NFDI4Energy Conference

1. NFDI4Energy Conference

10.5281/zenodo.10627762

Published: 2024-02-07

Towards a common standard for energy-related domain ontologies – Lessons learned from the OBO Foundry

Abstract for the 1. NFDI4Energy Conference 2024

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Keywords: OBO foundry, Open Energy Ontology, energy research, domain ontologies, interoperability, common standards

Interoperable energy ontologies

Ontologies enable the digitisation and publication of scientific data in a way that allow reuse, as well as transparency and reproducibility of research results. Therefore, the authors are involved in the development of the Open Energy Ontology (OEO)[1], an ontology that is dedicated to cover the domain of energy system modelling from a perspective of a less detailed but generic point of view [1].

Energy researchers are becoming increasingly aware of the advantages of using ontologies. As a consequence, the OEO development team has recently been approached with requests to extend the OEO in certain ways. These include technical details of wind turbines, hydrogen infrastructure, covering transportation and mobility in more detail, or the terminology of the German core energy market data register (Marktstammdatenregister, MaStR [2]).

Wind power, the transportation sector and hydrogen as an energy carrier are within the scope of the OEO. They are represented at a level of abstraction sufficient for energy system modeling. However, this does not include individual components of wind turbines, for example.

These requests to extend the OEO highlight a dilemma in developing ontologies for the energy domain. On the one hand, one could extend the scope of the OEO

[1]https://openenergyplatform.org/ontology/oeo/

[2]https://www.marktstammdatenregister.de/MaStR

to encompass all things related to energy. The most notable advantage of this approach is that the OEO would enable free integration and exchange of data across the whole field of energy research. However, the resulting ontology would need to be huge and a central development process would be unmanageable. On the other hand, we could encourage people to develop their own ontologies, tailored to their specific needs. Given the probable overlap and shared terminology between these resulting ontologies and the OEO, this approach is likely to result in a lot of redundant work, as well as competing and contradicting terminological choices. More importantly, if in the future the OEO, and – for example – a wind power ontology, a transportation ontology and a hydrogen infrastructure ontology are developed independently from each other, we will have replicated the interoperability problems on a higher level: The data annotated with terms from one ontology will not be seamlessly exchangeable with data annotated by another ontology.

In order to find a strategy to navigate this dilemma, we suggest to review the best practices that were established by ontologies in the life sciences, in particular by the OBO Foundry. The OBO Foundry consists of a network of independently developed ontologies that each follow certain common principles. This results in a standardisation of ontologies and that enables interoperability.

Harmonising ontology development: the OBO foundry

The use of ontologies in the research area of biology and biomedicine is well-established to organise, curate and interpret huge amounts of research data.

The Open Biological and Biomedical Ontologies (OBO) project reaches back to the early 2000s, as the number of ontologies and their applications grew [2]. At the time, ontologists became aware that when developing ontologies independently, integrating multiple ontologies can lead to incompatibilities. Therefore, the goal of OBO was to coordinate and guide the ontology development on behalf of common standards and principles. These standards should enable a modular composition of ontologies and provide guarantees of technical and scientific quality [3]. The OBO foundry was initiated to curate and to develop further the OBO principles, and to watch the quality of member ontologies. To this date, there are more than 150 active member ontologies.

OBO requires, that the domain of the ontology has to cover a biological or biomedical research area. However, the need for interoperable ontologies in other domains is emerging, too. Similar to OBO, yet smaller and less detailed, the BSSO foundry is a community of practice and exchange for the development, adoption and use of ontologies in the behavioural and social sciences[3].

OBO principles to guide ontology development

The guiding principles for OBO foundry are explained in detail on the OBO foundry website[4], some of which are mandatory and others recommended.

There are a couple of principles referring to format, publication and re-usability: *Openness*, being the first principle mentioned, is a must-have criterion for OBO. It requires that the ontology is published under an open licence that is equivalent to or less restrictive than CC-BY. This is justified by the fact, that an ontology can only contribute meaningfully to an interoperable research data infrastructure when ontology develop-

[3] https://www.bssofoundry.org/bsso/
[4] https://obofoundry.org/

ers are free to re-use terms from the respective ontology. OBO further requires the ontologies to be published in a common format, use a unique IRI, as well as a procedure of versioning. Existing relations from the Relations Ontology (RO)[5] should be re-used and a couple of naming conventions are recommended for the development. Although, it is not an official principle, most OBO Foundry domain ontologies use the Basic Formal Ontology (BFO) [4] as top level ontology, or de facto apply its basic structure, and follow BFO design principles. A shared upper ontology facilitates the reuse of existing OBO Foundry ontologies as part of others.

Another set of principles focuses on content and documentation: The *scope* of the ontology has to be specified clearly and orthogonal to other OBO ontologies. Orthogonality prevents overlapping vocabulary and competing definitions [4]. Other principles aim for textual definitions of classes, a detailed documentation for both users and developers, as well as maintaining the ontology to reflect changes in scientific consensus and remain accurate over time.

Finally, some principles guide the interaction with the user and developer community. Amongst others, as good and common practice in many standards-oriented scientific activities, the ontology should be developed in a collaborative fashion.

Applying OBO findings to the energy domains

Inspired by OBO, we propose to create an initiative, that considers the needs of energy-related ontology communities and supports interoperable and re-usable ontology development. We suggest to discuss and investigate, which guidelines and principles are useful and specifically important for our ontology communities, and thus derive a set of guidelines to standardize and align energy related domain ontologies. Our goal is to facilitate the development of a suite of harmonised and interoperable ontologies, which cover all aspects of energy and its usage such as technical provision, distribution, as well as their technical, socio-economic, infrastructural or environmental impacts. To succeed, we are aware that it will be necessary to broadly reach and interconnect energy researchers and ontologists on an international level.

Funding

We wrote this abstract as part of the research projects *SIROP* (grant number 03EI1035A-D), *Stadt-Land-Energie* (grant number 03EI1051A-D) and *LOD-GEOSS* (grant number 03EI1005A-G) funded by the 7th Energy Research Programme of the German Federal Ministry for Economic Affairs and Climate Action (BMWK).

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