logical (company, customer, contract) object that exists in the real-world is referred to as an ***object.***
- The equivalent of an object in the CIM is defined as an ***entity.*** All entities in the frESCO CIM will be introduced and modelled based on the previously completed standard analysis.
- The properties of each entity modelled in the frESCO CIM are defined as ***attributes***.

4.3 CIM Overview

The frESCO CIM has 37 entities in its original edition while 582 is the sum of the attributes in the entities. The categorization of entities in their various areas of interest is not shown in the frESCO CIM and was done only for the purpose of this section's presentation.

The frESCO CIM includes entities that are related to the:

- different **Actors** involved (encompassing: Aggregator, EnergyServiceCompany, Prosumer, BuildingManager)
- **Building Framework** (encompassing: Building, BuildingArea, BuildingLevel, Comfort, Tenancy, Tenant)
- **Appliances** (encompassing: SmartMetering, Gateway, Sensor, LightSource, AirConditioning, WaterHeater, Battery, ElectricVehicle, ElectricVehicleChargingPoint)
- **Measurements** (encompassing: EnergyMeasurements, SensingMeasurements, WeatherMeasurements)
- **Flexibility** (encompassing: Flexibility, DemandResponseEvent, DemandResponseReport)
- **Energy Market** (encompassing: TariffProfile, Settlement, ContractualAgreement, ContractualAgreementStructure)
- **Power Plants** (encompassing: VirtualPowerPlant, WeatherStation, PhotovoltaicPlant)
- **General Information** entities (encompassing: Address, ContactSpecifics, Location, Period, Status)

Table 5 shows all of the entities that have already been included in the frESCO CIM, together with the number of attributes for each entity.

frESCO CIM Entities	Number of Attributes
Address	19
Aggregator	7
AirConditioning	18
Battery	21
Building	18
BuildingArea	11
BuildingManager	10
BuildingLevel	12
ContactSpecifics	13
ContractualAgreement	20
ContractAgreementStructure	18
Comfort	25
DemandResponseEvent	16
DemandResponseReport	14
ElectricVehicle	14
ElectricVehicleChargingPoint	8
EnergyMeasurements	55
EnergyServiceCompany	7
Flexibility	16
Gateway	9
LightSource	14
Location	26
Period	19
PhotovoltaicPlant	19
Prosumer	14
SensingMeasurements	19
Sensor	10
Settlement	15
SmartMetering	10
Status	13
TariffProfile	14
Tenancy	13
Tenant	13
VirtualPowerPlant	8
WaterHeater	13
WeatherMeasurements	24
WeatherStation	7

Table 5 The entities of the frESCO CIM and their attributes

All entities depicted in Table 5 and their respective attributes will be available for extensive study in Annex I.

After defining the entities that constitute the frESCO CIM, the next step in the methodology's level 4, is to model the attributes per entity. Utilizing the Location, PhotovoltaicPlant and Building entities as an example, the list of attributes per entity is provided below.

Entity: **Location**

Attributes:

- addressLine
- altitude
- apartmentNumber
- areaSize
- buildingName
- buildingNumber
- buildingType
- cityCode
- cityName
- continentName
- countryCode
- countryName
- departmentName
- description
- directions
- districtName
- floorNumber
- id
- latitude
- longitude
- municipalityName
- name
- postalCode
- roomNumber
- streetName
- villageName

Entity: **PhotovoltaicPlant**

Attributes:

- brandName
- capitalCost
- code
- description
- efficiency
- id
- lifetime
- manufacturerName
- model
- name
- nominalCapacity
- nominalVoltage
- openCircuitVoltage
- operatingCost
- panelsCount
- serialNumber
- shortCircuitCurrent
- temperatureCoefficient
- type

Entity: **Building**

Attributes:

- Area
- description
- documentation
- elevation
- energyPerformanceCertificationClass
- FloorArea
- id

- lastRefurbishmentDate
- name
- occupancyType
- permanentIndicator
- GrossArea
- planningControlStatus
- smartReadinessAssessmentClass
- storeysCount
- subtype
- totalHeight
- type

The full list of attributes of every frESCO CIM entity identified can be found in Annex I.

