

Towards a National Research Data Infrastructure for Interdisciplinary Energy System Research (NFDI4Energy)

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OFFIS e. V. – Institute for Information Technology



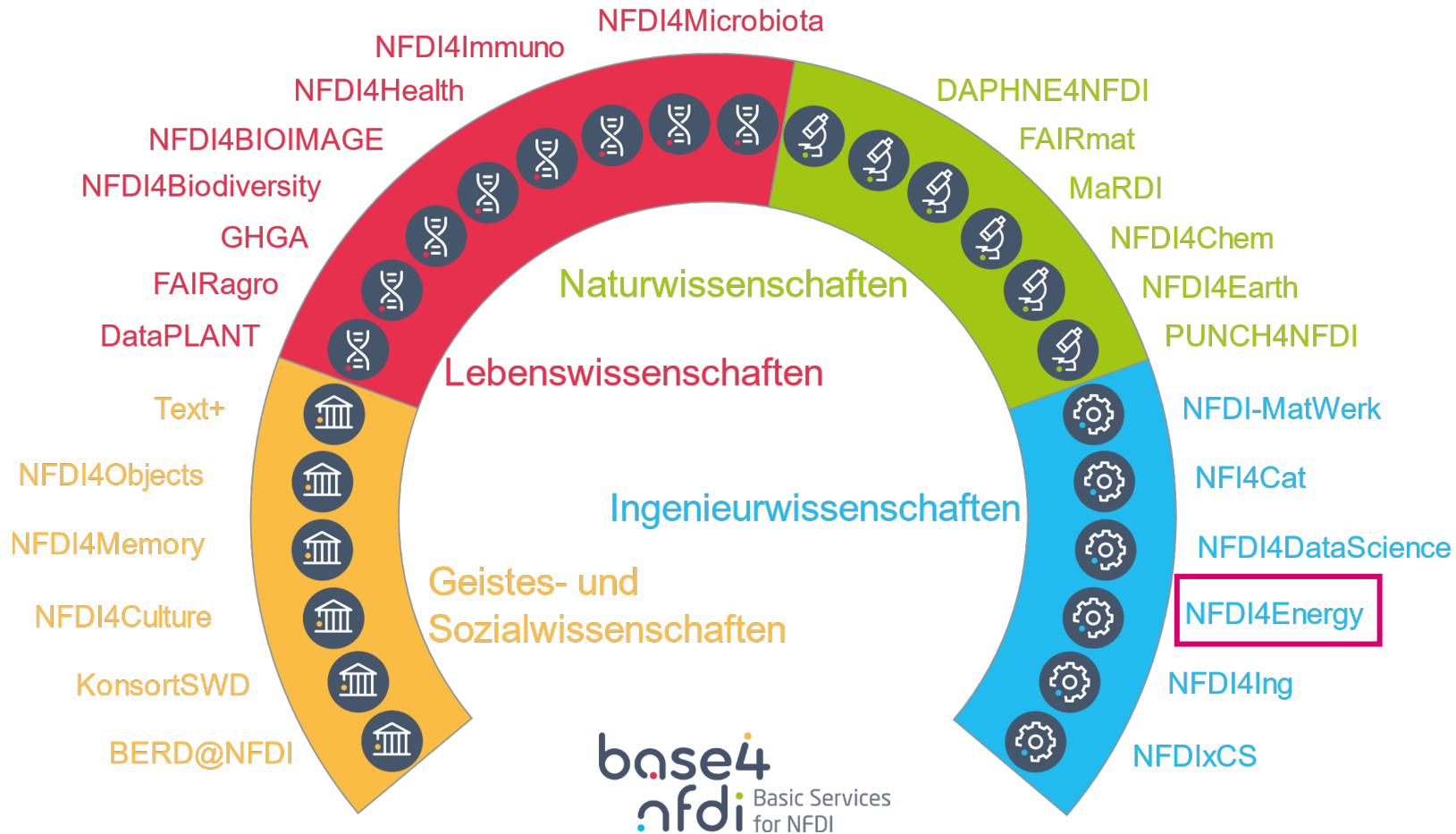
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NFDI: German National Research Data Infrastructure



- Vision: All research data is FAIR. For all. Forever.
- FAIR = Findable, Accessible, Interoperable, Reusable
- Goals:
 - Increase the efficiency of the entire German science system
 - Establish and develop comprehensive research data management in Germany
 - Develop a long-term solution for research data management infrastructure
- Funded by state and federal governments with up to 90 million € per year
- NFDI4Energy started in March 2023

Different Consortia



NFDI4Energy Coordination Office

Coordination Office (CO)



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Energy Research



Research artifacts required as input

Research artifacts created as output



Research artifacts should be reusable!



