COLDSPARK DRIVEN ENERGY AND COST-EFFICIENT METHANE CRACKING FOR HYDROGEN PRODUCTION

D8.4. Data Management Plan (M42)

ColdSpark® project partner	SEID AS
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Review History

Version	Date	Reviewer	Short Description of Changes
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Document Approval

Name	Role	Action	Date
Terje Hauan	Project Coordinator	Approved	28/11/2025

Nature of the deliverable

R	Document, report (excluding the periodic and final reports)	
DEM	Demonstrator, pilot, prototype, plan designs	
DEC	Websites, patent filing, press & media actions, videos, etc.	
DATA	Data sets, microdata, etc.	
DMP	Data management plan	X
Ethics	Deliverables related to ethics issues.	
SECURITY	Deliverables related to security issues	
Other	Software, technical diagrams, algorithms, models, etc.	

Dissemination level

PU	Public — fully open (automatically posted online on the Project Results platforms)	X
SEN	Sensitive — limited under the conditions of the Grant Agreement	

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This report forms part of the deliverables from the project ColdSpark® which has received funding from the European Union's Horizon Europe Research and Innovation Programme under grant agreement No. 101069931.

The ColdSpark® project will validate a novel non-thermal plasma technology to produce hydrogen at an industrial scale from methane, with a process energy efficiency of 79%, achieving a conversion rate of 85% aiming at zero CO_2 emissions. This will be achieved by designing an industrial-relevant reactor that leverages the best features of the non-thermal plasma technologies, gliding arc and corona discharge, to ensure high efficiency and scalability. The innovation addresses for the first time the critical step of matching the reactor with a pulsed power supply. It enables perfect fine-tuning of the cracking process parameters, to find the right electron density and energy distribution in the plasma reactor, to maximise energy efficiency. The up-and-downstream gas management will be optimised to further contribute to the system's compatibility with the existing infrastructure. The project will develop and test a novel plasma reactor at a lab scale and validate it in conjunction with the power supply at a large scale, pursuing the industry's most power-efficient generation of hydrogen alongside high-value carbon. Technology will assess its application for both natural gas and biomethane producers. A low energy cost (< 15 kWh/kg H_2 produced) without the need for catalysts and water, makes the proposed solution the most cost-competitive, environment-friendly, and less complex to implement. The reactor design and modularity bring lower CAPEX and OPEX and make it easily scalable and flexible. The project gathers the expertise of a mix of academic, research, and industrial partners from five countries, which bring both outstanding research and topic competence, as well as knowledge and access to the solution for end-user industries.

ColdSpark® is built on a strong consortium of 7 partners from Norway, Spain, Bulgaria, Germany, and the UK with SEID AS as a Coordinator.

More information about the project can be found at: www.coldspark.eu

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EXECUTIVE SUMMARY

This final Data Management Plan (DMP) provides a comprehensive overview of how data and related outputs have been managed within the ColdSpark® project up to M42, as well as an overview of how data will be managed in the post-project period. Build on the M6 and M24 versions, this final DMP consolidates the practices implemented by all consortium partners, confirms full compliance with the FAIR (Findable, Accessible, Interoperable, Reusable) data principles, and details the arrangements for long-term preservation and post-project accessibility.

The ColdSpark® project has successfully developed and validated a novel non-thermal plasma reactor for methane splitting into hydrogen and carbon. The research has generated extensive experimental, modelling, techno-economic, and dissemination data related to the development of an innovative non-thermal plasma reactor for hydrogen production via methane cracking. The data management framework implemented by the consortium ensures that all research outputs adhere to the FAIR principles providing Findable, Accessible, Interoperable, and Reusable data and comply fully with the Horizon Europe Open Research Data policy.

This final DMP confirms that all public data and documentation are permanently archived in trusted repositories such as Zenodo, each with assigned Digital Object Identifiers (DOIs). Sensitive and commercially valuable data sets remain securely stored in institutional repositories managed by project partners, with robust access control and backup systems in place.

This DMP also outlines procedures for long-term preservation and post-project governance, ensuring that ColdSpark® data remains accessible and reusable beyond the project's lifetime. Openly available datasets and publications will continue to be discoverable through the ColdSpark® Zenodo community and the project website, which will be active for at least 2 years after the project's end.

Through the consistent implementation of FAIR data principles, strong data governance, and adherence to ethical and legal requirements, including GDPR compliance, the ColdSpark® consortium has established a transparent, sustainable, and secure framework for managing and sharing scientific data. The practices described herein will not only maximise the visibility, reproducibility, and impact of ColdSpark® research outcomes but also provide a solid foundation for future collaboration, innovation, and commercial exploitation of the project's technological advancements.

ABBREVIATIONS

Abbreviation	Meaning
EC	European Commission
EU	European Union
DMP	Data Management Plan
DM	Data Management
FAIR	Findable, Accessible, Interoperable, and Reusable
DOI	Digital Object Identifiers
LCA	Life Cycle Assessment
WP	Work Package
GDPR	General Data Protection Regulation
OR	Open Repository
PR	Project Repository
CR	Company Repository
PMO	Project Management Office

TABLE OF CONTENTS

1. DATA SUMMARY

1.1. INTRODUCTION

This Final Data Management Plan (D8.4) for the ColdSpark® project presents the concluding framework for managing, preserving, and sharing all data generated and reused throughout the project's lifecycle. It builds upon the earlier DMP versions delivered at Month 6 (D8.2) and Month 24 (D8.3), consolidating the project's evolution in data governance, digital infrastructure, and compliance with the FAIR principles.

The document provides a comprehensive overview of how research data have been collected, processed, curated, and made available within and beyond the consortium, ensuring adherence to the Horizon Europe Open Research Data policy and to the data management obligations established in the project's Grant Agreement and Consortium Agreement.