To complete this step, and with the support of entity relationship (ER) diagrams, Figure 3 presents the same entities with a range of each entity's attributes, complemented with the relations between them.

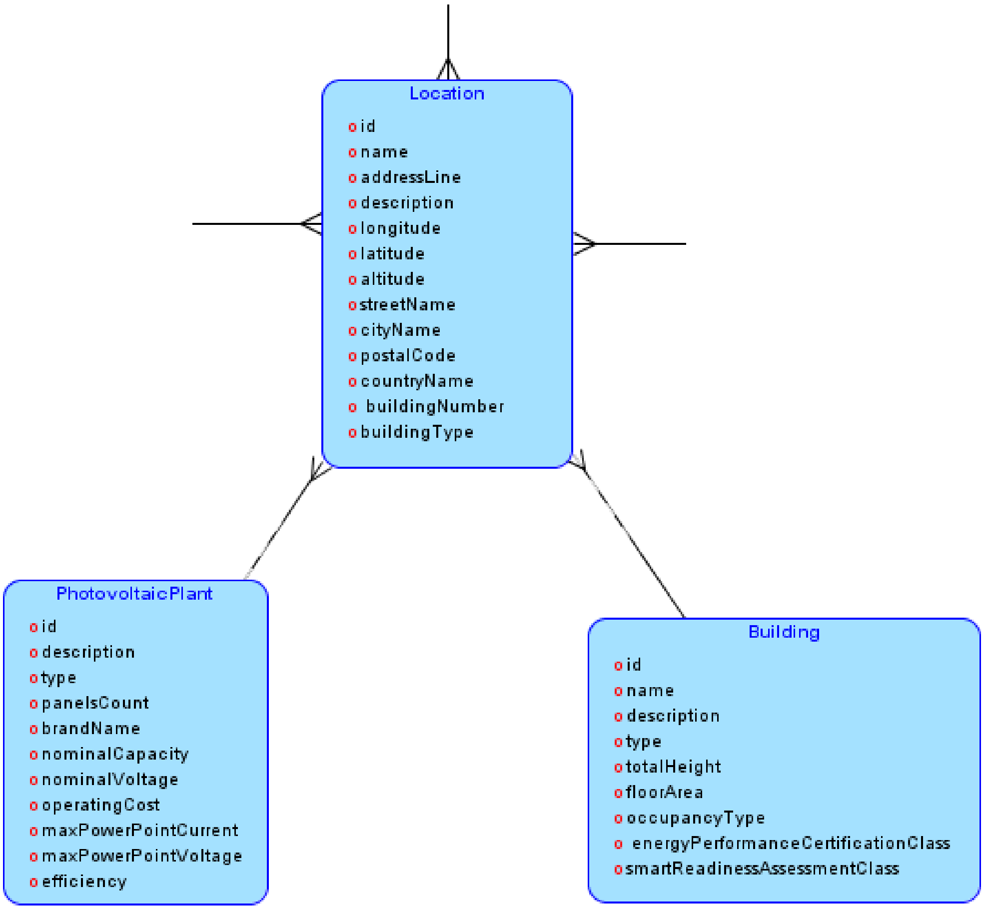

Figure 3 A high-level view of the entities PV, Location and Building, their attributes and relations

Using this method, reading the relationships between the entities becomes straightforward, and in that example a Building is related and can be found in a Location. A PhotovoltaicPlant has similar relation with the Location entity. At the same time, reading the relation in opposite direction, in a Location, multiple buildings as well as multiple PhotovoltaicPlants can be found. It is also visible in Figure 3, that the Location entity has additional relations to further entities, that are not displayed at this point for simplicity reasons.

The entire list of entities of the frESCO CIM accompanied with their respective relations, and all updates that will take place based on the collected data as the project progresses, will be provided as part of deliverables D4.6 and D4.7, planned for M20 and M32 respectively.

