Data Management Plan

D1.1

Project

Project Number:	101166783
Project Acronym:	SAFEr Grid
Project Name:	Store-And-Forward Energy Grid

Dissemination Level	Public

Data Management Plan

Date:	30/09/2025
Version:	V1.0

Funded by the European Union

European Research Council
Established by the European Commission

This project has received funding from the European Research Council (ERC) under the European Union's Horizon Europe research and innovation programme (grant agreement No 101166783).

Issue Record

Planned delivery date (V1.0)	30/09/2025
Actual date of delivery (V1.0)	30/09/2025
Planned delivery date (V2.0)	30/04/2027
Actual date of delivery (V2.0)	
Planned delivery date (V3.0)	30/04/2029
Actual date of delivery (V3.0)	
Planned delivery date (V4.0)	30/04/2031
Actual date of delivery (V4.0)	

History of Changes

Version	Date	Author(s)	Notes
V1.0	30/09/2025	Antonello Monti Frede Blaabjerg Frank Piller Klaus Wehrle Sebastian Schwarz Subham Sahoo Patrick Pollok Arthur Marcel Fibich	Initial version of the SAFEr Grid Data Management Plan - V1.0

List of Abbreviations and Acronyms

Acronym	Meaning
DOI	Digital Object Identifier
DMP	Data Management Plan
FAIR	Findability, Accessibility, Interoperability and Reusability
IBR	Inverter Based Resource
PHIL	Power Hardware-in-the-Loop
PI	Principal Investigator
RES	Renewable Energy Source
SAFEr Grid	Store-And-Forward Energy Grid

About the Project

The Store-And-Forward Energy Grid (SAFEr Grid) project addresses the pressing challenges faced by today's power grids, by replacing the traditional principle of synchronism in power systems with asynchronous energy coordination. Its mission is to create a resilient, scalable, and automated energy supply system based on Renewable Energy Sources (RESs) to facilitate decarbonization of energy supply.

For over a century, global synchronism, i.e., maintaining a tightly coupled grid frequency through centralized, inertia-rich fossil-fuel generators, has dominated power system operation. However, the massive integrating of Inverter-Based Resources (IBRs) is now fundamentally disrupting this model. As power systems become decentralized and dominated by low-inertia IBRs, the reliance on synchronism increasingly poses systemic vulnerabilities, including the risk of severe and widespread blackouts.

Prior research primarily strived to augment the existing synchronous model via virtual inertia, grid-forming controls, flexibility solutions and other power system stability measures. Despite significant investment, these (incremental) adjustments cannot resolve the inherent fragility of synchronous operations in low-inertia power systems at the large-scale infrastructural level.

The SAFEr Grid project thus proposes a radical shift from synchronism toward asynchronous energy balancing in power systems. It envisions modular, autonomous, and asynchronous subgrids ("a-grids") inspired by the decentralized architecture of the Internet. In this scenario, energy routers—programmable power-electronics devices—manage energy flows between a-grids without dependence on a global frequency, employing a store-and-forward logic to buffer and dispatch energy. Power electronics, historically seen as unsuitable for large-scale system management, become central to SAFEr Grid's asynchronous model. New technological building blocks, like smart transformers, energy storage, and multi-port converters, are part of the development to enable the project's vision. In addition, the development of complementary control algorithms and an integrated cyber-physical modeling framework requires completely novel theoretical foundations for dynamics, stability, and control in power systems, which the SAFEr Grid project will explore.

Beyond theses technical innovation, SAFEr Grid also introduces a new socio-economic framework inspired by the Internet economy, fostering an open, layered ecosystem around power and energy with diverse stakeholders, services, and business models. It advocates shifting investment from operational expenditures toward capital-intensive RES infrastructure and developing governance structures balancing innovation, openness, stability, and security. Participatory design approaches ensure stakeholder alignment and facilitate open standards and policies.

Executive Summary

This document is the initial version of the SAFEr Grid data management plan. The SAFEr Grid data management plan identifies and describes the datasets and metadata which are produced by and during the SAFEr Grid project, and how they are published as open data. The datasets will be freely available during and after the project. While the current issue of this document contains an introduction to the topic of data management following the “Findability, Accessibility, Interoperability and Reusability” principles, the document is considered a living document that will be regularly updated/revised during the duration of the project. In later versions, this document will contain all information concerning the data handling and datasets in the context of the SAFEr Grid project.