Over the course of its 42 months, ColdSpark® has produced a broad spectrum of datasets ranging from experimental plasma reactor measurements and process simulations to life cycle and techno-economic analyses, dissemination materials, and software tools. The diversity of these data types has required the adoption of a structured and collaborative approach to data management, integrating technical standards, ethical safeguards, and long-term preservation measures.

The objectives of this Final DMP are to:

- Summarize the types, formats, and sources of data generated and reused across all work packages
- Detail the repositories and access mechanisms established to ensure secure and open dissemination of results
- Describe the metadata standards, persistent identifiers (DOIs, ORCIDs), and documentation practices adopted to enhance data traceability and citation.
- Define the data security and confidentiality protocols safeguarding commercially sensitive or proprietary information
- Outline the long-term preservation strategy and post-project responsibilities to guarantee continued data availability and integrity.

By systematically implementing the FAIR principles, ColdSpark® has ensured that its scientific outputs are discoverable, citable, and reusable, while also protecting intellectual property critical to the future commercialization of its non-thermal plasma reactor technology. The finalization of this DMP demonstrates the consortium's commitment to open science, data transparency, and

sustainable innovation, establishing a solid foundation for future research, replication, and industrial uptake of the project's results.

1.2. WILL COLDSPARK® RE-USE ANY EXISTING DATA AND HOW?

Throughout the duration of the project, the ColdSpark® consortium has strategically reused a wide range of existing datasets to accelerate research progress, enhance modelling accuracy, and reduce duplication of experimental efforts. The reuse of pre-existing data has been an essential component of the project's data management strategy, supporting the FAIR principles by promoting efficiency, transparency, and interoperability across research activities.

Sources and Nature of Reused Data

Several partners have contributed to and benefited from data reuse:

- SEID AS leveraged over two decades of proprietary data from its earlier technological development programmes in plasma-driven air pollution control. These datasets include historical measurements of voltage, power, gas composition, and reactor configurations that have been instrumental in validating current experimental results.
- IREC CERCA has integrated datasets and publicly available environmental and energy datasets into its Life Cycle Assessment (LCA) and techno-economic analyses, ensuring methodological consistency and comparability with previous EU-funded research.
- The University of Liverpool reused experimental and modelling data obtained during earlier plasma research projects to refine kinetic models, calibrate simulations, and benchmark ColdSpark® reactor performance.
- Europroject Ltd. and IBBK incorporated publicly available information and data from the European Commission's repositories (e.g., CORDIS) to support dissemination, stakeholder mapping, and market analysis activities.

Data Access and Handling

To ensure that reused data are managed responsibly, the consortium established a dedicated, secure ColdSpark® Data Repository within the project's Microsoft Teams/SharePoint environment, managed by the project coordinator. This repository uses a two-tiered access control system:

- Level 1: General access for all project partners to non-sensitive data and reference materials

- Level 2: Restricted access for work package members handling confidential or proprietary data.

All reused datasets were carefully catalogued, with metadata specifying their origin, usage rights, and citation requirements. Partners ensured that reused materials comply with applicable licensing terms and intellectual property conditions, and that proper attribution is provided in all derived outputs.

Integration and Value of Data Reuse

The reuse of validated historical and public datasets has strengthened the reliability and comparability of project results. It has enabled partners to:

- Benchmark new reactor performance data against historical baselines
- Refine modelling and simulation frameworks with verified empirical inputs
- Enhance the robustness of environmental and economic assessments
- Reduce redundant data generation, ensuring efficient use of resources.

Furthermore, the consortium's approach to data reuse demonstrates ColdSpark®'s commitment to responsible research practices, open science, and data sustainability. By combining legacy datasets with newly generated results, the project has created a comprehensive, interoperable data ecosystem that will support future research, replication, and technology scaling beyond the project's lifetime.

Non-sensitive reused data are utilized across various project outputs, including presentations, posters, reports, brochures, public deliverables, and audio-visual materials that were created by all project partners. EP, as the partner responsible for dissemination and the project coordinator, plays a leading role in this process. These materials are promptly shared on the project repository hosted on Zenodo and made accessible through the project website. This ensures swift dissemination of information to stakeholders and the wider community, promoting transparency and collaboration within the ColdSpark® project.

1.3. TYPES AND FORMATS OF DATA TO BE GENERATED OR RE-USED BY THE PROJECT

The formats for generating and re-using data within the ColdSpark® project declared in the previous version of the Data management plan, remain consistent: .xlsx, .docx, .csv, .txt, .pdf, HTML, ASPEN files, Solid edge (.par, .psm, .asm, .dft, .pwd, .dwg, .dxf, .step, .stp), OpenScad (.scad), • SSI (*.dat), AIA (*.cdf), SSI ASCII (*.asc), SAMPL (*.SAMPL), TurboChrom (*.raw), ChemStation (*.ch). , Printed Circuit Board (PCB) use Altium designer.

For audio-visuals - JPEG, MP4, TIFF, PNG, MP3, M4V, WAVE.

Data analysis programs include Excel, MATLAB, Origin, R and Python, Diffract EVA, Renishaw Raman, Mettler Toledo TGA etc. that come along with instruments plus QtiPlot to plot the data.

1.4. PURPOSE OF THE DATA GENERATION OR RE-USE, ITS RELATION TO THE OBJECTIVES OF THE PROJECT AND USERS

1.4.1. PURPOSE

The data generated and reused within the ColdSpark® project serves as the foundation for achieving the project's overarching objective: to validate a novel non-thermal plasma reactor capable of producing hydrogen and solid carbon from methane in an energy-efficient, cost-effective, and carbon-neutral manner.

