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Guidance and plan to develop smart energy ontologies

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Guidance and plan to develop smart energy ontologies

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The text of this Systems Reference Deliverable is based on the following documents:

Draft	Report on voting
SyCSmartEnergy/289/DTS	SyCSmartEnergy/295/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Systems Reference Deliverable is English.

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INTRODUCTION

The smart energy and smart grid domains have undergone tremendous change as a result of different work on energy grids, markets, and services modelization and data exchanges. Information and knowledge on this domain are now shared in broad, public and standardized models. As a result, the challenge of knowledge representation and sharing is even more prominent. Any user such as software agents, intelligent devices, artificial intelligence, edge computing capabilities or people, is liable to use, create, and exchange information in large-scale ecosystems with a variety data models, exchange protocols and information modelling standards. To address this challenge, the smart energy community is looking into languages and frameworks for ensuring interoperability at the knowledge level between several ecosystems of users. The semantic web and its recent technological advancement for characterizing and preserving knowledge on the web as an architecture of computer-interpretable structured information is an inspiration to do so.

Semantic web technology is used to create knowledge domains and generates meaning from a hierarchy of data classification. It is an expansion of the current web in which knowledge is given a clear and unambiguous meaning via ontologies. Because they give structured vocabularies a formal specification of shared concepts, ontologies are crucial for achieving interoperability in large domains such as smart energy involving several ecosystems working on different standards and data models for exchanging information. Ontologies help to solve the issues caused by semantic heterogeneity by offering a common understanding of a particular area of interest. However, matching ontologies continue to be the biggest obstacle to data integration and interoperability. Ontologies can be used to address interoperability problems at the application level; as a result, ontologies have been utilized to express the capabilities of the services. Ontologies, which specify the semantics of the symbolic representations employed in communication, similarly enhance user interaction.

A substantial emphasis is placed on the work and technology development in semantic web languages, sensors and computing, graphs, and models, and linking and integration approaches. The Internet of Things, semantic web services, ontology mapping, building information modelling, bioinformatics, education, and e-learning, and semantic web languages are the main domains of development of the semantic web and interoperability field. Smart energy businesses functioning in a more-and-more digital environment today need more automation, interoperability, and data governance in their day-to-day operations. While the semantic web and interoperability research have attracted a lot of interest and made major improvements, there are few works available that address those concepts for the whole smart energy domain. This document's goal is to examine this knowledge gap by reviewing and analysing the existing ontology and semantic interoperability work in the domain and propose a framework and best practice for future standardization work in the domain.

So numerous ontologies are being developed to provide semantic interoperability solutions to many domains. From domestic IoT to industry, chemistry, biotechnologies or medical sector, many domains are working to ensure semantic interoperability of the knowledge and data they accumulate. These works can reach very different degrees of maturity, from research thesis works to the implementation of industrial services based on semantic interoperability between data models enabled by an ontology. The smart energy domain is not left behind when it comes to these works. There have been many studies among semantic interoperability in power grid and energy ontology and different ontologies have been developed to improve energy data interoperability. Choosing a reference ontology which meets the requirement and covers the large domains in smart energy systems is a big challenge as not all ontologies represent the same energy data domains and at the same level of data details. This heterogeneity results in interoperability issues in implementation of these ontologies. One of the several challenges to build a unified ontology for the smart energy domain is to identify semantically equivalent objects in already existing ontologies of the domain. Therefore, the determination of a method of unification or facilitating the necessary interoperability for smart energy is key to go one step beyond the major innovations and improvements achieved in the past decade.

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The approach proposed in this document is to build a framework for the selection, evaluation and analysis of pre-existing ontologies that are wholly or partially applicable to the smart energy domain, thus facilitating the identification of a federation of reference ontologies that can be used in this domain. This framework allows to identify overlaps and gaps not covered by these ontologies, to evaluate their quality, their maintainability, their ease of use and the associated extension needs, thus facilitating through normative work the emergence of an interoperable set of ontologies for the smart energy domain.

This publication provides a framework: guidance, evaluation criterion, best practices, and key issues to address, to develop a smart energy ontology federating established ontologies of the smart energy domain through semantic interoperability.

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1 Scope

This document provides guidance and a plan to develop smart energy ontologies and other domain-based ontologies within smart energy to achieve semantic interoperability through various standards, generic and specific ontologies projects. This includes but is not limited to the following.

- Assessment of a selection of existing ontologies for the purpose of smart energy applications:
  - identification of developed ontologies within the energy sectors;
  - limitations, best practices, and lessons learned;
  - use and reuse of existing ontologies in the smart energy domain;
  - cross-domain semantic interoperability support and link to other ontologies.
- Guidance and plan for smart energy ontologies development and usage including:
  - key principles to map or transform existing reference models to the IEC ontology framework;
  - definition of governance best practices for ontologies applied to process the smart energy domain;
  - guidance for developing or extending a smart energy ontology.

Domain-based ontologies have been developed for semantic interoperability in a specific domain but the interaction of semantically equivalent objects in different ontologies has not been defined. This document helps users and ontology developers to define the complete relationship in different domains and different ontologies for the purpose of smart energy applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 21838-1:2021, *Information technology – Top-level ontologies (TLO) – Part 1: Requirements*

ISO/IEC 21838-2:2021, *Information technology – Top-level ontologies (TLO) – Part 2: Basic Formal Ontology (BFO)*

ISO/IEC 21823-3:2021, *Internet of Things (IoT) – Interoperability for IoT systems – Part 3: Semantic interoperability*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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