Building an Open Ecosystem for FAIR Research Artefacts in Energy Systems Research

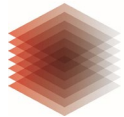
Building an Open Ecosystem for FAIR Research Artefacts in Energy Systems Research



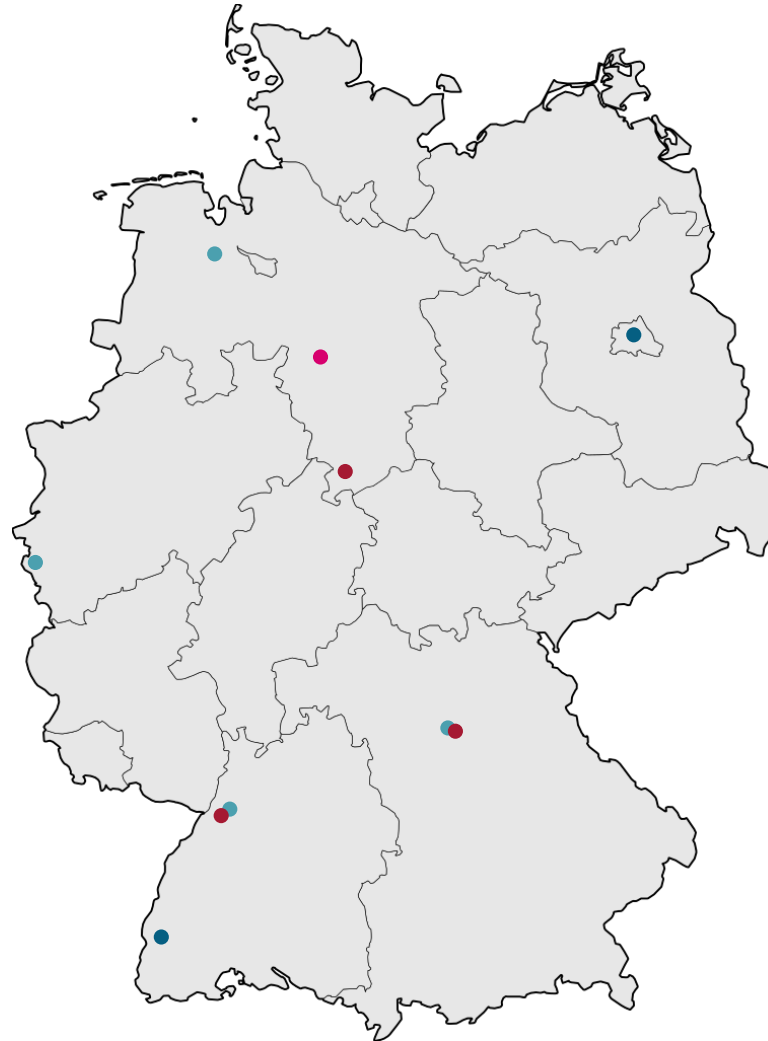
- Establish common research **community services** to allow **reproducibility, transparency, and reusability** of research artifacts.
- Simplify identification, integration, and coordination of **simulation-based models**.
- **Support the use of the services** in the research community.
- Enable and motivate the **involvement of society**.
- Promote better **collaboration and knowledge transfer** between scientific research institutes and **business partners**.
- Integrate the provided services within the **wider NFDI ecosystem**.



Our partners



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GESELLSCHAFT
FÜR INFORMATIK



Power grids, automation systems

Long-term energy scenarios

Energy policy and societal aspects

Infrastructure & service provider

Map by David Liuzzo, [CC BY-SA 2.0 DE](https://upload.wikimedia.org/wikipedia/commons/e/e3/Karte_Deutschland.svg), via Wikimedia Commons,
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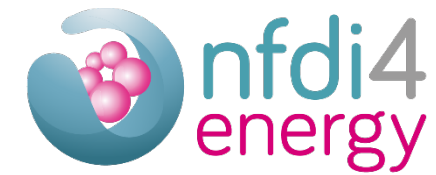


Diverse stakeholders?

Collaboration in NFDI4Energy

- Main aim number 4: Promote **better collaboration and knowledge transfer** between scientific research institutes and business partners via FAIR research data management.
- This aim has been successfully addressed when industry and business partners within the energy domain **participate actively** in data sharing, supported by the FAIR criteria, access services provided by NFDI4Energy, or **transfer scientific results into practice** using community services, as **verified by usage statistics** and validated by stakeholder feedback.

Building and Serving the Energy Community



Research Community

- Main producer and user of research artefacts
- Additional tools for handling of research artefacts are needed
- Need for easy information on services

Society and Policy

- Robust data on social and political factors are essential for energy modelling
- High need for communication of scientific results to these stakeholders

Business partners

- High relevance of data from business partners
- Need for anonymized and artificial data
- Data and models also relevant for business partners

Building and Serving the Energy Community through multiple mechanism



Collect requirements

- Identify key requirements as well as best practices from all stakeholders
- Use a methodical mix: interviews, surveys, and workshops

Community involvement

- We invite the different communities for involvement to different types of workshops and events
- e.g., industry workshops


Outreach

- Outreach to all stakeholders
- Through workshops, keynotes, booths at conferences, or other events

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Why simulations?