Introduction

Well-structured data management is an important task of every modern research project. A key element of data management is a well-defined process for the handling of research data. For transparency reasons, this process needs to be clearly defined and accessible for all potential stakeholders of the data. Therefore, it is today's common practice to maintain a Data Management Plan (DMP). The DMP describes how a research project processes research data. The DMP provides answers to all important questions about the data processing, including data security, licensing, origin of data, format and so on. Since these answers may change during the duration of a project, the DMP will be regularly updated and revised. This document is the initial version of project SAFEr Grid's DMP and provides a full definition/instruction of how research data will be published as open data.

In this context, the SAFEr Grid DMP will follow the Findability, Accessibility, Interoperability and Reusability (FAIR) Data Management Guideline [1], [2]. The FAIR data approach should support the exchange of scientific data and lead to knowledge discovery and innovation. It is described by its acronym as follows [1]:

- **F**indable data: clear naming and versioning of (meta-) data, easy to find by both humans and computers.
- **A**ccessible data: it is clearly specified how the data is made available, including needed tools, protocols, authentication and authorization.
- **I**nteroperable data: the published data uses standards and vocabularies that allow interoperability with applications and workflows for analysis, storage and processing.
- **R**eusable data: the goal of the FAIR is reusability; therefore, it is clearly defined when and for which duration data is made available and under which licensing the data was published.

1 Data Summary

The Horizon Europe DMP Template [3] asks:

- *Will you re-use any existing data and what will you re-use it for? State the reasons if re-use of any existing data has been considered but discarded.*
- *What types and formats of data will the project generate or re-use?*
- *What is the purpose of the data generation or re-use and its relation to the objectives of the project?*
- *What is the expected size of the data that you intend to generate or re-use?*
- *What is the origin/provenance of the data, either generated or re-used?*
- *To whom might your data be useful ('data utility'), outside your project?*

Where appropriate, the SAFEr Grid project will re-use existing datasets, tools, and models from the domains of power and energy systems, control theory, communication systems, and innovation management. This includes established simulation environments and libraries (e.g., RSCAD [4]), historical power system data (e.g., from the ENTSO-E Transparency Platform [5]), and benchmark power grid models (e.g., IEEE and CIGRE benchmark systems [6], [7]). These will primarily serve as the methodological building blocks for developing new theories, control policies, and testing/validation frameworks for asynchronous power system operation.

In line with the project's objectives, and building on these existing data and resources, the project will generate the following types of data through developments, experiments, data collection, and measurements by the beneficiaries:

- mathematical and computational models of asynchronous power system dynamics,
- simulation data and results from real-time Power Hardware-in-the-Loop (PHIL) experiments and large-scale benchmark models,
- prototype measurements from the envisioned energy router power electronics devices,
- socio-economic datasets from stakeholder analysis, business model experiments, and consumer studies.

These datasets will be produced and published by the SAFEr Grid Principal Investigators (PIs) and their groups responsible for the Work Packages (WPs) or tasks and will be labelled accurately to identify the dataset producer, data category and dataset.

The expected overall data volume will be moderate—on the order of up to tens of gigabytes—but will require structured storage, metadata documentation, and version control (cf. Section 2). Data formats will include machine-readable datasets (e.g., CSV, JSON, XML), human-readable documentation (PDF, Word/LaTeX reports,

Markdown files), and open-source software code and simulation model data (as compressed ZIP packages) where applicable.

The generated data will be of value to a range of stakeholders outside the project, including:

- academia: enabling transparency, reproducibility, and advancement of theoretical models and experiments,
- industry (e.g., utilities, grid operators, manufacturers of power electronics): providing open research results and technical validation of asynchronous power system concepts,
- policy makers and regulators: supporting the design of governance frameworks for decentralized and asynchronous power systems,
- standardization bodies (e.g., IEC, ENTSO-E, NIST): contributing to work on interoperability and grid codes,
- startups and innovators in the energy sector: offering models and prototypes to foster innovative applications and accelerate commercialization.