To support this mission, data collection and reuse activities have been designed to:

- Enable scientific understanding and optimisation of plasma-driven methane splitting through detailed experimental, modelling, and simulation data
- Validate process efficiency by quantifying conversion rates, energy consumption, and carbon yield under varied operational conditions
- Support life cycle and techno-economic assessments, demonstrating environmental and economic viability compared to conventional hydrogen production technologies; and
- Facilitate knowledge dissemination and technology replication by making non-sensitive data openly available to the scientific community and industry stakeholders.

In essence, ColdSpark®'s data activities bridge the gap between fundamental research and industrial implementation, providing a robust evidence base for both technological validation and market exploitation.

1.4.2. EXPECTED SIZE

The overall volume of raw data generated during the project remains consistent with earlier estimates and is less than 1 terabyte, comprising experimental records, modelling results, simulation files, LCA datasets, and dissemination materials.

The consortium has maintained efficient data storage and backup systems, ensuring that all datasets are organised, version-controlled, and traceable through persistent identifiers and metadata records.

The project's data ecosystem encompasses both quantitative and qualitative datasets, including:

- Experimental measurements (plasma diagnostics, gas composition, reactor parameters)
- Simulation and modelling data (ASPEN, COMSOL, MATLAB, Python)
- LCA and techno-economic inputs
- Dissemination materials, publications, and digital assets (audio-visuals, reports, and communication resources).

1.4.3. TO WHOM MIGHT YOUR DATA BE USEFUL ('DATA UTILITY'), OUTSIDE YOUR PROJECT?

The data produced and curated by ColdSpark® hold substantial value for a wide range of audiences within and beyond the consortium, including:

- Academic and research institutions investigating plasma-assisted processes, hydrogen production, and carbon valorisation
- Industrial partners and technology developers seeking scalable, low-carbon hydrogen production solutions
- Policy makers and regulators focused on clean energy transition, circular carbon use, and greenhouse gas reduction strategies
- The broader scientific and innovative community, through access to open datasets, models, and software tools shared under FAIR principles.

While most technical and experimental datasets are confidential due to their direct relevance to future intellectual property and commercialization, ColdSpark® ensures that high-level findings, models, and methodological insights are disseminated through open-access repositories (Zenodo, CORDIS) and the project website. This balance between openness and protection of proprietary knowledge allows the project to contribute to the advancement of scientific research while safeguarding the competitiveness of its industrial partners.

1.5. ORIGIN/PROVENANCE OF THE DATA, EITHER GENERATED OR RE-USED

All consortium partners contributed to data generation and collection through diverse methodologies and instrumentation tailored to their specific research objectives. For example, SEID AS conducts verification of key operational parameters for the non-thermal plasma reactor, including voltage, power, frequency of the high-voltage supply, gas flow rate, reactor geometry, and electrode-to-wall distance (discharge gap). Variations in these parameters directly influence the resulting gas composition and solid carbon characteristics, providing critical insight into reactor performance and optimisation.

Comparable measurements and modelling efforts have previously been undertaken by several research groups. Where relevant, such pre-existing datasets and results are being integrated into

the ColdSpark® project to complement new experimental findings. All instances of data reuse or adaptation are appropriately acknowledged through proper citation and attribution, ensuring transparency, traceability, and alignment with FAIR data principles.

A general overview of the data type and how the data is gathered for this project within the consortium is provided in APPENDIX 1.

2. FAIR DATA

2.1. WILL DATA BE IDENTIFIED BY A PERSISTENT IDENTIFIER?

2.1.1. WILL DATA BE IDENTIFIED BY A PERSISTENT IDENTIFIER?

To ensure that all datasets and research outputs produced under the Coldspark® project are findable, citable, and permanently accessible, each publicly available dataset is assigned a Persistent Identifier (PID), primarily in the form of a Digital Object Identifier (DOI).

The project uses the Zenodo repository as its principal open-access data platform. Upon deposition, each dataset, publication, or software release within the ColdSpark® Zenodo Community is automatically assigned a DOI through the DataCite registration system if a DOI does not pre-exist before adding the entry in the repository. This persistent identifier guarantees long-term traceability, secure referencing, and interoperability across digital repositories and scientific indexing services.

Each DOI is linked to a rich metadata record that captures essential information such as the dataset title, authors and affiliations, funding details, version, publication date, keywords, and access conditions. These identifiers ensure that data remains discoverable and citable even if their physical storage location changes, thereby safeguarding the sustainability and visibility of the project's outputs.

In addition to Zenodo DOIs:

- Institutional datasets stored in internal repositories (e.g., Microsoft SharePoint/Teams or partner-specific archives) include internal identifiers and version tracking codes, ensuring traceability within the consortium.
- Wherever applicable, authors' ORCID iDs are linked to datasets to provide transparent attribution and enhance data provenance.

Through this structured use of persistent identifiers, ColdSpark® guarantees that all public datasets and associated outputs meet the FAIR principles of findability and accessibility, while maintaining integrity, accountability, and proper recognition for contributors.

2.1.2. METADATA

Will rich metadata be provided to allow discovery? What metadata will be created?

Comprehensive and rich metadata are provided for all datasets generated or reused within the ColdSpark® project to ensure that they are fully discoverable, interpretable, and reusable in line with the FAIR data principles. Metadata creation and management follow standardised practices consistent with the DataCite Metadata Schema implemented by the Zenodo repository.

Each publicly available dataset deposited in the ColdSpark® Zenodo Community is accompanied by a detailed metadata record that includes, at minimum, the following core elements:

- Title: Descriptive title of the dataset or research output
- Authors and affiliations: Including ORCID iDs for contributor identification
- Description: Summary of dataset contents, purpose, and context
- Date of creation and publication
- Version information to ensure traceability and reproducibility
- Persistent Identifier (DOI)
- Keywords and subject classifications for enhanced discoverability
- License type and access conditions (e.g., CC BY, CC BY-SA, or restricted access)
- Funding information, including the Horizon Europe Grant Agreement number (No. 101069931)
- Associated project identifiers and Work Package references
- Links to related publications, datasets, and software; and
- Contact information for responsible partner(s) or data owner(s).