Research Artifacts in Energy Research (Examples)

VILLASweb

Sample visualization [Edit](#)

Menu

- Home
- Projects
- Simulations
- Simulators
- User Management
- Logout

Table with signals and current value


Signal	Value
Voltage 1	0.146
Voltage 2	
Voltage 3	

Single value

Plots

Simulator 1 - Plot with selectable signals list


home - features - docs - install - publications - blog - live-



Mosaik is a flexible Smart Grid co-simulation framework.

Mosaik allows you to reuse and combine existing simulation models and simulators to create large-scale Smart Grid scenarios – and by *large-scale* we mean thousands of simulated entities distributed over multiple simulator processes. These scenarios can then serve as test bed for various types of control strategies (e.g., multi-agent systems (MAS) or centralized control).

Mosaik is written in [Python](#) and completely open source ([LGPL](#)), including some simple simulators, a binding to [PYPOWER](#) and a [demonstration scenario](#).



Input controls

Value input

Horizontal slider

Button 1 Button 2 Button 3

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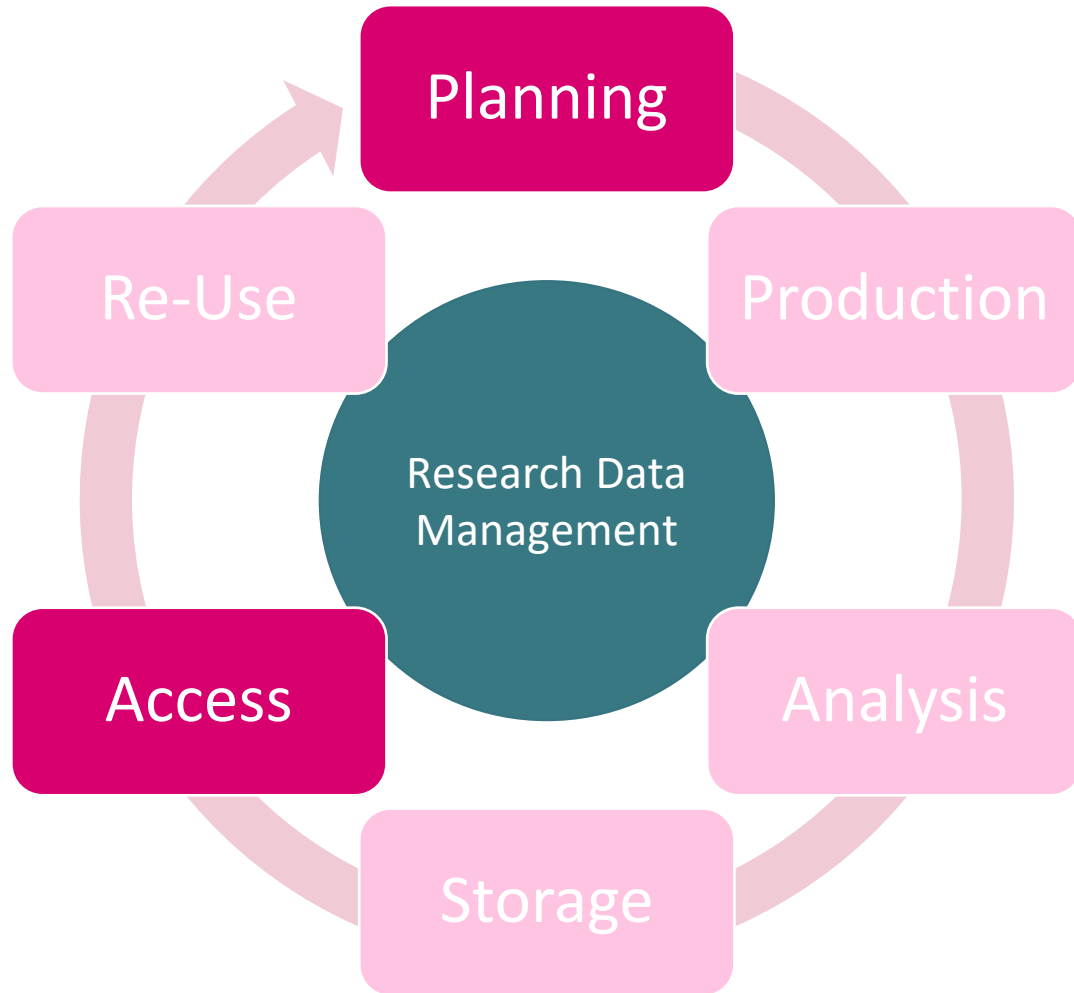
What kind of services?

