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Extension of the Open Energy Ontology

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1 Introduction

An important prerequisite for the development of a connected database infrastructure is the documentation of a consistent terminology. The aim is to ensure that data is understood equally by both human and machine users. A categorization is to be developed from which a common data model can be derived. The overarching goal is to bring together many experts from different fields and capture their knowledge in a shared ontology.

Ontologies enable the unambiguous categorization of terms and definitions. With a standardized ontology, it becomes possible to compare data with different structures. The foundation of the Open Energy Ontology (OEO) is being developed in the research project *SzenarienDB*. The OEO is using the Web Ontology Language (OWL) with the help of the open-source software Protégé[1]. Based on this foundation, a modular system of ontologies is being developed. Since the research field of energy system analysis covers a wide range of areas, the ontology will be divided into well-defined subdomains. Conceptual spaces such as geography, economics, social science, and computer science and modeling play a role.The general structure and the development process is described in more detail in Booshehri et al. (2021).

Technical goal of the extension of the OEO is to increase the level of formalization of data schemas and ontologies. An important factor that ensures the sustainability of the results is the availability of tools and processes for domain experts within the consortium and the community to ensure long-term maintenance and expansion of the created ontologies.

This report consists of several chapters corresponding to different work packages that focus on various data types and areas within the LOD-GEOSS project. Each work package is led by different institutions with significant expertise in the respective data domains. Other participating stakeholders contribute their experiences from their diverse modeling worlds to ensure the developed results have broad applicability.

[1] https://protege.stanford.edu/

2 Enhancements of the OEO

In order to use the distributed data infrastructure of LOD-GEOSS, data should be annotated with the OEMeatadata string and use the Open Energy Ontology within the description of the data set and the data collumns. For this, the ontology has been enhanced by a number of new terms and some concepts and terms needed to be revisited and changed.

The following terms were added or updated to characterize energy technologies, socio-economic and statistical data, model parameters, time resolved data, infrastructure data and model results.

The listing give the added terms and their defintions or the changes which have been applied to the Open Energy Ontology.

2.1 Statistical Data and Model Parameters

This chapter focuses on input data with little or no temporal variability. The data, such as technology data characterizing the properties of energy technologies and their changes due to technological learning, as well as socio-economic data like economic and price developments of relevant goods or official statistics, undergo minimal changes, often on an annual basis. Additionally, less dynamic geospatial data, such as administrative boundaries, land use, protected areas, or renewable generation potentials, are included. These datasets are typically represented as raster data with fixed spatial resolution.

The following classes were created or edited by project employees during the developer meetings and in GitHub discussions:

Statistical Data

- Gross Domestic Product (GDP): A gross domestic product is an economic value that represents the broadest measure of aggregate economic activity, measuring the total unduplicated market value of all final goods and services produced within a statistical area in a period.

- Gross Value Added: Gross value added is an economic value that is the value of goods and services produced in a sector of an economy, measuring that sector's contribution to gross domestic product (GDP). It is calculated as the monetary value of products and services produced, less the value of intermediate consumption.

- Cost: Cost is an economic value that describes the amount of money needed to buy, make, or do a thing.

- Delivery Cost: A delivery cost is a cost for a product or service that refers to the total unit cost of a product or commodity delivered to a certain market, city, or customer. It is normally composed of all associated transport costs and the unit cost of production for that product.
- Fixed Cost: A fixed cost is a cost for operation and maintenance that does not vary with the amount of goods or services produced.
- Investment Cost: Investment costs are costs of a long-term commitment of financial resources in tangible or intangible assets.
- System Cost: System costs are the total costs of a system.
- Variable Cost: A variable cost is a cost that depends on an amount of goods or services.
- Levelised Cost of Electricity: Levelised cost of electricity is the net cost of converting energy to electricity/electric energy over the lifetime of an energy transformation unit. They are calculated considering all relevant costs, including investment, operation, maintenance, and fuel cost, etc.
- Discount Rate: A discount rate is an economic value with the unit percent that refers to the interest rate used in discounted cash flow (DCF) analysis to determine the present value of future cash flows.
- Marginal Cost: Marginal cost is the economic value that corresponds to the change in the total cost that arises when the quantity produced is incremented by one unit; that is, it is the cost of producing one more unit of a good.
- Sector Activity
  - is sector of:A relation that holds between a sector and the processes or material entities it covers.
  - sectoral energy consumption: A sectoral energy consumption is the energy use of a sector.
  - sectoral emission: A sectoral emission is an emission caused by a certain sector.
- CO2 Price: A CO2 price is an emission price of emitting a certain CO2 emission value.
- Purchasing Power Parity: Purchasing power parity is an economic value representing the ratio between currencies that equalizes differences in monetary price levels between countries for the same set of goods.
- Monetary Price: A monetary price is an economic value that describes the amount of money requested, expected, required, or given in exchange for something else.
- Electricity Price: Electricity price is the monetary price per energy unit of electricity.