For internal and confidential datasets stored within the consortium's SharePoint/Teams repositories, a simplified metadata structure is used. This includes dataset identifiers, file descriptions, authorship, date of upload, version control, and access permissions. These records are maintained within a central metadata catalogue managed by the Project Management Office (PMO) to ensure consistency and traceability across all work packages.

Metadata are periodically reviewed and updated to reflect any changes in dataset versions, access conditions, or associated publications. This ongoing curation ensures that the metadata remains accurate, up to date, and compliant with both Horizon Europe and ColdSpark® internal data management standards. This continuous data curation will be extended beyond the end of the project, enabling the respective IPR holders to pursue further research and development based on the project results.

By maintaining detailed, standardised, and interoperable metadata, ColdSpark® ensures that all its publicly available research outputs can be easily discovered, cited, and reused by the wider research and innovation community.

What disciplinary or general standards will be followed?

The ColdSpark® project adheres to both general metadata and disciplinary standards to ensure consistency, interoperability, and reusability of all datasets generated and shared across the consortium. These standards guarantee that data can be efficiently exchanged, interpreted, and integrated with other research outputs within the wider scientific community.

General standards applied:

- DataCite Metadata Schema (v4.5): Adopted through the Zenodo repository for all public datasets to ensure uniformity in citation, description, and long-term accessibility.
- FAIR Data Principles: Serving as the overarching framework for all data management activities, ensuring data are Findable, Accessible, Interoperable, and Reusable.
- OpenAIRE Guidelines for Data Archives (v4): Ensuring compliance with the European Open Science Cloud (EOSC) and open data interoperability practices.

Disciplinary and methodological standards:

- Scientific and engineering data standards include compliance with internationally recognised measurement and calibration protocols, including SI units and instrument-specific standards (e.g., ISO/IEC 17025 for testing and calibration).
- Simulation and modelling data are structured according to best practices for computational modelling, using reproducible file formats from platforms such as ASPEN HYSYS, COMSOL Multiphysics, MATLAB, and Python scripts.

By adhering to these standards, ColdSpark® ensures that all data, whether experimental, computational, or analytical will remain consistent, interoperable, and scientifically credible, facilitating reuse across disciplines and contributing to the broader goals of Open Science and sustainable innovation.

2.1.3. KEYWORDS TO BE PROVIDED IN THE METADATA TO OPTIMISE THE POSSIBILITY FOR DISCOVERY AND POTENTIAL RE-USE

To enhance the discoverability, visibility, and reusability of all ColdSpark® datasets, a structured and standardised set of keywords is included in the metadata accompanying each dataset deposited in the project's repositories. The consistent use of well-defined keywords enabled efficient indexing by search engines, supports metadata harvesting, and facilitated linkage with related research within the broader scientific community.

Approach to Keyword Definition

Keywords were selected to reflect the scientific, technological, and thematic scope of the project, following both general metadata practices (as recommended by DataCite and OpenAIRE) and domain-specific terminology. Each dataset deposited in the ColdSpark® Zenodo Community includes a minimum of five to ten keywords describing:

- The core technology and processes (e.g., plasma reactor, methane splitting, hydrogen production)
- The scientific discipline (e.g., materials science, chemical engineering, environmental technology)
- The research context and applications (e.g., carbon valorisation, process optimisation)
- The data type or methodology (e.g., simulation, modelling, techno-economic assessment)

Examples of Common Keywords Used Across the Project

To maintain coherence and improve interoperability between datasets, a controlled keyword set has been applied across the consortium, including terms such as:

Non-thermal plasma, methane cracking/splitting, hydrogen production, solid carbon, energy efficiency, reactor design, plasma chemistry, techno-economic analysis, life cycle assessment (LCA), sustainable hydrogen, biomethane, decarbonisation, ColdSpark® reactor, and hydrogen economy.

These keywords have been harmonised and validated by the consortium's dissemination and data management teams to ensure consistency across repositories and project deliverables.

Maintenance and Updates

Keyword lists are periodically reviewed and updated as the project evolves to ensure continued relevance and alignment with emerging research trends and terminologies in the fields of hydrogen technologies and plasma science. The finalised keyword taxonomy will be maintained in the project's internal data catalogue and reflected in all metadata entries within Zenodo, CORDIS, and the ColdSpark® project website.

By applying this structured keyword strategy, ColdSpark® ensures that all its research outputs remain easily discoverable, contextually linked, and optimally reusable by researchers, policymakers, and industry stakeholders, thereby maximising the impact and visibility of the project's results.

2.1.4. HOW METADATA CAN BE HARVESTED AND INDEXED

The ColdSpark® project ensures that all metadata associated with its publicly available datasets can be automatically harvested, indexed, and integrated into international data discovery systems.

Metadata Harvesting and Interoperability

All open-access datasets produced within ColdSpark® are deposited in the ColdSpark® Zenodo Community, which is fully compliant with the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH). Through this protocol, metadata can be systematically harvested by multiple aggregators and repositories, including:

- OpenAIRE – the European Open Science platform that indexes Horizon Europe-funded outputs
- DataCite – ensuring DOI-based discoverability across global research databases
- Google Dataset Search and other scholarly indexing services
- CORDIS, via the integration of public deliverables and open datasets

This interoperability allows external platforms and users to seamlessly access dataset descriptions, citations, and related outputs without duplicating storage or data management functions.

Metadata Availability and Accessibility

Each Zenodo record created under the ColdSpark® project includes standard DataCite metadata fields, which are machine-readable and publicly accessible. These metadata are openly licensed under CC0 (public domain dedication), enabling unrestricted reuse and ensuring their long-term availability even if data access becomes restricted in the future.