Services from NFDI4Energy for FAIR Research Data Management

- NFDI4Energy aims to provide useful services for energy researchers in FAIR Research Data Management:

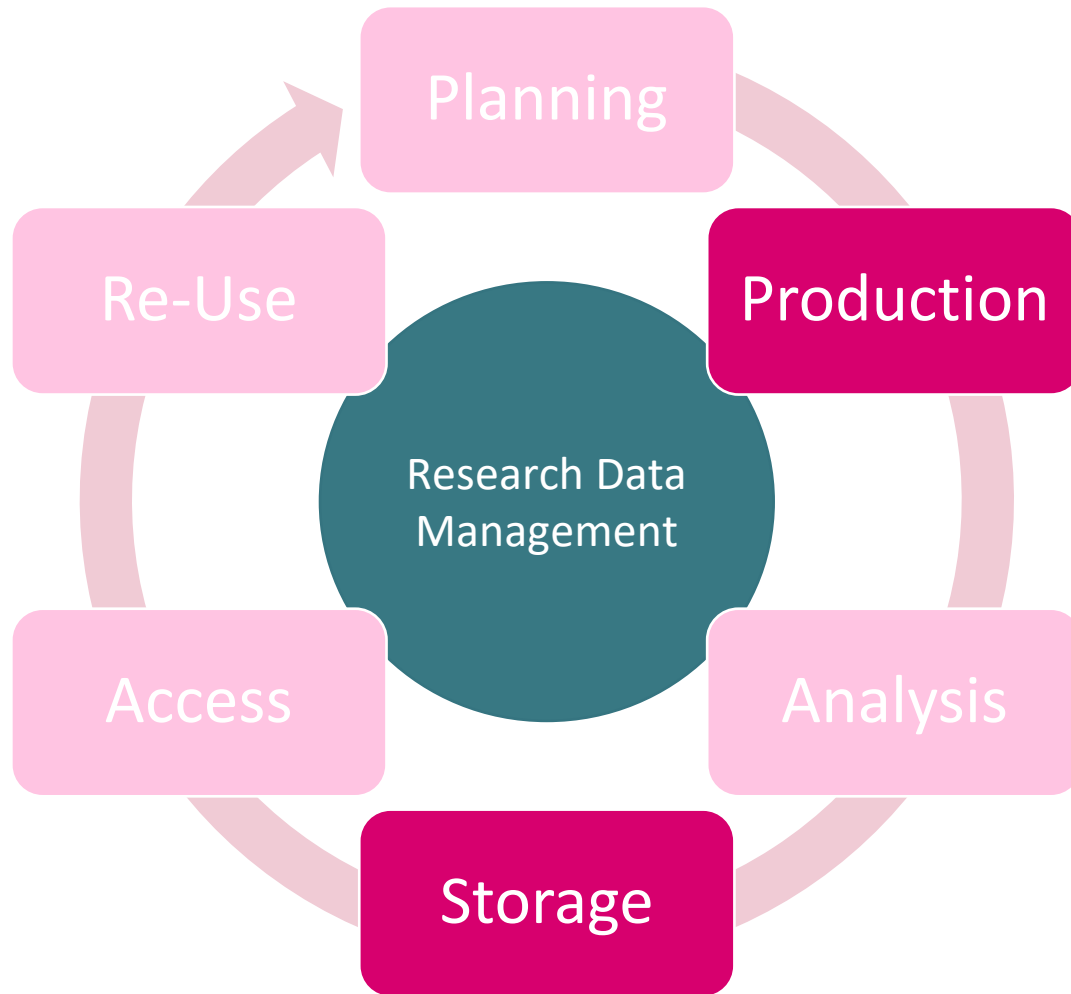


Services from NFDI4Energy for FAIR Research Data Management



- Help to navigate in an interdisciplinary field:
- Provision of a **database** for **profiles** from scientists and industry partners that are open to new ideas.
- Provision of **research networks** through visualizations.
- Provision of **overviews** on existing databases and experimental set-ups.

Services from NFDI4Energy for FAIR Research Data Management



- Help to produce and store FAIR data and results:
- Provision of **recommendations for existing data repositories** and **source codes** for specific needs (e.g. high-temporal resolution) through a **registry**.
- Provision of **terminology services**.
- Provision of a **tool for assigning Persistent Identifiers** to FAIR research objects.
- Provision and linkage to **Open Research Knowledge Graphs**.
- Provision of **metadata** for FAIR research objects.