- Emission Certificate Price: Emission certificate price is a monetary price of an emission certificate that allows the emission of a certain emission value.
- Export Price: An export price is the monetary price for the export of a material entity.
- Import Price: An import price is the monetary price for the import of a material entity.
- Eurostat Synonyms: Added synonyms from Eurostat statistics for
  - secondary energy production: alternative label: secondary production of energy.
  - primary energy production: alternative label: primary production of energy.
  - gigawatt-hour: alternative label: gigawatt hours.
  - kilowatt-hour: has_exact_synoym: kWh, alternative label: kilowatt hours.
- population: A population is an aggregate of people in a spatial region.
- urban population: An urban population is a population living in urban areas, as defined by national statistical offices.
- rural population: A rural population is a population living in rural areas, as defined by national statistical offices.
- labor force: The labour force is the population of people ages 15 and older who supply labour to the production of goods and services. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time job-seekers.
- working age population: The working age population is the population of people aged 15 to 65.
- Consumption subclasses

Geodata

- considered region: A considered region is a spatial region that is used in an analysis.
- interacting region: An interacting region is a spatial region that interacts with a study region. It is part of a considered region, but not a study region.
- study region: A study region is a spatial region that is under investigation and consists entirely of one or more subregions.
- subregion : A subregion is a spatial region that is a part of spatial region.

- space requirement: A space requirement is a two-dimensional spatial region that covers the area needed by an object or object aggregate.
- operational space requirement: An operational space requirement is space requirement that covers the area needed by an artificial object in order to operate properly.
- personal living space: A personal living space is a space requirement that one person uses for living.
- space requirement for construction: A space requirement for construction is space requirement of an artificial object that covers the area needed in order to construct an artificial object.
- protected area: A protected area is a two-dimensional spatial region recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values.
- flow potential: A flow potential is a potential of an input or output of a process, per time unit.
- economic flow potential: An economic flow potential is a type of flow potential that identifies the proportion of the technological potential that can be utilised economically (based on economic boundary conditions).
- developable flow potential: A developable flow potential is a type of flow potential that describes the fraction of the economic potential that can be developed under realistic conditions (regulations, environmental and social restrictions).
- sustainable flow potential: A sustainable flow potential is a type of flow potential that takes into account all aspects of sustainability, which usually requires careful consideration and evaluation of different ecological and socio-economic aspects. The differentiation of the sustainable potential is blurred, since ecological aspects may already have been considered for the technological or economic potential, depending on the author.
- theoretical flow potential: A theoretical flow potential is a type of flow potential that identifies the physical upper limit of an input or output of a process in a spatial region of reference per unit time.
- technological flow potential: A technological flow potential is a type of a flow potential derived from a theoretical flow potential, taking account of the annual efficiency of the respective conversion technology and the additional restrictions regarding the area that is realistically available for energy generation.
- stock potential: A stock potential is a potential of the stock of a source or sink.

Technology data

- industrial process: An industrial process is a process that has output object or object aggregates that are economic goods. An industrial process consists of several subprocesses. Examples of subprocesses that can be involved in an industrial process are energy transformations, mechanical operations and chemical reactions.
- solar chemical energy transformation: A solar chemical energy transformation is a solar energy transformation that converts solar energy into chemical energy.
- stream-electric process: A steam-electric process is an energy transformation that converts thermal energy to electrical energy. A steam turbine and an electro motive generator are participating in a steam-electric process.
- geothermal energy: Geothermal energy is thermal energy that is released from within the earth's crust.
- ambient thermal energy transfer: Ambient thermal energy transfer is a heat transfer from the ambient air to a transportable material entity.
- marine wave energy converting unit: A marine wave energy converting unit is a hydro power unit that uses marine wave energy.
- marine wave energy power plant: A marine wave energy power plant is a power plant that has marine wave energy units as parts.
- marine wave energy transformation: Marine wave energy transformation is a hydroelectric energy transformation that converts marine wave energy to electrical energy.
- marine wave energy: Marine wave energy is the natural hydro energy of a wave.
- Carbon Capture and sequestrations
  - carbon captureCarbon capture is a process that captures carbon dioxide from a gas.
  - direct air capture Direct air capture (DAC) is carbon dioxide capture from air.
  - carbon storage: Carbon storage is a process that stores CO2 in a geological formation.
  - carbon capture and storage: Carbon capture and storage (CCS) is a process that combines carbon capture and carbon sequestration.
- outage : An outage is a process during which an artificial object cannot perform or operate.