Metadata records are also cross-linked with:

- DOIs of associated publications, datasets, and software
- ORCID iDs of contributing authors
- Grant information (Horizon Europe GA No. 101069931)
- Relevant project identifiers, such as work package codes and deliverable references

Confidential and Internal Metadata

For datasets classified as confidential or restricted, metadata are maintained within the consortium's secure Microsoft SharePoint/Teams environment. While such metadata are not exposed to public harvesters, they are catalogued internally using a consistent schema to support traceability, provenance, and internal collaboration.

Long-Term Harvesting and Sustainability

Zenodo guarantees the long-term preservation of metadata, as outlined in its data policy. Should repository migration become necessary, metadata and identifiers will be transferred to another trusted repository to ensure uninterrupted discoverability.

Through these practices, ColdSpark® ensures that all metadata including both public and internal datasets remain searchable, interoperable, and permanently retrievable, supporting future research, citation, and policy development within the European and global scientific communities.

2.2. ACCESSIBLE PROJECT DATA

The following access options and policies remain unchanged from the previous version of the DMP:

OR – Open repository

An Open Access repository (Zenodo community) has been created to upload publicly available outcomes. Thus, ColdSpark® complies with the requirement of long-term open access to the public project results.

PR – Project repository

The ColdSpark® project utilises a secure, password-protected data repository hosted on Microsoft Teams and SharePoint, managed centrally by the Project Coordinator (SEID AS). This platform ensures the integrity and continuity of all project-related data.

To safeguard sensitive information and uphold confidentiality obligations defined in the Grant Agreement and Consortium Agreement, a two-tier access control system has been implemented:

- General access (Level 1): Granted to all project partners for shared, non-confidential materials and working documents
- Restricted access (Level 2): Limited to authorised partners and work package members handling confidential or proprietary data.

The structure, permissions, and data management procedures for this repository are clearly defined in the Project Management Manual (Deliverable D8.1). This framework ensures that data access, storage, and version control are handled consistently across the consortium, providing a robust and traceable mechanism for collaborative research while maintaining full compliance with the project's data security and confidentiality requirements.

CR - Company/Institution repository

Each partner organisation uses cloud and offline data storage solutions that must comply with the cybersecurity rules of the company/institution/organisation. The access is limited to the company/institution/organisation employees/contracted staff.

Project Website - www.coldspark.eu

The public data generated by the project (dissemination and communication materials, public deliverables, etc.) are published in open access on the project website (www.coldspark.eu). The project website will remain online for at least 2 years after the end of the project.

European Commission's repository - CORDIS

Public deliverables and results are made available on CORDIS.

The project coordinator, SEID AS, is responsible for centralisation and giving access to the relevant repositories. Each partner is responsible for their data (security measurements depending on internal rules).

2.2.1. DATA DEPOSITION IN A TRUSTED REPOSITORY

All research data and publications that include non-sensitive data are deposited in the ColdSpark® repository in Zenodo, which is a well-established open dissemination research data repository available for data, publications, and software and has been chosen by the project partners as suitable for the project's needs. It is each partner's responsibility to provide and update the repository regularly for each data set. All publications in the repository were approved by the PMO upon uploading. In case of post-project data generation (eg. publications disseminating the ColdSpark® results), this process will be implemented in the same way in the post-project period.

GitHub, a development platform to host and review code and building software was used as the repository for software. The data generated from OpenScad will also be deposited in GitHub.

2.2.2. ARRANGEMENTS WITH IDENTIFIED REPOSITORIES WHERE THE DATA WILL BE DEPOSITED

Project partners are working with the systems described above. Special attention was paid to keep all data management procedures and their implementation in line with the FAIR principles and ensure the required access and reuse of data.

2.2.3. DOES THE REPOSITORY ENSURE THAT THE DATA IS ASSIGNED AN IDENTIFIER? WILL THE REPOSITORY RESOLVE THE IDENTIFIER TO A DIGITAL OBJECT?

Zenodo assigns all publicly available data a Digital Object Identifier (DOI). This ensures that the uploaded data is easily citeable. The repository accepts any file format that provides easy storage of data produced.

2.2.4. COLDSPARK® OPENLY AVAILABLE DATA – LEGAL, CONTRACTUAL, INTENTIONAL PARTNER-SPECIFIC RESTRICTIONS

Most data generated within the Coldspark® project is classified as sensitive and are therefore accessible only within the consortium. Data identified as publishable or non-confidential are deposited in the project's open repository in a timely manner, following the data-sharing procedures outlined in both the Grant Agreement and the Consortium Agreement.

In accordance with these governing documents:

- Ownership of results: Each partner retains ownership of the data they generate and holds the authority to assess and determine its confidentiality status.
- Confidential information: Sensitive or confidential data are shared with the European Commission at the appropriate level of access, as required under the project's contractual obligations.
- Background data: Access to background information defined as the data, know-how, or intellectual property necessary for implementing the project or exploiting its results, is regulated under the Consortium Agreement.
- Dissemination and publication: Any dissemination or publication of project results requires prior approval from the data-owning partner. Notice of intended publication has been provided to all consortium partners at least 45 calendar days in advance. Should any partner raise an objection, it must be submitted in writing to the Coordinator and the proposing partner within 30 calendar days of notification. In the absence of objections, publication is deemed authorised. This procedure will be kept for the post-project period in case of post-project publications.

The main goal of this policy is to ensure that all non-sensitive data are made openly and responsibly available, thereby promoting transparency, collaboration, and synergies among the partners, related European projects, and external stakeholders. Wherever possible, the consortium strives to make data accessible under open licences (such as Creative Commons) or, when appropriate, to place them in the public domain.