5 CONCLUSIONS

In the context of Task T4.1 " Open Standards, Interoperability and Common Information Model Adaptation," this deliverable, D4.1 "frESCO Common Information Model," focused on the systematic approach to design the frESCO CIM.

The CIM design was based on an in-depth examination of the available demonstrator's data and the module's data requirements. A broad examination of widely used data standards enabling data exchanges amongst various actors was performed, taking under consideration the project's use case scenarios. As part of this process, relevant data standards (e.g., SAREF, OpenADR) were identified and chosen as the foundation for shaping the frESCO CIM based on their alignment to the frESCO requirements.

Establishing a "common language" for all data to be collected enables both syntactic and semantic interoperability, fosters exchange of knowledge and expansion across organizations, and allows for the use of data from different systems across various domains and the integration of their services. This deliverable, in this context, provides an initial specification of the frESCO CIM, which consists of 37 entities and 582 attributes and efficiently explains the semantics and structure of each entity and its attributes.

The Common Information Model is essentially considered as an ever-expanding model in frESCO, which will adapt and evolve according to the project's needs and to demonstrator's data, that will be become available as the project progresses. The consortium's technical partners, who are responsible for the modules' implementation, will be able to identify new data requirements, which will lead to the integration of new entities to the frESCO CIM with existing ones, without jeopardizing the data already stored. That way, the consistency of previously imported data is preserved, and the frESCO platform's stability is ensured.

6 REFERENCES

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7 ANNEXES

Annex I

The following layouts depict all of the frESCO CIM entities and their associated attributes in detail.

Entity: Address

Attributes:

- addressLine
- apartmentID
- buildingName
- buildingNumber
- cityCode
- cityName
- continentName
- countryCode
- countryName
- description
- districtName
- floorNumber
- id
- name
- postalCode
- postOfficeBox
- region
- streetName
- type

Entity: Aggregator

Attributes:

- brandName

- departmentName
- description
- id
- legalName
- name
- type

Entity: AirConditioning

Attributes:

- brandName
- code
- Capacity
- coolingCapacity
- coolingMedium
- description
- externalSurfaceArea
- heatingCapacity
- id
- internalSurfaceArea
- model
- name
- nominalHeatTransferArea
- nominalNoiseLevel
- nominalVoltage
- performanceCoefficient
- serialNumber
- type

Entity: Battery

Attributes:

- brandName

- chargeVoltage
- cycleLife
- depthOfDischarge
- description
- dischargeRate
- duration
- id
- manufacturerName
- Capacity
- maxChargeCurrent
- maxChargeRate
- maxDischargeCurrent
- minChargeStatus
- model
- name
- nominalEnergyDelivered
- roundTripEfficiency
- serialNumber
- throughput
- type
-

Entity: Building

Attributes:

- area
- description
- documentation
- elevation
- energyPerformanceCertificationClass
- floorArea
- id

- lastRefurbishmentDate
- name
- occupancyType
- permanentIndicator
- grossArea
- planningControlStatus
- smartReadinessAssessmentClass
- storeysCount
- subtype
- totalHeight
- type

Entity: BuildingArea

Attributes:

- description
- documentation
- elevation
- energyPerformanceCertificationClass
- floorArea
- id
- name
- occupancyType
- smartReadinessAssessmentClass
- spaceHeight
- type

Entity: BuildingManager

Attributes:

- brandName
- departmentName
- description

- familyName
- firstName
- gender
- id
- legalName
- name
- type

Entity: BuildingLevel

Attributes:

- actualGrossArea
- actualNetArea
- Area
- description
- elevation
- height
- id
- maxOccupants
- minOccupants
- name
- storeyNumber
- zonesCount

Entity: ContactSpecifics

Attributes:

- departmentName
- description
- eMailAddress
- familyName
- faxNumber
- givenName

- jobTitle
- landline
- mobileNumber
- name
- role
- title
- type

Entity: ContractualAgreement

Attributes:

- activationDateTime
- capacity
- createdDate
- customerType
- description
- duration
- effectiveDate
- expiryDate
- flexibilityEventsNumber
- id
- name
- payment
- penalties
- phase
- price
- retailTariff
- serviceCategory
- signatureDate
- startDate
- updatedDate