- forced outage: A forced outage is an outage of an artificial object caused by a failure.
- planned outage: A planned outage is an outage during which an artificial object is being maintained.
- curtailment : Curtailment is a process in which a power generating unit is forced to reduce its output, in order to balance energy supply and demand or due to transmission constraints.
- space requirement: A space requirement is a two-dimensional spatial region that covers the area needed by an object or object aggregate.
- operational space requirement: An operational space requirement is space requirement that covers the area needed by an artificial object in order to operate properly.
- personal living space: A personal living space is a space requirement that one person uses for living.
- space requirement for construction: A space requirement for construction is space requirement of an artificial object that covers the area needed in order to construct an artificial object.
- net capacity factor: A net capacity factor is a utilisation value that is calculated by dividing the net electricity generation over a given time step by the declared net capacity times the length of this time step.
- rotor diameter: Rotor diameter is a quality of a wind energy converting unit that measures the diameter of the wind rotor.
- ramping : Ramping is a process attribute that describes the change in power of an energy transformation unit or an energy converting component per time step.
- heat generation process: A heat generation process is an energy transformation that has thermal energy as energy output.
- industrial and material subclasses
  - industrial material: An industrial material is a portion of matter that is the physical output of an industrial process and that has a good role.
  - chemical substance A chemical substance is a portion of matter of constant composition and that is neither a metal or mineral. It is composed of molecular entities of the same type or of different types that is used in or produced by a chemical reaction involving changes to atoms or molecules. It is the physical output of an industrial process and has a commodity role.

  - paper: Paper is a portion of matter that is made from cellulose fibres and other plant materials. It is used for paper-based products. It has a solid normal state of matter. It is the physical output of an industrial process and has a commodity role.
  - cement: Cement is a portion of matter that is made from limestone and clay; other elements may be present. It is used as a building material to set as a solid mass or is used as an ingredient in making mortar or concrete. It has a solid normal state of matter. It is the physical output of an industrial process and has a commodity role.
  - mineral: A mineral is a portion of matter that is normally crystalline formed.
  - non-metallic mineral: A non-metallic mineral is a mineral that does not contain any metallic content within themselves. It is the physical output of an industrial process and has a commodity role.
  - metal: A metal is a portion of matter consisting of an atom of an element that exhibits typical metallic properties, being typically shiny, with high electrical and thermal conductivity.

- energy service demand: An energy service demand is a demand of an agent to use energy as a means to obtain or facilitate desired end services or states.
- photovoltaic cell: A photovoltaic cell (PV cell) is a generator that converts solar energy into electrical energy.
- steam reforming: A steam reforming process is a chemical reaction that converts hydrocarbons and steam to syngas. As it converts chemical energy and thermal energy to a different type of chemical energy (and waste heat), it is also an energy transformation process.
- measurement device: A measurement device is an artificial object that is used in some measurement process.
- more heat items
  - rotary heat exchanger: A rotary heat exchanger is a heat exchanger that uses a wheel for a heat transfer process.
  - Okate heat exchanger: A plate heat exchanger is a heat exchanger that uses a plate for a heat transfer process.
  - boiler: A boiler is a heater that increases the thermal energy of fluids.
  - tube collector: A tube collector is a solar thermal collector that consists of tubes.
  - flat-plate collector A flat-plate collector is a solar thermal collector that consists of flat-plates.
- combined cycle electricity generation process: A combined cycle electricity generation process is a fuel-powered electricity generation process in which a gas turbine process is followed by an steam-electric process.