2.2.5. PERIOD OF AN EMBARGO (IF APPLIED) TO GIVE TIME TO PUBLISH OR SEEK THE PROTECTION OF THE INTELLECTUAL PROPERTY (E.G., PATENTS)

Why and how long this will apply, bearing in mind that research data should be made available as soon as possible?

Sensitive data under an embargo status in a repository, an end date for the embargo will be provided. Under the conditions of Zenodo, these data will be available to the public automatically. This rule applies also for data uploaded in the post-project period.

2.2.6. WILL THE DATA BE ACCESSIBLE THROUGH A FREE AND STANDARDIZED ACCESS PROTOCOL?

ColdSpark® data files are deposited either as closed, open or with embargoed access under the conditions of Zenodo, as the chosen repository. Access to metadata and data is provided through Zenodo, which uses Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) interface.

2.2.7. ACCESS TO THE DATA DURING AND AFTER THE END OF THE PROJECT IF RESTRICTIONS EXIST

Access to data within the ColdSpark® project is governed by clearly defined procedures that ensure both data security and compliance with confidentiality obligations, while also promoting the principles of transparency and reusability where possible.

During the active phase of the project, data classified as confidential or restricted were accessible only to authorised consortium members who are directly involved in the relevant work packages.

If restrictions apply, data sharing with third parties outside the consortium requires explicit written consent from the data owner and approval from the Project Coordinator, in line with the Grant Agreement and Consortium Agreement. Such access requests are evaluated on a case-by-case basis to ensure that intellectual property rights, privacy regulations, and contractual obligations are upheld. This procedure will be kept also after the project end to ensure that no sensitive data will be shared without permission of the partners involved.

Following the completion of the project, public and non-sensitive data sets will remain permanently accessible via the ColdSpark® Zenodo Community, under open or appropriately licensed access conditions. In contrast, restricted or proprietary data will continue to be securely stored in the consortium's internal repositories for a minimum of five years after project closure, as stipulated by the data preservation policy.

During this post-project period, the Project Coordinator (SEID AS) will act as the primary data custodian, maintaining oversight of all archived datasets and managing any justified requests for access or reuse in consultation with the original data owners.

This structured approach ensures that ColdSpark® data remain secure, traceable, and ethically managed throughout their lifecycle both during and after the project while maximising the long-term scientific and industrial value of the consortium's research outputs.

2.2.8. THE IDENTITY OF THE PERSONS ACCESSING THE DATA IS TO BE ASCERTAINED

Published data will be accessible to everyone without any restrictions or authentication requirements via the project's repositories and project website.

Data stored within the consortium's internal Microsoft Teams/SharePoint environment will continue to be managed under controlled access protocols. Overseeing of this system will be maintained by the PMO, which is responsible for granting and monitoring user permissions based on project roles and confidentiality requirements. Access to institutional accounts is provided upon formal request from project partners and is limited to authorised personnel directly involved in relevant work packages.To uphold data security and integrity, the PMO also manages account lifecycle procedures. When an individual concludes their participation in the project, the PMO promptly revokes or transfers their access rights to prevent unauthorised entry or data misuse. Access to the SEID's ColdSpark® repository will be accessible for project partners for at least a year after the end of the project.

2.2.9. DATA ACCESS COMMITTEE (E.G., TO EVALUATE/APPROVE ACCESS REQUESTS TO PERSONAL/SENSITIVE DATA)

Given the explicit nature of all regulations pertaining to data access, no need has been identified so far for the establishment of a dedicated Data Access Committee. Instead, decisions regarding data management were made by the General Assembly, serving as the supreme governing body within the ColdSpark® project.

2.2.10. OPENLY AVAILABLE METADATA AND LICENCED UNDER A PUBLIC DOMAIN DEDICATION CC0, AS PER THE GRANT AGREEMENT

Non-sensitive metadata are made publicly available and licensed under a public domain dedication CC0, in accordance with the terms outlined in the Grant Agreement. These metadata are accessible via OAI-PMH and are available for harvesting: https://about.zenodo.org/policies/. Metadata of confidential outcomes is not openly available.

2.2.11. HOW LONG WILL THE DATA REMAIN AVAILABLE AND FINDABLE? WILL METADATA BE GUARANTEED TO REMAIN AVAILABLE AFTER DATA IS NO LONGER AVAILABLE?

Currently, Zenodo's retention policy ensures data availability for the lifetime of the repository, which is stated to be at least 20 years ahead: https://about.zenodo.org/policies/. Should closure of the repository occur for any reason, ColdSpark® partners will endeavour to migrate all available data to suitable alternative institutional and/or subject-based repositories. The data will be stored in file formats that have a high chance of remaining usable and findable for the long term.

Metadata may remain available even after data is no longer available.

The datasets will be preserved for at least five years beyond the project's completion, or longer if required for ongoing intellectual property protection, regulatory compliance, or potential commercial exploitation.

Importantly, even in cases where underlying data is no longer publicly available-such as due to expiry of storage periods, confidentiality agreements, or IP constraints-their metadata records will remain permanently accessible. Metadata describing the dataset's origin, scope, authorship, and DOI will continue to be available via Zenodo and linked open data platforms (e.g., OpenAIRE, DataCite).

2.2.12. WILL DOCUMENTATION OR REFERENCES 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)?

All publicly accessible data published as a result of the activities within the ColdSpark® project can be viewed and utilised using widely known software tools. The Consortium strongly favours open-source software solutions. In case specialised software is necessary, the Consortium will provide links to the required software or relevant documentation to facilitate the access and utilisation of the data.

2.3. INTEROPERABLE PROJECT DATA

2.3.1. DATA AND METADATA VOCABULARIES, STANDARDS, FORMATS OR METHODOLOGIES FOR DATA INTEROPERABILITY DATA EXCHANGE AND REUSE WITHIN AND ACROSS DISCIPLINES? WILL YOU FOLLOW COMMUNITY-ENDORSED INTEROPERABILITY BEST PRACTICES? WHICH ONES?