Provision of Metadata for FAIR Research Objects

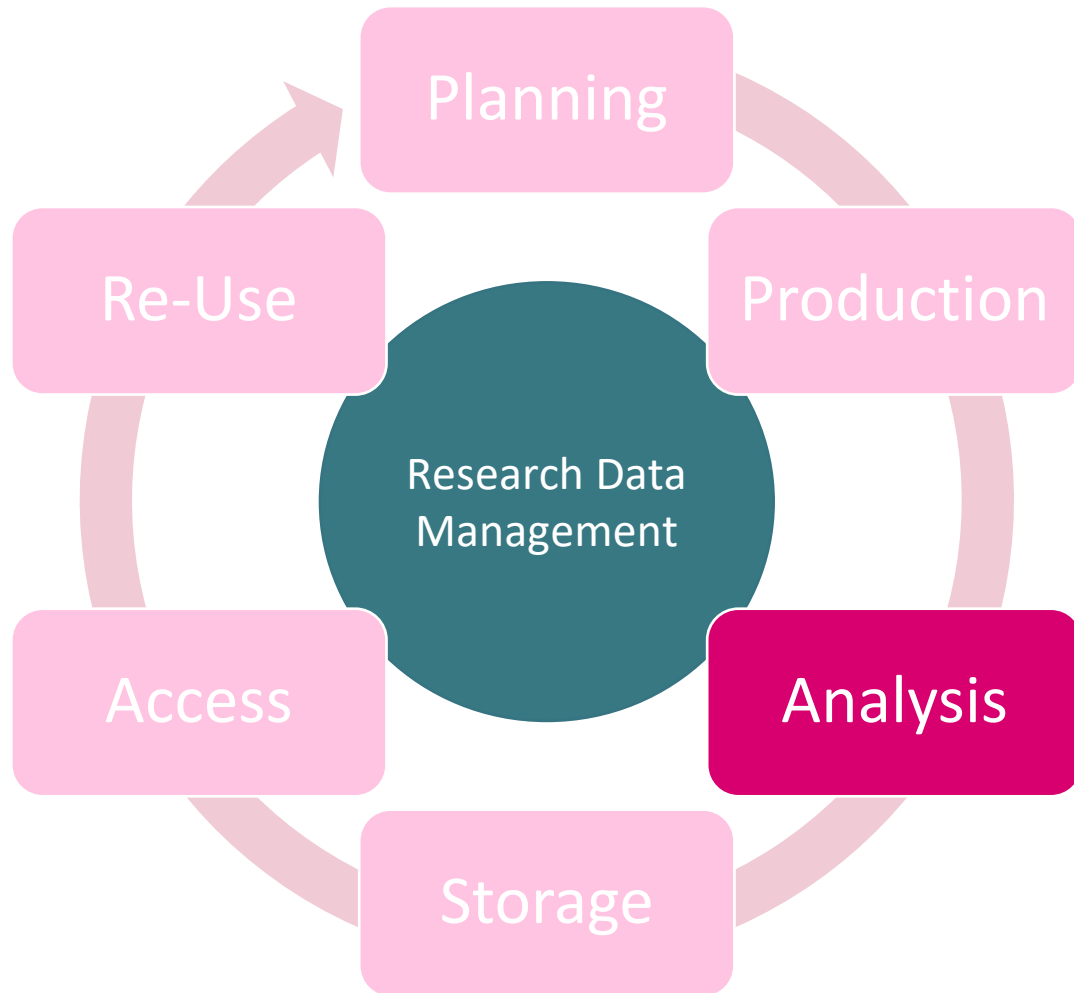
- Metadata is indispensable to meet the requirements of the FAIR principles for research data and other research objects.

- From our proposal:

Year	Milestones
1	[MS4.3.1] Requirements for metadata standards for energy system research data collected
2	[MS4.3.2] Overview of domain-independent standards completed
5	[MS4.3.3] Metadata standards for energy research data developed

- We also have a working group that has the following objectives:
 - Establish a common ontology development process.
 - Coordinate the development of ontologies and metadata standards to ensure interoperability with the NFDI4Energy services.
 - Provide a discussion forum for sharing knowledge, tools, and techniques related to ontology development among the task areas.