2 FAIR data

2.1 Making data findable, including provisions for metadata

The Horizon Europe DMP Template [3] asks:

- *Will data be identified by a persistent identifier?*
- *Will rich metadata be provided to allow discovery? What metadata will be created? What disciplinary or general standards will be followed? In case metadata standards do not exist in your discipline, please outline what type of metadata will be created and how.*
- *Will search keywords be provided that optimize possibilities for re-use?*
- *Do you provide clear version numbers?*
- *What metadata will be created? In case metadata standards do not exist in your discipline, please outline what type of metadata will be created and how.*

To ensure that data in SAFEr Grid is well findable, each dataset will contain a rich metadata file describing the resource and explaining the meaning of the data in detail. Metadata will include, where applicable: title, authors/creators, organizations, creation date, venue, grant reference, project acronym, funding ID, version, persistent identifier, description of the data, data provenance, search keywords, access information, methods of collection or generation, software/hardware dependencies, file formats, embargo, licensing terms, cross-references, and contact information. These metadata will follow established standards used by the different research disciplines such as, for instance, the DataCite Metadata Schema [8].

Digital Object Identifiers (DOIs) will be used to give the data resources persistent and unique identifiers. Moreover, the individual data resources in the datasets will be given explicit version numbers to distinguish different versions of data produced during the project. Versioning will follow a clear scheme (e.g., v1.0, v1.1, v2.0) and will be documented in the metadata files.

Furthermore, all datasets will be assigned appropriate search keywords, e.g., *energy; market; flexibility; profile; power electronics; communication; governance; grid; production; demand; battery; time; load; theory; stability*. These keywords will facilitate dataset discovery and enhance the potential for re-use across different disciplines and stakeholders.

2.2 Making data openly accessible

The Horizon Europe DMP Template [3] asks:

- *Will the data be deposited in a trusted repository?*
- *Have you explored appropriate arrangements with the identified repository where your data will be deposited?*
- *Does the repository ensure that the data is assigned an identifier? Will the repository resolve the identifier to a digital object?*

All SAFEr Grid datasets will be published on the Zenodo trusted repository [9]. Zenodo is a general-purpose open-access repository developed under the European OpenAIRE project [10] and operated by CERN. Zenodo is free of charge to upload and access. It allows researchers to deposit research papers, data sets, research software, reports, supplementary materials, and any other research related digital artefacts. Moreover, external entities and stakeholders, e.g., industry, can use the interface of the Zenodo repository to search for and download the data produced by SAFEr Grid. The Zenodo platform is freely available to be used by the public, without the need to register or open an account for browsing or downloading data. Moreover, the Zenodo platform ensures that data is assigned a persistent DOI and resolved to a downloadable digital object.

2.3 Making data interoperable

The Horizon Europe DMP Template [3] asks:

Data:

- *Will all data be made openly available? If certain datasets cannot be shared (or need to be shared under restricted access conditions), explain why, clearly separating legal and contractual reasons from intentional restrictions. Note that in multi-beneficiary projects it is also possible for specific beneficiaries to keep their data closed if opening their data goes against their legitimate interests or other constraints as per the Grant Agreement.*
- *If an embargo is applied to give time to publish or seek protection of the intellectual property (e.g. patents), specify why and how long this will apply, bearing in mind that research data should be made available as soon as possible.*
- *Will the data be accessible through a free and standardized access protocol?*

- *If there are restrictions on use, how will access be provided to the data, both during and after the end of the project?*
- *How will the identity of the person accessing the data be ascertained?*
- *Is there a need for a data access committee (e.g. to evaluate/approve access requests to personal/sensitive data)?*

Metadata:

- *Will metadata be made openly available and licenced under a public domain dedication CC0, as per the Grant Agreement? If not, please clarify why. Will metadata contain information to enable the user to access the data?*
- *How long will the data remain available and findable? Will metadata be guaranteed to remain available after data is no longer available?*
- *Will documentation or reference about any software be needed to access or read the data be included? Will it be possible to include the relevant software (e.g. in open source code)?*

In SAFEr Grid, all data and metadata will be made openly available by default through free and standardized access via the trusted Zenodo repository (cf. Section 2.2). Persistent identifiers (DOIs) will be assigned to datasets to ensure long-term accessibility.

The SAFEr Grid project consortium does not foresee major restrictions on data sharing. However, in cases where temporary embargoes are required (e.g., to secure intellectual property protection through patents), data will be deposited in the repository upon creation and released after the embargo period, typically no longer than 6–12 months. If data should contain confidential or personally identifiable information, only aggregated and anonymized datasets will be made open; raw sensitive data will remain restricted to protect privacy and legitimate interests.