Within the ColdSpark® project community, Zenodo serves as the primary platform for data storage and dissemination. The metadata standards employed align with those provided by Zenodo, ensuring compliance with DataCite's Metadata Schema. In addition, Zenodo's metadata incorporates a few supplementary enrichments that further enhance data discoverability and accessibility within the ColdSpark® project community.

2.3.2. USE OR GENERATION OF UNCOMMON PROJECT-SPECIFIC ONTOLOGIES OR VOCABULARIES AND AVAILABILITY

ColdSpark® will not use or generate uncommon project-specific ontologies.

2.3.3. QUALIFIED REFERENCES TO OTHER DATA

ColdSpark® project reuses qualified references to other data from consortium partners' previous

research. In all cases where data reuse extends beyond the project partner's contributions, proper attribution to the source is diligently provided.

2.4. INCREASE DATA RE-USE

2.4.1. HOW DOCUMENTATION WILL BE PROVIDED TO VALIDATE DATA ANALYSIS AND FACILITATE DATA RE-USE

The information is being provided through readme files, analyses, and variable definitions.

2.4.2. AVAILABILITY IN THE PUBLIC DOMAIN TO PERMIT THE WIDEST RE-USE POSSIBLE

Will the data be licensed using standard reuse licenses, in line with the obligations set out in the Grant Agreement?

All public deliverables are automatically published in the EC public domain, CORDIS, and available on the project website and the ColdSpark® community on Zenodo upon approval. To enhance the visibility of our data resources, the ColdSpark® website features direct links to both CORDIS and Zenodo. These links serve as convenient entry points for stakeholders seeking comprehensive access to our project's datasets and deliverables.

Non-sensitive data produced from ColdSpark® use creative common licences such as CC BY-SA, CC BY-NC or CC0 licences depending on the data/document.

2.4.3. WILL THE DATA PRODUCED IN THE PROJECT BE USEABLE BY THIRD PARTIES, IN PARTICULAR AFTER THE END OF THE PROJECT?

The project has been designed to ensure that all publicly available data and research outputs remain fully usable, accessible, and citable by third parties both during and after the project's completion. This commitment aligns with the FAIR data principles and the Horizon Europe Open Science framework, ensuring that the project's results continue to deliver value to the wider scientific, industrial, and policy communities.

All non-confidential datasets, publications, and models produced by the consortium are stored and permanently preserved in the ColdSpark® Zenodo Community, where they are accessible under clearly defined open licences (such as Creative Commons CC BY 4.0 or CC BY-SA 4.0). Each dataset is accompanied by comprehensive metadata, a DOI, and documentation to facilitate interpretation and reuse without the need for direct contact with the original data producers.

Third parties, including research institutions, technology developers, policy makers, and industrial stakeholders-can reuse these datasets for further scientific research, process optimisation, comparative analysis, or educational purposes. Reuse is encouraged provided that the data are

properly cited and the original source acknowledged.

For restricted or confidential data, access by third parties after the project's end may be granted under specific conditions. Such access requires the explicit consent of the data owner and must comply with the intellectual property and confidentiality clauses outlined in the Consortium Agreement. Where feasible, summary information or anonymus versions of sensitive data may be made available to support transparency and knowledge transfer while preserving commercial interests.

2.4.4. WILL THE PROVENANCE OF THE DATA BE THOROUGHLY DOCUMENTED USING THE APPROPRIATE STANDARDS?

The provenance of all data generated within the project will be thoroughly documented to ensure full transparency, traceability, and reliability. Detailed provenance information is essential for assessing data quality, validating research processes, and supporting the reproducibility of results by external users.

Comprehensive documentation accompanies each dataset, describing its origin, methodology, processing steps, and any transformations applied. This allows users, especially those who were not involved in the data generation, to fully understand the context and integrity of the information provided.

2.4.5. DESCRIBE ALL RELEVANT DATA QUALITY ASSURANCE PROCESSES

Each project partner within the Consortium complies to their established quality assurance procedures, which enclose data calibration in accordance with international standards. Data quality receives special attention during the review of all ColdSpark® deliverables, regardless of whether they are public or confidential. Additionally, the consortium implements versioning of products and data to facilitate their reusability over an extended period.

2.4.6. FAIR PRINCIPLES, CONSIDERATION OF RESEARCH OUTPUTS OTHER THAN DATA AND ASPECTS RELATED TO THE ALLOCATION OF RESOURCES, DATA SECURITY AND ETHICS

All partners are involved in the development of the DMP and its updating process and are responsible for ensuring that the documents and files they upload comply with the general guidelines set out in the Grant Agreement and the Consortium Agreement.

3. OTHER RESEARCH OUTPUTS

3.1. MANAGEMENT OF OTHER RESEARCH OUTPUTS THAT MAY BE GENERATED OR RE-USED THROUGHOUT THEIR PROJECTS

Partners within the ColdSpark® project deliver datasets and metadata generated or collected during the project, adhering to the guidelines outlined in Annex 1 of the Grant Agreement. The project coordinator leads the ongoing updating of the DMP and ensures that all partners comply with the documented rules. These efforts aims to maintain consistency and integrity in data management practices throughout the project duration and enhance the data reuse after the project's lifetime.

3.2. FAIR DATA PRINCIPLES AND MANAGEMENT OF OTHER RESEARCH OUTPUTS

Agreements on standards, quality level and sharing practices were defined within the consortium.

