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Guidance and plan to develop smart energy ontologies

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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CONTENTS

FOREWORD 4
INTRODUCTION 6
1 Scope 8
2 Normative references 8
3 Terms and definitions 8
4 State of art on existing ontologies and their structure and architecture 9
4.1 General 9
4.2 Key concepts on semantic interoperability and ontologies 11
4.2.1 Definition and key concepts in ontologies 11
4.2.2 Definition and key concepts in semantic interoperability 12
4.2.3 Structure of an ontology 14
4.2.4 Ontology-based reasoning 15
4.3 Languages used within ontology 16
4.3.1 General 16
4.3.2 RDF/RDFS 16
4.3.3 OWL/RDFS-Plus 16
4.3.4 SHACL 17
4.3.5 SPARQL 17
4.3.6 XKOS 17
4.3.7 SKOS-reference 17
4.3.8 DCAT 17
4.3.9 The Reified Requirements Ontology 17
4.3.10 Schema.org 18
4.3.11 Articulation of languages in semantic through the semantic web layer cake 19
4.4 Landscape of ongoing ontology work in smart energy domain 19
4.4.1 General 19
4.4.2 SAREF4ENER 20
4.4.3 IEC Common Information Model (CIM) 23
4.4.4 Microsoft Energy Grid Ontology for Digital Twins 23
4.4.5 IEC Interface Reference Model (IRM) 24
4.4.6 Smart energy domain ontology (SARGON) 25
4.4.7 SEPA's Smart Grid Ontology 26
4.4.8 InterConnect ontologies 27
4.5 Relevant work on ontologies in cross-domains with smart energy 28
4.5.1 LOV4IoT-Energy Ontology Catalog 28
4.5.2 OpenADR 29
4.5.3 QUDT 29
4.5.4 GeoSPARQL 29
4.5.5 W3C SSN 30
4.5.6 The Organization Ontology 30
4.5.7 BRIDGE 30
4.6 Smart energy data models key for semantic interoperability 31
4.6.1 IEC Common Data Dictionary (CDD) 31
4.6.2 IEC 61850 32
4.6.3 DLMS/COSEM 33
4.6.4 Matter 34

4.6.5 KNX 35
4.7 Graphical representation and visualization of ontologies 37
4.8 Future trends 37
5 Smart energy cross-domain use cases involving ontology 38
5.1 Common Grid model, ENTSO-E – CGMES 38
5.1.1 Use cases description 38
5.1.2 Use of the ontology 38
5.1.3 Benefit to implement it 39
5.2 Illustration on energy management in buildings 39
5.2.1 Use cases description 39
5.2.2 Use of the ontology 39
5.2.3 Benefit to implement it. 40
5.3 Illustration in electromobility 40
5.3.1 Use cases description 40
5.3.2 Use of the ontology 41
5.3.3 Benefit of implementing it 42
5.4 InterConnect 42
5.4.1 Use cases description 42
5.4.2 Use of the ontology 43
5.4.3 Benefit of implementing it 44
6 Proposal for a smart energy ontology framework 44
6.1 Smart energy ontology framework 44
6.1.1 General 44
6.1.2 Requirements 45
6.1.3 Processes on validation or evaluation of an ontology 46
6.1.4 Governance requirements 46
6.2 Guidance and best practices to build such a framework 47
6.2.1 General 47
6.2.2 Ontological requirements specification 48
6.2.3 Ontology implementation 49
6.2.4 Ontology publication 49
6.2.5 Ontology maintenance 49
7 Conclusion and recommendation for standardization work on smart energy ontology in the IEC 49
Bibliography 51

Figure 1 – Four layers of interoperability 13
Figure 2 – Links between interoperability layers 14
Figure 3 – Ontology languages layer cake 16
Figure 4 – RRO illustration of a requirement 18
Figure 5 – Semantic web layer cake 19
Figure 6 – Smart energy main data models and related ontologies 20
Figure 7 – Overview of the SAREF ontology 21
Figure 8 – Overview of the SAREF4ENER ontology 22
Figure 9 – IEC standardized Interface Reference Model 24
Figure 10 – Smart energy domain ontology (SARGON) network structure 26
Figure 11 – SEPA project ontology overview 27

Figure 12 – Ontology Catalog for Energy 28
Figure 13 – GeoSPARQL vocabulary 29
Figure 14 – European energy data exchange reference architecture DERA 3.0 31
Figure 15 – DLMS main data models 34
Figure 16 – HBES elements 36
Figure 17 – Main KIM source 36
Figure 18 – Main KIM ontology classes 37
Figure 19 – CIM-CGMES usage illustration 38
Figure 20 – Energy in buildings scenario with semantic interoperability problems 39
Figure 21 – Semantic interoperability problems solved without using SEN ontology 40
Figure 22 – Semantic interoperability problems solved using SEN 40
Figure 23 – Electromobility scenario with semantic interoperability problems 41
Figure 24 – Semantic interoperability problems solved without using SEN 41
Figure 25 – Semantic interoperability problems solved using SEN 42
Figure 26 – InterConnect ontologies extending SAREF ontologies 43
Figure 27 – Subset of the SAREF-compliant sensor dictionary applied to energy 44
Figure 28 – LOT Base methodology workflow 48
Figure 29 – FIESTA IoT ontology federation 50

Table 1 – Ontology best practices: check list summary 46

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Guidance and plan to develop smart energy ontologies

FOREWORD

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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.

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*