All openly available datasets will be downloadable via standardized protocols (e.g., HTTPS). No authentication or access restrictions will apply for open datasets, i.e., the identity of the person accessing the data remains anonymous. For any datasets under restricted access, individual requests for access can be issued to the SAFEr Grid consortium. These requests will be evaluated by the consortium on a case-by-case basis, but given the project scope, there is no need for a specific data access committee.

Making data interoperable depends on the use of suitable standards for the creation of metadata (cf. Section 2.1) along with an appropriate associated vocabulary (e.g., search keywords) and information to enable users to access the data. In SAFEr Grid, the use of a machine-readable text format for metadata will facilitate interoperability.

In line with the Grant Agreement, metadata will always remain openly available, independent of the data, and will be licensed under the latest available version of the Creative Commons Public Domain Dedication (CC 0) [11] license. Metadata records will include sufficient information to enable users to understand and access the datasets. Metadata will remain available on Zenodo even if specific datasets are withdrawn or restricted at a later stage. Metadata will remain available and findable on Zenodo for at least 10 years beyond the end of the project (until 2041).

Where specific (commercial) software is needed to access or process the data (e.g., MATLAB/Simulink models), appropriate documentation metadata will be provided, as well. Whenever possible, the corresponding software, scripts, or models will be shared as open-source code via Zenodo, with cross-links to the corresponding datasets. This will support transparency and reproducibility of research results.

2.4 Increase data re-use

The Horizon Europe DMP Template [3] asks:

- *How will you provide documentation needed to validate data analysis and facilitate data re-use (e.g. readme files with information on methodology, codebooks, data cleaning, analyses, variable definitions, units of measurement, etc.)?*
- *Will your data be made freely available in the public domain to permit the widest re-use possible? Will your data be licensed using standard reuse licenses, in line with the obligations set out in the Grant Agreement?*
- *Will the data produced in the project be useable by third parties, in particular after the end of the project?*
- *Will the provenance of the data be thoroughly documented using the appropriate standards?*

To increase data re-use, all datasets generated in SAFEr Grid will be accompanied by comprehensive data documentation files (e.g., README files in Markdown or PDF). These will include (whenever applicable):

- description of the data format and encoding
- description of the methodology and/or experimental setup
- description of the variable definitions (including type, units, and ranges)
- example code blocks and scripts
- information on data cleaning and processing steps
- information on (third-party) software dependencies and version requirements
- information on data provenance

By using an appropriate standard (cf. Section 2.1), this thorough documentation will ensure that datasets are understandable, reproducible, and re-usable by external researchers and stakeholders.

In line with the Grant Agreement, all datasets generated in SAFEr Grid will be made freely available in the public domain to permit the widest re-use possible. All data will be licensed under the latest available version of the Creative Commons Attribution International Public License (CC BY) [12]. The data produced will be usable by third parties during and after the project. Data will be maintained on Zenodo for at least 10 years beyond the end of the project (until 2041).

3 Other research outputs

The Horizon Europe DMP Template [3] asks:

> *In addition to the management of data, beneficiaries should also consider and plan for the management of other research outputs that may be generated or re-used throughout their projects. Such outputs can be either digital (e.g. software, workflows, protocols, models, etc.) or physical (e.g. new materials, antibodies, reagents, samples, etc.).*
>
> *Beneficiaries should consider which of the questions pertaining to FAIR data above, can apply to the management of other research outputs, and should strive to provide sufficient detail on how their research outputs will be managed and shared, or made available for re-use, in line with the FAIR principles.*

In addition to classical datasets, SAFEr Grid will generate a range of other research outputs, including software, computational models, and hardware prototypes. Software will be managed through version-controlled repositories and archived on Zenodo with DOIs, accompanied by documentation and released under open-source licenses. Computational models will be published in open formats (e.g., FMI/FMU, CIM) with metadata describing assumptions, parameter sets, and intended use. Hardware-related outputs such as smart energy router prototypes will be documented through schematics and firmware descriptions, with public release following any required intellectual property protection. All outputs will follow the FAIR principles, ensuring findability, accessibility, interoperability, and reusability.