Entity: ContractualAgreementStructure

Attributes:

- baselineFlexibility
- ceilingUsageConsumption
- ceilingUsagePower
- code
- createdDate
- customerType
- description
- endDate
- flexibilityPrice
- floorUsageConsumption
- floorUsagePower
- id
- name
- region
- serviceCategory
- startDate
- status
- type

Entity: Comfort

Attributes:

- 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

Entity: DemandResponseEvent
Attributes:

- code
- comment
- createdDateTime
- description
- id
- marketContext
- modificationCount
- modificationDateTime
- modificationReason
- name

- occurenceDateTime
- priority
- rampUpDuration
- startDateTime
- status
- testEvent

Entity: DemandResponseReport

Attributes:

- backDuration
- code
- createdDateTime
- dataSource
- description
- duration
- granularity
- id
- marketContext
- name
- optInType
- requestID
- status
- type

Entity: ElectricVehicle

Attributes:

- brandName
- code
- description
- efficiency
- id

- manufacturerName
- name
- nominalDrivingRange
- nominalVoltage
- releaseDateTime
- serialNumber
- type
- typicalRechargeTime
- upstreamEmissions

Entity: ElectricVehicleChargingPoint

Attributes:

- chargingMode
- effectiveChargingPower
- effectiveCurrent
- id
- maxChargingPower
- maxCurrent
- name
- type

Entity: EnergyMeasurements

Attributes:

- actualEnergyStored
- airConditioningSystemLoad
- apparentPower
- averageCurrent
- averageVoltage
- baseLoad
- batteryLoad
- chargeSetpoint

- chargeStatus
- createdDateTime
- dayAheadDemand
- demandFactor
- description
- deviceLoad
- diversifiedLoad
- electricVehicleLoad
- energyDeliveredSinceLastCharge
- EnergyExport
- energyObtainedFromStorage
- forecastDateTime
- forecastLoad
- frequency
- generation
- gridLoad
- id
- instantaneousCurrent
- instantaneousPower
- instantaneousVoltage
- lightingDeviceLoad
- loadFactor
- loadProfileHourly
- name
- numberofCycles
- observedDateTime
- operationTimeSinceLastCharge
- peakCurrent
- peakLoad
- peakVoltage

- Power
- powerFactor
- remainingUsefulLife
- rmsCurrent
- rmsVoltage
- stateOfCharge
- stateOfHealth
- stateOfSafety
- targetEnergyStored
- throughput
- totalConsumption
- totalConsumptionHourly
- totalEnergyDelivered
- totalOperationTime
- unmetLoad
- updatedDateTime
- utilizationFactor

Entity: EnergyServiceCompany

Attributes:

- brandName
- departmentName
- description
- id
- legalName
- name
- type

Entity: Flexibility

Attributes:

- activationTime

- baselineFlexibility
- defaultDuration
- demandFlexibility
- description
- duration
- flexibilityEvent
- flexibilityForecast
- flexibilityResponseTime
- forecastDateTime
- generationFlexibility
- maxFlexibilityCapacity
- observedDateTime
- price
- storageFlexibility
- type

Entity: Gateway

Attributes:

- brandName
- code
- description
- id
- manufacturerName
- model
- name
- serialNumber
- type

Entity: LightSource

Attributes:

- brandName

- code
- colorAppearance
- colorTemperature
- contributedLuminousFlux
- description
- id
- manufacturerName
- model
- name
- nominalPower
- numberOfDimmingScales
- serialNumber
- type

Entity: Location

Attributes:

- addressLine
- altitude
- apartmentNumber
- areaSize
- buildingName
- buildingNumber
- buildingType
- cityCode
- cityName
- continentName
- countryCode
- countryName
- departmentName
- description
- directions

- districtName
- floorNumber
- id
- latitude
- longitude
- municipalityName
- name
- postalCode
- roomNumber
- streetName
- villageName

Entity: Period

Attributes:

- defaultDuration
- description
- earliestStartDateTime
- elapsedDuration
- endDateTime
- id
- latestEndDateTime
- maxDuration
- minDuration
- name
- optionalIndicator
- pauseTime
- referenceDateTime
- seasonCode
- sequenceNumeric
- startDateTime
- type

- weekdayIndicator
- weekendIndicator

Entity: PhotovoltaicPlant

Attributes:

- brandName
- capitalCost
- code
- description
- efficiency
- id
- lifetime
- manufacturerName
- model
- name
- nominalCapacity
- nominalVoltage
- openCircuitVoltage
- operatingCost
- panelsCount
- serialNumber
- shortCircuitCurrent
- temperatureCoefficient
- type

Entity: Prosumer

Attributes:

- age
- birthDateTime
- category
- description

- familyName
- gender
- givenName
- id
- maidenName
- middleName
- name
- nationality
- profession
- title

Entity: SensingMeasurements

Attributes:

- acousticPressure
- airQualityIndex
- batteryCoolantIntakeTemperature
- batteryCoolantOutputTemperature
- createdDateTime
- forecastTemperature
- forecastTemperatureRange
- maxTemperature
- minTemperature
- noiseLevel
- occurenceDateTime
- observedDateTime
- observedLuminance
- observedSoundPower
- observedSoundPowerLevel
- observedTemperature
- temperatureAlarm
- temperatureChangeRate

- vocConcentration

Entity: Sensor

Attributes:

- accuracy
- brandName
- code
- description
- id
- manufacturerName
- model
- name
- serialNumber
- type

Entity: Settlement

Attributes:

- actualPower
- availablePower
- baselineReference
- deliveredFlexibilityPower
- id
- netSettlement
- offeredPower
- orderedFlexibilityPower
- penalty
- powerDeficiency
- price
- requestedPower
- reservedPower
- settlementDate

- settlementStatus

Entity: SmartMetering

Attributes:

- acquiredDateTime
- brandName
- code
- description
- id
- manufacturerName
- model
- name
- serialNumber
- type

Entity: Status
Attributes:

- conditionCode
- conditionIndicator
- description
- id
- name
- overchargedStatusIndicator
- referenceDateTime
- reasonCode
- remarks
- statusCount
- statusDateTime
- type
- underchargedStatusIndicator

Entity: TariffProfile

Attributes:

- chargeKind
- code
- consumptionSequenceNumber
- consumptionStartValue
- creationDate
- description
- endDateTime
- fixedCostPart
- id
- name
- scheduleCycle
- sequenceNumber
- startDateTime
- variableCostPart

Entity: Tenancy

Attributes:

- areaPerOccupant
- code
- description
- id
- maxOccupantsCount
- minOccupantsCount
- name
- occupancyTimePerDay
- occupancyTimePerWeekDay
- occupancyTimePerWeekendDay
- occupantsCount
- occupantsPeakCount

- type

Entity: Tenant

Attributes:

- age
- birthDateTime
- category
- description
- familyName
- gender
- givenName
- id
- middleName
- name
- nationality
- profession
- title

Entity: VirtualPowerPlant

Attributes:

- capacity
- description
- energySource
- id
- name
- powerSourcesCount
- scalability
- type

Entity: WaterHeater

Attributes:

- brandName
- code
- description
- id
- manufacturerName
- model
- name
- nominalPerformanceEffciency
- nominalPower
- serialNumber
- title
- type
- volume

Entity: WeatherMeasurements

Attributes:

- absoluteHumidity
- atmosphericPressure
- cloudiness
- conditionDetails
- conditionIntensity
- conditionStatus
- description
- id
- measuredDateTime
- precipitationProbability
- precipitationRate
- proximity
- realFeelTemperature
- relativeHumidity
- reportedDateTime

- temperature
- temperatureMax
- temperatureMin
- uvIndex
- visibilityMax
- visibilityMean
- visibilityMin
- windDirection
- windspeed

Entity: WeatherStation

Attributes:

- accuracy
- id
- description
- manufacturerName
- model
- name
- type