Services from NFDI4Energy for FAIR Research Data Management



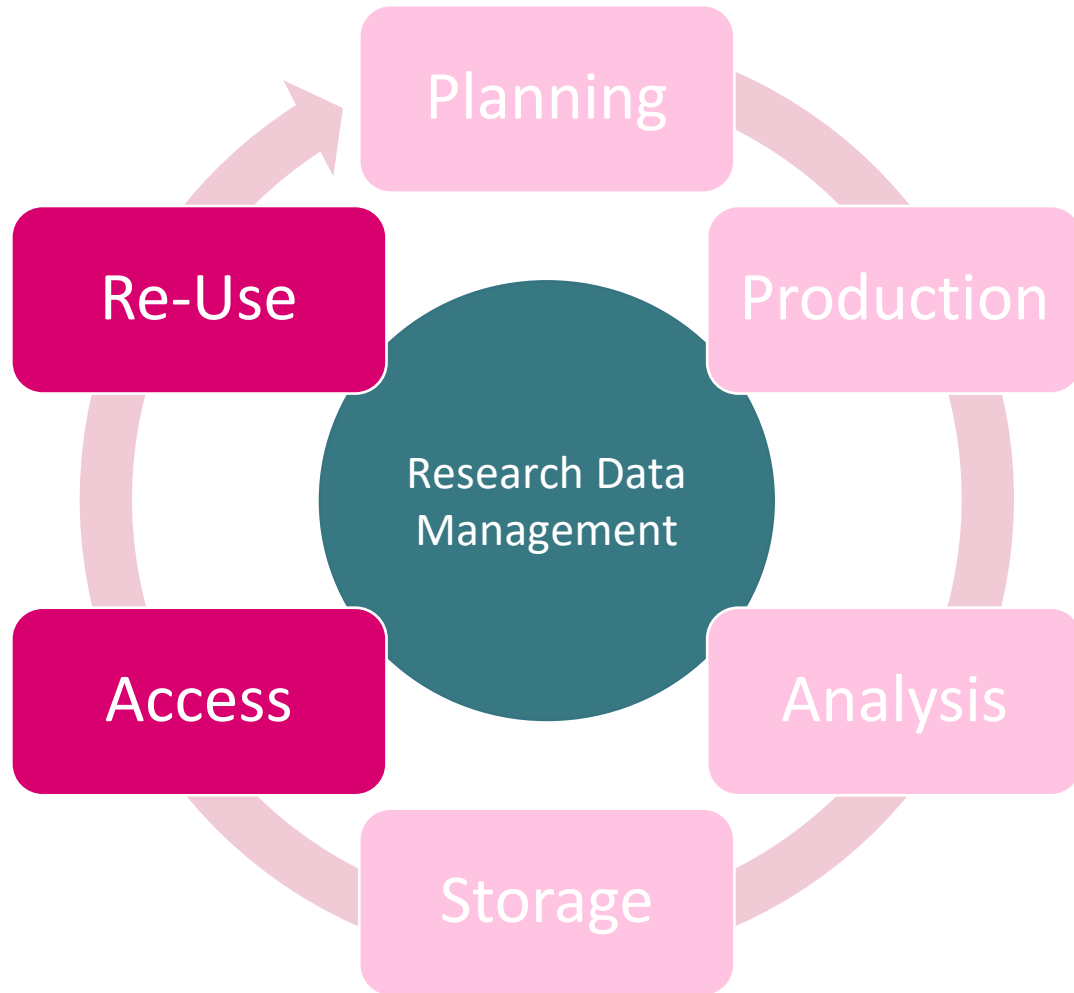
- Couple and analyse the different models and data to one simulation scenario:
- Provision of FAIR **co-simulation-as-a-service tools**, like mosaik or villasnode.
- Allow to **run** simple co-simulation online as simulation-as-a-service.



VILLASframework



Services from NFDI4Energy for FAIR Research Data Management



- Help to make results re-usable:
- Provision an **overview** of **best practices** on how to conduct FAIR RDM through teaching materials and reports.
- Provision of a tool for the **publication** of research artifacts as FAIR Data Objects.
- Provision of **hands-ons** for publishing energy research results.

An example: Open Research Knowledge Graphs



The image shows a screenshot of the Open Research Knowledge Graph (ORKG) interface. On the left, a sidebar displays the ORKG logo and navigation options like 'View', 'Tools', and 'About'. The main area is divided into two parts: a knowledge graph on the left and a detailed view of a research contribution on the right.

Knowledge Graph (Left):

- Properties:** A list of properties and their values, including 'instance of' (cyberattack) and 'same as' (multiple Wikidata URIs).
- Contributions:** A list of research contributions, including 'Coordinated Risk Mitigation Strategy For Integrated Energy Systems Under Cyber-Attacks' and 'Detection and Mitigation of False Data Injection Attacks in Networked Control Systems'.

Research Contribution Detail (Right):

- Title:** Multi-Agent Based Attack-Resilient System Integrity Protection for Smart Grid
- Metadata:** July 2020, 61 citations, Energy Systems, Pengyuan Wang, Manimaran Govindarasu.
- Published in:** IEEE Transactions on Smart Grid
- DOI:** <https://doi.org/10.1109/tsg.2020.2970755>
- Contributions:** A list of contributions, including 'blocked_channel', 'disturbed information exchange', 'failure', 'unavailable communication', 'denial-of-service attack', 'anomaly detection', and 'Control'.
- Provenance:** Added on 29 Jan 2024, Added by Emilie Frost, Contributors Emilie Frost.

