Task-Based Semantic Framework for Organizing Energy Research

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Abstract

Effective management, discovery, and reuse of research software in the energy domain crucially depend on rich and standardized metadata [1], [2], [3]. Among these, the “purpose” or “scope” of a software package is one of the most important pieces of information [4]. Today, such information is typically captured as free-text entries [5], [6], [7], which require human interpretation and cannot be processed or categorized automatically. This limitation hinders automated discovery, categorization, combination, and topic-driven cross-linking to datasets, publications, and researchers.

To address this challenge, we propose the Open Energy Task Ontology, an approach that formalizes the purpose of research software through tasks: semantically defined activities within energy research that can be organized hierarchically, ranging from abstract tasks (e.g., “Wind Resource Assessment”) to specific actions (e.g., “Turbine Placement” or “Power Generation Simulation”). Tasks are defined as ontological classes with clear, human-readable definitions and associated goals representing the intended outcomes, rather than mere keywords, enabling machine-readable categorization and logical reasoning. They are interconnected through relationships such as predecessor/successor, contains/part-of, alternative-for, and can be applied across multiple granularities. By chaining multiple tasks, researchers can construct workflows that capture complex sequences of activities. These workflows can be implemented and executed through software packages, with task relationships enabling automated suggestions of compatible components and alternative solutions.

The utility of tasks extends beyond software. A task-centric metadata model enables a wide range of applications. Software can declare the tasks it implements and the purpose it serves, while task relationships help identify compatible components, upstream and downstream steps, and alternative solutions. For example, we have implemented and published a multi-step workflow for wind-potential assessment that illustrates how tasks can structure complex processing pipelines [8]. Datasets can be annotated as inputs or outputs for specific tasks, which supports targeted dataset discovery and integration within task-based workflows. Textual resources such as publications and tutorials can reference the tasks they describe or discuss, turning tasks into a formalized semantic anchor for scientific literature and educational materials. Tasks also offer a way to characterize researchers’ skills and expertise, facilitating

the discovery of individuals capable of performing or supervising specific research activities. Finally, research organizations and projects can be associated with the tasks they pursue, providing a structured overview of task-specific activities across the community. In this way, tasks act as semantic glue, harmonizing heterogeneous metadata types and enabling powerful cross-object discovery: one can query, for example, “Which datasets support the Turbine Placement?”, “Which software implements this task?”, “Who has expertise in this task?”, or “Which publications explain this task?”. The task-centric approach also forms a natural foundation for domain-specific metadata standards such as ERSmeta [9], and is likewise compatible with more general frameworks for software-interface metadata such as DataDesc [10], into which these principles can be seamlessly integrated.

The current status of the Open Energy Task Ontology includes a prototype hierarchy of tasks, several examples integrated into the Open Research Knowledge Graph [11], and the previously mentioned workflow demonstrating task-based structuring of research software [8]. To ensure conceptual consistency and interoperability, the ontology reuses established ontological concepts and hierarchies, for example those from the Open Energy Ontology [12]. While the ontology is still in its conceptual phase, these initial results highlight the potential of tasks as a central organizing principle in energy research, with the capacity to fundamentally transform how software, data, and expertise are discovered, connected, and reused across the field.

At the NFDI4Energy 2026 conference, we aim to present this concept to the community, illustrate its applications, and gather feedback on the proposed hierarchical task structure and its semantic relationships. Our goal is to explore community perspectives, identify opportunities for collaboration, and critically assess the overall approach. By involving the research community early on, we hope to collaboratively explore the full potential of task-based metadata for software, data, text publications, and expertise in energy research.

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