- conventional energy: A conventional energy is an energy that has a conventional origin.
- fuel supply system: A fuel supply system is an energy system covering the distribution of fuels.
- final energy consumption: Final energy consumption is an energy consumption value accounting for the energy delivered to and consumed by end users.
- Capacities
  - energy storage capacity: An energy storage capacity is the quantity value stating the maximum energy an energy storage object can store.
  - power rating: Power rating is a power capacity stating the maximum power an energy converting component can convert.
  - declared net capacity: Declared net capacity is a power capacity stating the maximum power a power generating unit or a power plant can deliver to the electrical grid. It equals the sum of the rated powers of all plant generators minus all power used internally within the plant.
  - nameplate capacity: Nameplate capacity is the power capacity stating the maximum power an artificial object, e.g. a power generating unit or a power plant, can generate, and the sum of the power ratings of all energy converting component of that power plant.

2.2 Time-Resolved Data

This chapter concentrates on data with high temporal dynamic, usually available at least on an hourly basis and often with high spatial resolution. This includes time series data from weather models (including forecasts) and remote sensing, as well as individual observations. Consumption, feed-in, and energy trading time series, as well as grid node load flows, are also considered. These datasets are significantly larger, and their spatial and temporal structure needs to be adequately addressed. Proposals for formatting such data will align with established standards within the data-generating community and be further developed for energy system analysis as needed. A crucial aspect is processing and documenting the quality standards of time-resolved data, particularly the conversion of meteorological variables into power (e.g., wind, irradiation). Clear structures and documentation rules are necessary when, for example, irradiation data is converted into PV power using different calculation methods that are not generic across all energy system models. This work package designes the necessary structures to ensure seamless documentation from raw data to feed-in data. The data processing and format changes should be as automated as possible to eliminate manual and non-transparent data manipulation.

The following classes were created or edited by project employees during the developer meetings and in GitHub discussions:

- time stamp: A time stamp is a zero-dimensional temporal region that is used to describe a time step.
  - time stamp alignment: A time stamp alignment is a data descriptor that indicates the position of a time stamp in a time step.
  - start alginment: A start alignment is a time stamp alignment indicating that the time stamp marks the start of the time step.
  - middle alginment: A middle alignment is a time stamp alignment indicating that the time stamp marks the middle of the time step.
  - end aligment: An end alignment is a time stamp alignment indicating that the time stamp marks the end of the time step.
- aggregation type: An aggregation type is a data descriptor that contains information on the aggregation method applied on a data set.
  - instantaneous: value measured at or modelled for exactly one 0-dim temporal region, referenced by a time stamp, e.g. to represent a time step in a time series.
  - integral: Sum or integral of values, e.g. within a time step or a spatial region.
  - arithmetic mean: Average value calculated by arithmetic mean over a set of data values, e.g. within a time step or spatial region.
  - minimum: Minimum value within a set of data values, e.g. in a time step or spatial region.
  - maximum: Maximum value within a set of data values, e.g. in a time step or spatial region.
- radiation : Radiation is an energy transfer by emitting or transmitting energy in the form of waves or particles through a spatial region or a material entity.
- direct solar radiation: Direct solar radiation is radiation that is the non-scattered part of solar radiation from the sun within the extent of the solar disk only.
- diffuse solar radiation: Diffuse solar radiation is radiation that is the part of solar radiation that has been scattered by gas molecules in the atmosphere and by particles such as cloud droplets and aerosols.
- solar radiation: Solar radiation is radiation that is emitted by the sun.
- non-scattered radiant flux density: A non-scattered radiant flux density is an areal solar power density that measures the direct solar radiation within the extent of the solar disk only (half-angle 0.266 deg).
- solar tracking: Solar tracking is a process in which a radiation receiving surface is following the path of the sun on the sky.

- single axis tracking: Single axis tracking is solar tracking in which a radiation receiving surface is following the path of the sun by roting along a fixed axis. Typical axis orientations are North-South or East-West.
- two axis tracking: Two axis tracking is solar tracking in which a radiation receiving surface is following the sun by rotating around two axes. The surface is always oriented normal.
- solar tracked receiving surface: A solar tracked receiving surface is a solar radiation receiving surface that participates in solar tracking.
- single axis tracked receiving surface: A single axis tracked receiving surface is a solar radiation receiving surface that participates in single axis tracking.
- two axis tracked receiving surface: A two axis tracked receiving surface is a solar radiation receiving surface that participates in two axis tracking.
- time step: A time step is a one-dimensional temporal region that has a start time and an ending time and thus a finite duration.
- scenario year: A scenario year is a time step that has a duration of one year and is part of a scenario horizon.
- weather time series: A weather time series is a time series that contains data about a specific meteorological year.
- meteorological year: A meteorological year is a time step in which meteorological data was collected and that has a duration of one year.
- delivery time: Delivery time is a one-dimensional temporal region expressing the amount of time that it takes for goods that have been bought to arrive at the place where they are wanted.
- start time: A start time is a zero-dimensional temporal region that indicates the beginning of a one-dimensional temporal region.
- ending time: An ending time is a zero-dimensional temporal region that indicates the end of a one-dimensional temporal region.
- time stamp: A time stamp is a zero-dimensional temporal region that is used to describe a time step.
- time stamp alignment: A time stamp alignment is a data descriptor that indicates the position of a time stamp in a time step.
- aggregation type: An aggregation type is a data descriptor that contains information on the aggregation method applied on a dataset.
- surface azimuth angle: A surface azimuth angle is a quantity value with a plane angle unit that measures the deviation of the projection on a horizontal plane of the normal to the plane from the local meridian, with zero due south, east negative, and west positive.