4 Allocation of resources

The Horizon Europe DMP Template [3] asks:

> *What will the costs be for making data or other research outputs FAIR in your project (e.g. direct and indirect costs related to storage, archiving, re-use, security, etc.)?*
>
> *How will these be covered? Note that costs related to research data/output management are eligible as part of the Horizon Europe grant (if compliant with the Grant Agreement conditions)*
>
> *Who will be responsible for data management in your project?*
>
> *How will long term preservation be ensured? Discuss the necessary resources to accomplish this (costs and potential value, who decides and how, what data will be kept and for how long)?*

No significant additional resources and costs are expected for making data or other research outputs FAIR in SAFEr Grid. Storage, archiving, and re-use of data will primarily rely on Zenodo, which is free. Security and access management requirements are minimal, given the commitment to open access by default. Any incidental costs (e.g., for preparing documentation or metadata) are covered within the regular personnel effort already foreseen in the project.

Responsibility for data management lies with the PIs of the SAFEr Grid project, supported by their host institutions. Each PI will ensure that the data generated in their work package is properly curated, documented, and deposited in line with the FAIR principles and the Grant Agreement.

For long-term preservation, all datasets and research outputs will be deposited on Zenodo, which guarantees availability for at least 10 years beyond the end of the project, and in some cases permanently. Host institutions will additionally ensure that critical project outputs of long-term value (e.g. computational models, software, protocols) are mirrored in institutional repositories. Decisions about which data to preserve beyond the standard retention period will be made collectively by the consortium at the end of the project, based on criteria such as scientific relevance, reproducibility needs, and potential value for future research or industrial use. Metadata records will remain openly available indefinitely, even if specific datasets are retired.

5 Data security

The Horizon Europe DMP Template [3] asks:

> *What provisions are or will be in place for data security (including data recovery as well as secure storage/archiving and transfer of sensitive data)?*
>
> *Will the data be safely stored in trusted repositories for long term preservation and curation?*

Each PI is responsible for data security, data recovery, data storage/archiving/curation, and data transfer, in line with institutional policies and best practices. All beneficiaries use secure institutional storage infrastructures with regular backups to ensure recoverability of data in case of hardware or software failures.

As described in Section 2 of this document, the datasets to be published by the SAFEr Grid beneficiaries are not expected to contain sensitive personal data and are therefore suitable for open publication. Nevertheless, in the case of restricted data, it will be stored on secure institutional servers with controlled access only.

6 Ethics

The Horizon Europe DMP Template [3] asks:

> *Are there, or could there be, any ethics or legal issues that can have an impact on data sharing? These can also be discussed in the context of the ethics review. If relevant, include references to ethics deliverables and ethics chapter in the Description of the Action (DoA).*
>
> *Will informed consent for data sharing and long term preservation be included in questionnaires dealing with personal data?*

The reference for ethical and legal issues in SAFEr Grid is the EU General Data Protection Regulation (EU) 2016/679 (GDPR) [13]. If necessary, informed consent for data sharing and long-term preservation be included in questionnaires dealing with personal data.

7 Other issues

The Horizon Europe DMP Template [3] asks:

Do you, or will you, make use of other national/funder/sectorial/departmental procedures for data management? If yes, which ones (please list and briefly describe them)?

SAFEr Grid will not make use of other national/funder/sectorial/departmental procedures for data management.

References

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[2] Wilkinson, M., Dumontier, M., Aalbersberg, I. et al, *The FAIR Guiding Principles for scientific data management and stewardship*, Sci Data 3, pp. 160018, 2016. DOI: 10.1038/sdata.2016.18

[3] European Commission, Horizon Europe Data Management Plan Template

[4] RTDS Technologies, RSCAD FX: REAL-TIME SIMULATION SOFTWARE PACKAGE

[5] European Network of Transmission System Operators for Electricity (ENTSO-E), ENTSO-E Transparency Platform

[6] IEEE Power System Dynamic Performance Committee, Benchmark Systems for Small-Signal Stability Analysis and Control

[7] CIGRE Task Force C6.04, *Benchmark Systems for Network Integration of Renewable and Distributed Energy Resources*, Technical Report, 2014. URL: https://www.e-cigre.org/publications/detail/575-benchmark-systems-for-network-integration-of-renewable-and-distributed-energy-resources.html

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