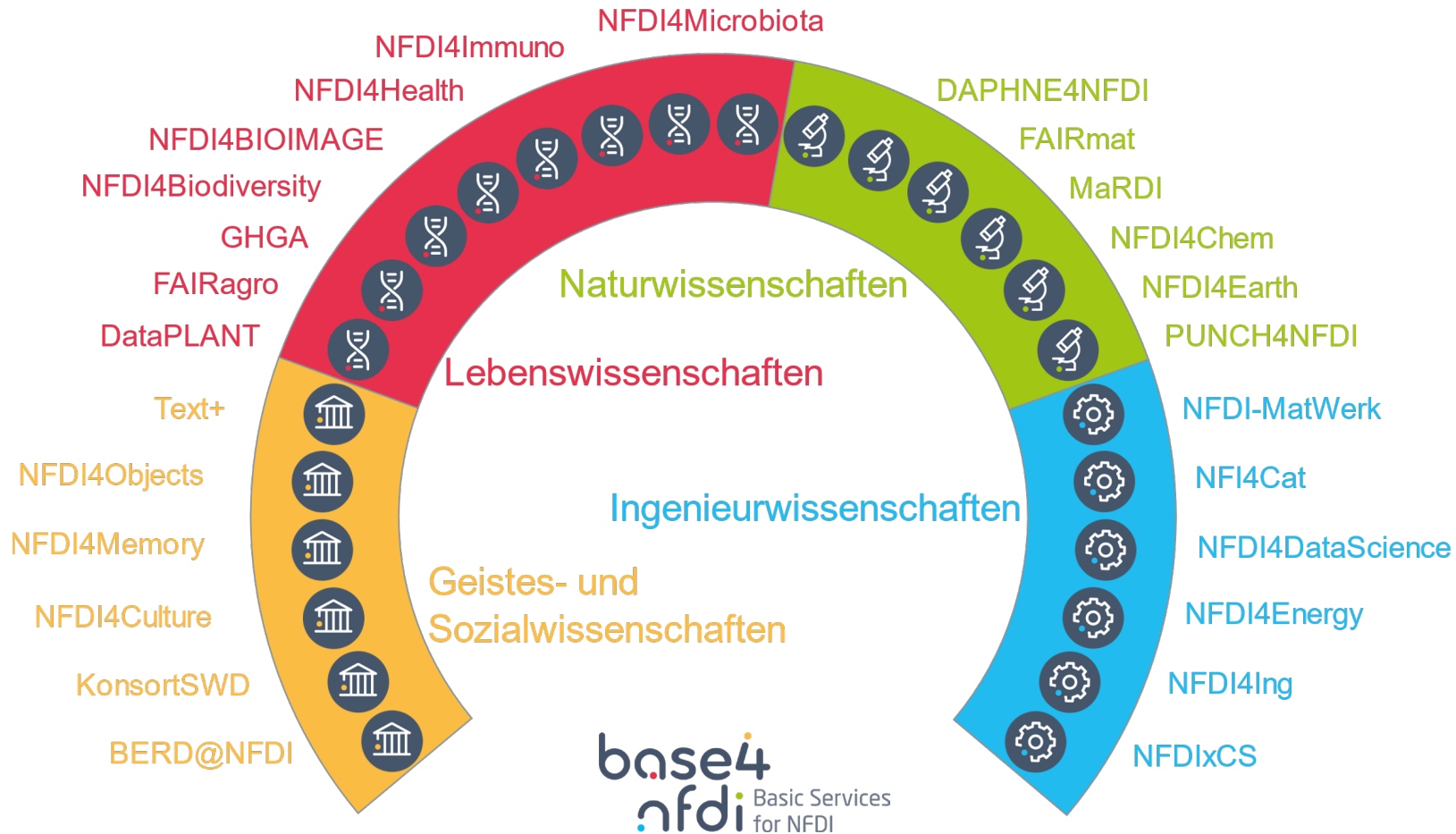
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Wider NFDI ecosystem?

Different Consortia



Services within the wider NFDI ecosystem

- An example from NFDI4Energy: **NFDI4Energy Terminology Service**
- What is a terminology?
 - Terminologies: A body of terms used with a particular technical application in a subject of study summarized and visualized in **Ontologies**.
- Energy researchers can explore energy-related ontologies effortlessly with the NFDI4Energy Terminology Service and find the most recent versions.
- In NFDI4Energy we orchestrate and link existing terminology service-related offers from the (NFDI)-community.

Services within the wider NFDI ecosystem

- **NFDI4Energy Terminology Service:**



https://terminology.tib.eu/ts/collections?col=NFDI4Energy

VHB-V4 Scholar LEO LimeSurvey IS Theory Qualitative Researc... ORCID Projektverwaltung... Terminplaner FBE-P_nfdi4energy... Logou

NFDI4Energy Project

Explore energy-related ontologies effortlessly with the NFDI4Energy Terminology Service, and Technology. Access the latest ontology versions, with options for both human users and machines. This invaluable service is a key component of the NFDI4Energy consortium's involvement in the energy research ecosystem.

Project Homepage: <https://nfdi4energy.uol.de/>

Domain-specific terminolgy service:

Ontologies: brick oeo openadr dogont emkpi s4ener bont dices



https://openenergyplatform.org/about/

VHB-V4 Scholar LEO LimeSurvey IS Theory Qualitative Researc... ORCID Projektverwaltung... Terminplaner FBE-P_nfdi4energy... Logou

Scenario Bundles - Ontology - Academy - About

- Overview
- OEO Modules
- OEO Viewer
- OEO Steering Committee
- TIB Terminology Service**

Open Energy Family and Open Energy Platform



The diagram shows the Open Energy Family components: Factsheets, Tutorials, API & Python ORM, Open Process Integration, Open Energy Database, OEO Metadata, Open Energy Platform, Open Metadata Integration, and Open Energy Ontology.

General Introduction

The Open Energy Family aims to ensure quality, transparency and reproducibility in energy system research. It is a collection of [various tools and information](#) that help working with energy related data. It is a collaborative community effort, everything is openly developed and therefore constantly evolving.

