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Conference Abstract

# Implementation of a Photovoltaic System Model Using FAIR Digital Objects

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## Abstract

The energy transition is an urgent and challenging subject in research and for society. For this, transitioning to renewable energies is one key element of the energy transition, but renewable energies have drawbacks with regard to their reliability of power supply. The weather as well as day and night periods induce a very high volatility, that requires multiscale coordination of power supply and demand. Therefore, the power grid will undergo a drastic change from a puely demand-driven towards a supply and demand-driven network. The operation of these highly coordinated future smart grids will create huge data volume which needs to be managed appropriately. In the scientific domain as well as in operations FAIR Digital Objects (FDOs) are envisaged to be a key technology for this task. FDOs provide access to metadata allowing applications to automatically retrieve the referenced data, interpret it semantically and support energy researchers and operational staff to handle it in a more sustainable way.

In Schweikert et al. (2022) a concept is proposed which allows to describe different aspects of an object. Arbitrary schemas and ontologies can be utilized and a coherent object graph is provided by using FDOs. As an conceptual example the authors employed a photovoltaic system (PV system). The data of this system is divided into two kinds: static data and dynamic data. Static data is further divided into *structural composition metadata*, which describes the entities of the PV system and their relations to each other, and *master data* which are used to describe the properties of the different entities (comparable to a

technical information data sheet). Dynamic data is the measurement data which is acquired at several locations within the PV system. The structural composition metadata is described by using an in-house developed ontology called *PV Ontology* based on the Web Ontology Language*[1]. The master data is described using the standards IEC 61850*[2], GeoJSON*[3] and SensorML*[4] (for the master data of the sensors). The dynamic data - the structure of the measurement data and its geo-position - is also described with SensorML.

By describing every entity in the PV system using the mentioned schemas, a lot of description objects (instances of the schemas) are created. For instance, a PV module is comprised of three description objects, one written in IEC 61850 (technical data sheet), another in GeoJSON (geo-position and dimensions), and the third is the ontology instance where the PV module is represented as a node in the ontology instance graph. How can these three objects be linked with each other to make clear that the containing information is about this PV module? Schweikert et al. (2022) uses FDOs to create these associations. The profile used in the FDOs is the Helmholtz Kernel Information Profile (KIP) (Pfeil et al. 2022) which is an extension of the Research Data Alliance (RDA)*[5] KIP (Weigel et al. 2018). It introduces several new properties, inter alia, the property *hasMetadata*. This property allows to reference further FDOs providing metadata to the current one. Using the Helmholtz KIP Schweikert et al. (2022) constructs the description of the PV system as follows: An FDO is created for the ontology instance (hereinafter referred to as ONT-FDO). For every entity of the system with description objects an FDO (Bridge-FDO) is created. The *digitalObjectLocation* of these FDOs is referencing the ONT-FDO plus adding the ID of the corresponding entity in the ontology instance as fragment identifier. This bridges the border between the ontology and the FDOs and allows unambiguous referencing of ontology graph nodes. An application using the PV ontology and a given Bridge-FDO can infer the position of the entity in the PV system. For every description object an FDO is created and linked to its entity by using the *hasMetadata* property on the Bridge-FDO. Alternatively, if one wants to reduce the number of FDOs, a collection (e.g, using RDA's Collection Recommendations (Weigel et al. 2017)) containing all description objects can be created and referenced through the Bridge-FDO by creating an FDO for the collection. Lastly, a final Bridge-FDO can be created pointing with its *digitalObjectLoaction* to the PV system root node and referencing all other Bridge-FDOs with its *hasMetadata* property.

Schweikert et al. (2022) did not implement the discussed concept. In the present work we introduce for the first time an implementation of the concept, in which we develop an application that allows users to browse and visualize all the data (structural design, technical information of the components and measurement data) of a PV system. A user provides a persistent identifier (PID) to the application and the application starts to resolve all the data associated with the PID. Three possible cases of a given PID can occur: First, the PID of the entire PV system is entered, the application retrieves the data for all components of the system and presents them to the user. Second, the PID of one component is entered, the application retrieves all the data of this component and presents them to the user, and an option to browse the complete system is offered. In these two cases it is assumed that the entered PID belongs to a Bridge-FDO. In the last case a PID of a description object is entered, then the application behaves as in the second case. The

implementation verifies the concept in which any information about the PV system can be obtained by any starting node in the object graph spanned by the FDOs. It also provides insight into the applicability in a real-world use case uncovering possible problems and pitfalls. It also gives energy researchers and operational staff a useful tool to browse and visualize information about a PV system.

This work is an essential contribution to use FDOs for accessing, visualizing and studying similarly modeled systems.

## Keywords

Ontology, Data Management

## Presenting author

Jan Schweikert

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## References

- Pfeil A, Jejkal T, Schweikert J, Pirogov A, Videgain Barranco P, Krebs F, Koch C, Günther G, Curdt C, Weinelt M (2022) Helmholtz Kernel Information Profile. Helmholtz Metadata Collaboration. not yet published.
- Schweikert J, Stucky K, Süß W, Hagenmeyer V (2022) A Photovoltaic System Model Integrating FAIR Digital Objects and Ontologies. 10th International Conference on Smart Energy Grid Engineering (SEGE). IEEE-Sege, (in press), 2022-08-10. IEEE
- Weigel T, Almas B, Baumgardt F, Zastrow T, Schwardmann U, Hellström M, Quinteros J, Fleischer D (2017) Recommendation on Research Data Collections. Research Data Alliance https://doi.org/10.15497/rda00022
- Weigel T, Plale B, Parsons M, Zhou G, Luo Y, Schwardmann U, Quick R, Hellström M, Kurakawa K (2018) RDA Recommendation on PID Kernel Information. Research Data Alliance https://doi.org/10.15497/rda00031

## Endnotes

**\*1**    https://www.w3.org/OWL
**\*2**    https://webstore.iec.ch/publication/6028
**\*3**    https://geojson.org/
**\*4**    https://www.ogc.org/standards/sensorml
**\*5**    https://www.rd-alliance.org/