- slope : A slope is a quantity value with a plane angle unit that measures the angle between the plane of a surface and the horizontal plane.

- quality control flat: A quality control flag is a data descriptor that describes the measurement quality of a data set, e.g. a time series.

2.3 Infrastructure Data

This chapter focuses on gas, electricity, and heat network infrastructure data, which often exist as vector data with varying levels of georeferencing quality. This workpackage develops consistent terminologies for vector-based geospatial energy infrastructure data. The focus is on describing energy networks, which includes not only the geographical dimensions (e.g., power line routes, power cables per route, overhead line pylons, network areas) but also the electrical parameters. The delimitation of individual sub-areas must be considered initially, and existing ontologies can potentially serve as a foundation.

The following classes were created or edited by project employees during the developer meetings and in GitHub discussions:

- international transport: An international transport sector is a transport sector of international transport processes.

- freight transport: Freight transport is a transport process which moves goods from one place to another.

- private transport: A private transport is a passenger transport in which people use their own vehicle for movement e.g. bicycle, motorcycle and cars.

- public transport: A public transport is a passenger transport in which a number of passengers share a common vehicle.

- industry sector: An industry sector is a sector that covers industrial activities with other main purposes of energy transformation.

- industrial material: An industrial material is a portion of matter that is the physical output of an industrial process and that has a good role.

- agriculture, forestry and land use sector: A agriculture, forestry and land use (AFOLU) sector is a sector that covers activities and natural processes from agriculture, forestry, land use and land use change.

- waste and wastewater sector: A waste and wastewater sector is a sector that covers activities related the collection and treatment of waste and wastewater.

2.4 Model Result Data

This chapter aims to develop the ontology for different types of models and relevant variables, enabling the structured and machine-readable representation of result data. This facilitates increased usability for target audiences. This sub-activity package is a crucial prerequisite for utilizing the database infrastructure for comparative experiments within a model type.

The following classes were created or edited by project employees during the developer meetings and in GitHub discussions:

- emission factor: An emission factor is a process attribute that quantifies the emissions or removals of a gas per unit activity.
- consumption: Consumption is the process of using something and thereby reducing its amount.
- energy use: Energy use is the consumption of an energy carrier making use of the energy it carries.
- non-energy use: Non-energy use is the consumption of an energy carrier without making use the energy it carries.
- final energy consumption: Final energy consumption is an energy consumption value accounting for the energy delivered to and consumed by end users.
- gross inland energy consumption: Gross inland energy consumption is an energy consumption value accounting for the total consumption of energy in a spatial region (e.g. a country).
- primary energy consumption: Primary energy consumption is an energy consumption value accounting for the total consumption of energy in a spatial region excluding the non-energetic use of fuels.
- demand: A demand is a realizable entity that is characterised by a person, organisation or object needing it for a specific purpose.
- energy demand: Energy demand is a demand for energy.
- energy service demand: An energy service demand is a demand of an agent to use energy as a means to obtain or facilitate desired end services or states.
- energy service demand for passenger-kilometre: Energy service demand for passenger-kilometre is the energy service demand that is consumed to transport one person over a distance of one kilometre.
- energy service demand for ton-kilometre: Energy service demand for ton-kilometre is the energy service demand that is consumed to transport one metric ton over a distance of one kilometre.

- energy conversion efficiency: Energy conversion efficiency is a process attribute describing the ratio between the input of an energy transformation and the outputs that are used.
- electricity generation process: An electricity generation process is an energy transformation that has electrical energy as physical output.
- combined heat and power plant: A combined heat and power plant (CHPP) is an energy transformation unit that consists of combined heat and power generating units, a grid component feeding electric energy into an electricity grid, and a grid component feeding thermal energy into a heating grid.