The main module is the Open Energy Platform (OEP), a web interface to access most of the modules, especially the community database. It provides a way to publish data with proper documentation (metadata), and link it to source code and underlying assumptions.

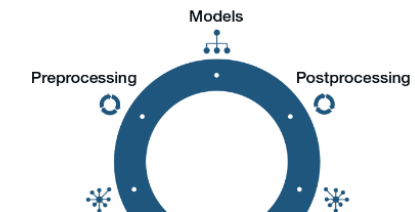
To address the problem of different name and data(base) formats, the [Open Energy Ontology \(OEO\)](#) was developed. The ontology provides a controlled vocabulary with clear definitions of terms and relationships between those terms. Data annotation adds the possibility of enhanced searching functions and logical querying across data sets.

What? Energy System Modelling and Data

Openly licensed data relevant in the field of climate and energy research can be published and accessed here. Especially energy system modelling data and scenarios can be found, along with further information on the underlying models, frameworks and studies.

Energy system models are used to explore the current and future energy systems and are often applied to questions involving the expansion of renewables and energy storages as well as energy and climate policy. The models themselves vary widely in terms of their type, design, programming, application, scope, level of detail, sophistication, and shortcomings.

The OEP considers the entire modelling process from the preprocessing of the raw data, the simulations, the postprocessing of the result data. The heart of the OEP is the underlying [Open Energy Database \(OEDB\)](#), which can be used by everyone and is maintained by a team of developers from different institutes.



How does NFDI4Energy fit into the international landscape?

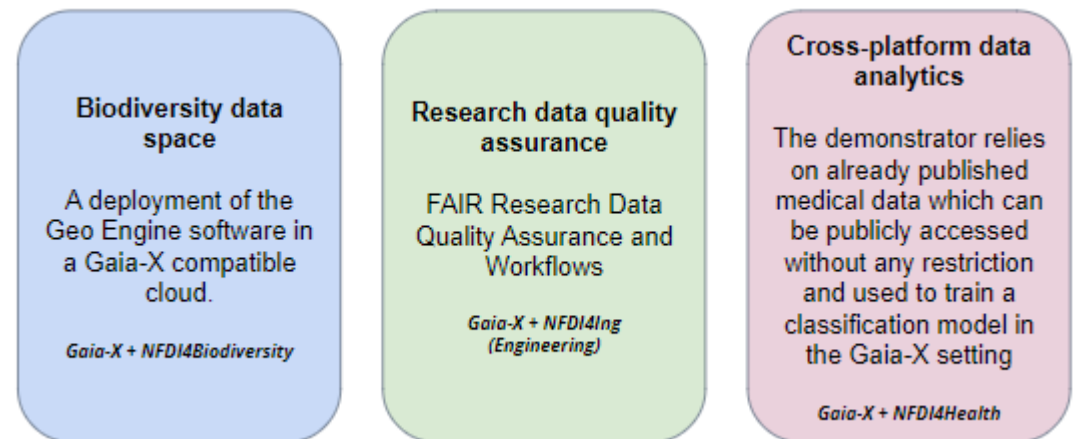


- NFDI e.V. is the mandated member of the European Open Science Cloud (EOSC) for Germany
 - “The ambition of the European Open Science Cloud (EOSC) is to develop ‘Web of FAIR Data and services’ for science in Europe.”
- Our (co-)spokesperson(s) are highly active in the ACM SIG Energy
- We are connected to multiple EU Horizons projects with similar focus like **EriGrid**, int:net, ...
- Ontology-connected work items work on integrating the OSS world (Open Energy Family) with international industry standards CIM/IEC61970



NFDI and GAIA-X Activities (FAIR Data Spaces)

- Funded by the Federal Ministry of Education and Research (BMBF) from May 2021 to May 2024.
- Vision: Common cloud-based data space for business and science (based on the FAIR data principles).
- Mission: Create and expand synergies between existing technologies and communities.
- Some examples:



Join us: 2nd NFDI4Energy Conference

- 2nd NFDI4Energy Conference - Bringing the community of energy research data management together
- Location: KIT, Karlsruhe, Germany
- Date: Tuesday, 25.03.25 – Thursday, 27.03.25
- Participants: Open for all, Submissions will be possible
- Limit: 150 participants



How to stay in touch

Website

All Information
on one site:
<http://nfdi4energy.org>



LinkedIn

Get the latest news!
<https://bit.ly/46aFeDF>



Newsletter

Stay up-to-date with
our newsletter:
<https://bit.ly/48qeIrs>



Coordination Office

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Contact

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„Towards a National Research Data Infrastructure for Interdisciplinary Energy System Research (NFDI4Energy)” (2024-09-24) © Carl von Ossietzky Universität | CC BY 4.0

Funded by

DFG Deutsche
Forschungsgemeinschaft
German Research Foundation

The authors would like to thank the German Federal Government, the German State Governments, and the Joint Science Conference (GWK) for their funding and support as part of the NFDI4Energy consortium. Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 501865131.