4. ALLOCATION OF RESOURCES

4.1. COSTS FOR MAKING DATA OR OTHER RESEARCH OUTPUTS FAIR

All costs associated with resource allocation, data security, and ethical considerations were planned in the project budget. These expenses were covered by the EU funding and allocated through the dedicated budget of each project partner. This process ensured that all necessary measures to safeguard data, maintain security protocols, and uphold ethical standards are adequately financed and continuously implemented throughout the project lifetime.

4.2. DM RESPONSIBILITIES

In accordance with the Grant Agreement and Consortium Agreement, each partner retains ownership of the data they generate and has full responsibility for its management, including secure storage, controlled access, and compliance with project-wide quality standards including the period beyond the project's end. Data owners are required to upload and maintain their datasets promptly, including cases of post-project data generation, ensuring that all records are accurate, complete, and consistent with the project's established data management procedures.

The overall coordination and supervision of the data management process fell under Work Package 8 (Project Management), Task 8.3, led by SEID AS in collaboration with Europroject Ltd. This structure ensured that all consortium members adhere to uniform standards for data curation, security, and dissemination.

Prior to the publication or deposition of any dataset or research output intended for open access, a formal review and approval process is conducted by the Project Coordinator. All partners are notified 45 calendar days in advance of any planned release and are given a 30-day period to review the material and provide feedback. This procedure safeguards the confidentiality of proprietary information and ensures that no content containing sensitive or intellectual property-protected

data is made publicly available without the explicit consent of the data owner. This procedure will be in full force after the project end.

4.3. LONG-TERM PRESERVATION, NECESSARY RESOURCES AND DECISION-MAKING

During the ColdSpark® project, public data is available in the project's Zenodo community, which ensures its long preservation. All sensitive data is stored in the project's Teams repository and backed in the internal repositories of the partners involved in the project.

5. DATA SECURITY

5.1. PROVISIONS FOR DATA SECURITY (INCLUDING DATA RECOVERY AS WELL AS SECURE STORAGE/ARCHIVING AND TRANSFER OF SENSITIVE DATA)

As stated in the previous version of the DMP, the project coordinator uses Microsoft 365 Business premium with storage in Europe and has an online backup solution. Also, they use extra security and backup from a computer security service company. A two-factor security on user accounts is implemented. Raw data is archived on a local server in the partner's lab, calibrated data is shared through Microsoft Teams and SharePoint.

5.2. SAFELY STORED DATA IN TRUSTED REPOSITORIES FOR LONG-TERM PRESERVATION AND CURATION

ColdSpark® stores public data in Zenodo. According to their policy, data files and metadata are backed up nightly and replicated into multiple copies in the online system.

6. ETHICS

6.1. ETHICS OR LEGAL ISSUES THAT CAN HAVE AN IMPACT ON DATA SHARING

No ethical issues are expected from the data generated in the ColdSpark® project.

6.2. INFORMED CONSENT FOR DATA SHARING AND LONG-TERM PRESERVATION

All partners responsible for collecting confidential data adhere to strict protocols for archiving on secured internal servers. Sharing of confidential data is restricted in accordance with the provisions outlined in the ColdSpark® Consortium Agreement. These measures are designed to maintain the

confidentiality and integrity of sensitive information while upholding legal and ethical standards regarding data protection and privacy and remain in force after the project's end.

The collection and processing of personal data including information such as email addresses used for newsletters, event registrations, or stakeholder engagement activities, are carried out in accordance with Regulation (EU) 2016/679 of the European Parliament and of the Council (the General Data Protection Regulation – GDPR) and all applicable national data protection laws. Appropriate technical and organisational safeguards are implemented across all consortium partners to ensure lawful processing, prevent unauthorised access, and uphold the privacy rights of all individuals whose data are collected or processed within the project.

7. OTHER ISSUES

ColdSpark® will not use other national/funder/sectorial /departmental procedures for DM.

APPENDIX 1: DATA COLLECTED, PRODUCED AND REUSED IN THE COLDSPARK® PROJECT

Partner	Data Type	Data gathered by
SEID AS	Plasma electrical signals, power supply parameters (Voltage, current, frequency), gas analysis data, emission spectra, reactor performance parameters (gas flow rate, electrode configuration (electrode shape, distance between the electrode and the reactor wall), reaction sets	Oscilloscope, Gas Chromatography (GC), Spectrometer, data analysis, modelling, COMSOL Multiphysics
University of Stavanger	Gas-solid equilibrium analysis, carbon characterization data, dynamic study on gas separation, Adsorbent Characteristics	Gas sorption instrument, scanning electron microscope (SEM), Transmission electron microscopy (TEM), Raman Spectroscopy, X-ray diffraction (XRD), surface area, Gas separation test instrument, powder diffraction (PXRD), thermogravimetric analysis (TGA), surface area
NORCE	Aspen HYSYS	Modelling data

University of Liverpool	Plasma electrical signals, gas analysis data, carbon characterization, emission spectra, reaction performance, reaction sets	Oscilloscope, GC, SEM, TEM, Raman Spectroscopy, XRD, and spectrometer, analysis of collected data, modelling, data previously collected include reaction rate constants from the literature
IREC	Quantities of material and energy flows and yields, technical specifications of equipment (power rates, operating times, efficiencies), compositions in weight % of the mass, volume % (v%), ppm, recyclability rates, databased (foreground data), the composition of H_2 streams, pressure, temperature	Research and literature revision (Background data), Foreground data by filling templates from experts in the core technology, GaBi Professional databases. Data is previously collected from scientific journals and other recognized sources, recognized reports, EU reports, and other recognized sources, readable documentation source
IBBK	Participation in dissemination events, workshops	Market analysis, Dissemination of results
EuroProject	Publicly available data from the European Commission's public repository CORDIS in relation to the involvement of other projects, initiatives, and stakeholders and from other publicly available sources; EP may use data from stock image banks	Research, Market analysis, Dissemination of results (gather data from the workshops conducted)