3 Contributions to OEO development

Contributing to the development of the OEO is possible on various level. Depending if contributions are rather technical or more content-related, different workflows are in place and skillsets are requiered. Domain experts can contribute in discussions to share and help with their knowledge. Ontology experts can contribute in discussions to help categorize proposed terms and implement them.

The main prerequisite for contributions of either type is a GitHub account. To join the OEO community on GitHub, either use the OEFamily contact form[1] or open an issue on GitHub.

3.1 Content-related contributions

Domain experts can discuss and propose new terms and concepts in GitHub issues. It is recommended to propose definitions and labels without using *Basic Formal Ontology* words to encourage other domain experts to engage in discussions. When proposing new concepts, look for parent classes and add relations to make contributions specific. When 20 or more comments on an issue are reached, the topic is put on the agenda of a Thursday's bi-weekly developer meeting (even weeks)[2] for discussion in person. Generally, it is encouraged to make counter proposals when you disagree on definitions and to follow through with issues without long breaks.

3.2 Technical contributions

Once an agreement on a term is reached, it will be implemented.
Terms are added through pull requests to the existing code base on GitHub. A specific pull request workflow is in place to standardise the process and to control the contribution quality[3].

[1] https://openenergy-platform.org/contact/
[2] https://github.com/OpenEnergyPlatform/ontology/wiki/oeo-dev-meeting-plan
[3] https://github.com/OpenEnergyPlatform/ontology/wiki/pull-request-workflow

4 Publications

- Booshehri, Meisam, et al. *Introducing the Open Energy Ontology: Enhancing data interpretation and interfacing in energy systems analysis.* Energy and AI 5 (2021): 100074. https://doi.org/10.1016/j.egyai.2021.100074
- Stappel, M., Emele, L., Hülk, L., & Förster, H. (2022). *The representation of energy, energy carriers and fuels in the Open Energy Ontology.* https://cuer-ws.org/Vol-3249/paper1.Ensusto.pdf
- Ruiz, Eugenio S. Arellano, Ulrich Frey, and Carsten Hoyer-Klick. *Competency questions for a test first development of an energy systems analysis ontology.* (2022). https://ceur-ws.org/Vol-3249/paper2-Ensusto.pdf

5 Community building and networking

The chapter touches upon initiatives and activities of community building and networking to cultivate the OEO community.
The development and adoption of the Open Energy Ontology (OEO) is not only technical but also relies on the active engagement and collaboration of the energy system modeling community. We recognize that the success and sustainability of any ontology development heavily depend on the involvement of domain experts, stakeholders, and interested parties who collectively contribute their expertise, insights, and perspectives.

Community building plays a crucial role in fostering a collaborative and inclusive environment where knowledge sharing, best practices, and continuous improvement can flourish. It involves establishing channels for communication, coordination, and collaboration among individuals and organizations working on the development, maintenance, and utilization of the OEO. A OEO strategic development goal is to create a supportive ecosystem that promotes the growth and adoption of the ontology, ensuring its relevance and usefulness for the energy modelling domain.

Effective communication channels in the OEO community exist, such as the regular developer meetings, mailing lists, GitHub issues and GitHub wiki as main documentation, which facilitate information exchange, discussions, and the dissemination of updates and announcements. However, community events, workshops, and conferences complement digital communication and provide opportunities for face-to-face interactions, collaboration, and the establishment of personal connections[1].

Furthermore, collaborative bodies, such as developer meetings, working groups, and the OEO steering committee, play a crucial role in shaping the ontology, resolving issues, addressing conflicts, and aligning the efforts of community members. These structures and processes ensure transparency, accountability, and effective collective decision-making.

Networking and collaboration beyond the OEO community itself is paramount to establish connections and partnerships with other initiatives, organizations, and standardization bodies in the energy sector and from industry. Collaborations and interoperability with other ontology's avoid duplication of efforts, and contribute to a more comprehensive and interconnected energy knowledge landscape. The mentioned measures and OEO design decisions strive to build a strong and sustainable foundation for the OEO that serves the diverse needs of the energy modeling domain and its stakeholders.

[1] https://openenergyplatform.github.io/organisation/family_community/

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URL: *https://www.sciencedirect.com/science/article/pii/S2666546821000288*