TRI-HP PROJECT

Trigeneration systems based on heat pumps with natural refrigerants and multiple renewable sources

Data Management Plan DMP

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Authors:	Ángel Álvarez Pardiñas, NTNU
Peer review:	Mihaela Dudita, SPF-HSR
Approval:	Daniel Carbonell, SPF-HSR

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TRI-HP CONSORTIUM

SPF INSTITUT FÜ SOLARTECHI HSR HOCHSCHULE FÜR TECHNIK RAPPERSWIL FHO Fachhochschule Ostschweiz	Oberseestrasse 10 CH-8640 Rapperswil, Switzerland	Dr. Daniel Carbonell Dani.Carbonell@spf.ch
tecnalia Inspiring Business	Área Anardi, 5. E-20730 Azpeitia (Gipuzkoa), Spain	Mr. Andoni Diaz de Mendibil andoni.diazdemendibil@tecnalia. com
cadena	Murtenstrasse 116, CH-3202, Frauenkappelen, Switzerland	Mr. Raphael Gerber raphael.gerber@cadena.ch
IREC 10 YEARS Shaping Energy for a Sustainable Future	Jardins de les Dones de Negre 1 2ªpl. 08930 Sant Adrià de Besòs (Barcelona)	Dr. Jaume Salom jsalom@irec.cat
ALFA LAVAL	Box 74, 22100 Lund, Sweden	Mr Mats Nilsson MatsR.Nilsson@alfalaval.com
ILAG swiss quality coatings	Hämmerli 1, CH-8855, Wangen, Switzerland	Mrs. Stephanie Raisch stephanie.raisch@ilag.ch
Institut für sozial-ökologische Forschung	Hamburger Allee 45, Frankfurt am Main, 60486, Germany	Dr. Immanuel Stiess stiess@isoe.de
NTNU Norwegian University of Science and Technology	Kolbjørn Hejes vei 1D (B249), No-034 Trondheim, Norway	Dr. Ángel Álvarez Pardiñas angel.a.pardinas@ntnu.no
DANISH TECHNOLOGICAL INSTITUTE	Kongsvang Allé 29, 8000 Aarhus C, Denmark	Mr Claus Bischoff claus.bischoff@gmail.com
IKKU Institut für Kälte-, Klima- und Umwelttechnik Hochschule Karlsruhe Technik und Wirtschaft UNIVERSITY OF APPLIED SCIENCES	Moltkestr. 30, 76133 Karlsruhe, Germany	Dr. Prof. Michael Kauffeld Michael.Kauffeld@hs-karlsruhe.de
REHVA Federation of European Heating, Ventilation and Air Conditioning Associations	Rue Washington 40, 1050 Brussels, Belgium	Ms. Anita Derjanecz ad@rehva.eu
GRUPO E.F.C. EQUIPOS FRIGORIFICOS COMPACTOS,S.L.	C/Zuaznabar 8 Pol. Ind. Ugaldetxo, Oiartzun, 20180, Spain	Mr. Gabriel Cruz g.cruz@equiposfrigorificoscompactos.com

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Executive Summary

TRI-HP EU project is aiming to develop trigeneration integrated solutions that combine heating, cooling and electricity generation, based on heat pumps running with natural refrigerants and using multiple renewable energy sources.

During TRI-HP project, research data will be generated, collected and even reused. These data will be made available to the general public through publication with open access, which is a mandate for H2020 projects. In addition, TRI-HP participates in the Open Research Data Pilot (ORDP), which is a program that aims to make data accessible and available for anybody. It applies primarily to the data needed to validate the results presented in scientific publications, but other data can also be provided by the beneficiaries on a voluntary basis, as stated in their Data Management Plans (DMPs).

Having a DMP is mandatory for projects participating in ORDP. The purpose of DMP is to facilitate good data handling during and after the end of a project, indicating which data to collect/process/generate, the methodologies and standards followed, which data will be shared/made open access, and how data will be curated and preserved.

In TRI-HP project, the following tasks/activities will generate data that need to be handled:

- Task 2.3. Barriers, hindrances and incentives towards the social acceptance of TRI-HP systems.
- Task 3.3. Laboratory testing at sample scale (icephobic coatings).
- Task 3.4. Laboratory testing of immersed coaxial tubes with circulating water (icephobic coatings).
- Task 4.2. Testing and optimizing of supercoolers.
- Task 4.4. Testing and optimizing a tri-partite gas cooler.
- Task 4.6. Testing and optimizing a dual-source heat exchanger.
- Task 4.7. Simplified TRNSYS modelling and validation (heat exchangers).
- Task 5.3. Assembly of the prototypes and first experimental campaign.
- Task 5.4. Heat pump upgrading and second experimental campaign.
- Task 5.6. TRNSYS modelling and validation (heat pumps).
- Task 6.2. Experimental validation of the efficiency-self-diagnosis system.
- Task 6.5. Preliminary validation of the advanced management system in a simulation environment.
- Task 7.4. Whole system test and optimization.
- Task 7.6. Model calibration and yearly simulation assessment.
- Task 7.7. Simulation scale-up, cost assessment and extrapolations to EU-28.

It has been decided that these data will be uploaded to the repository currently used in the project, SWITCHdrive, to allow the access and collaboration of the project partners. Data and metadata will be added and prepared following the guidelines indicated in this document.

In addition to this, the Norwegian Centre for Research Data (NSD) repository will be used to comply with H2020 ORDP, making research data underlying publications available. If additional public data not directly related to publications are uploaded to this repository, this will be indicated in future updates of this DMP. Datasets will be given a persistent identifier DOI, with relevant metadata and closely linked to 814888 grant number and TRI-HP project acronym. Data are licensed after signature of the "Archiving Agreement" with NSD, in which the project partners will specify the access and reuse of the datasets. Data security arrangements are defined for the SWITCHdrive and NSD repositories. Ethical aspects affecting data sharing have been considered.

List of Acronyms

DMP	Data Management Plan
DOI	Digital Object Identifier
ICT	Information and Communications Technology
IPR	Intellectual Property Right
NSD	Norwegian Centre for Research Data
ORDP	Open Research Data Pilot

1 Introduction

1.1 Data Management Plan

During TRI-HP project, research data will be generated, collected and even reused. These data will be made available to the general public through publication with open access, which is a mandate for H2020 projects. In addition, TRI-HP participates in the ORDP, which is a program that aims to make data accessible and available for anybody. It applies primarily to the data needed to validate the results presented in scientific publications. Other data can be provided by the beneficiaries on a voluntary basis, as stated in their DMPs.

Having a DMP is mandatory for projects participating in ORDP. The purpose of DMP is to facilitate good data handling during and after the end of a project, indicating which data to collect/process/generate, the methodologies and standards followed, which data will be shared/made open access, and how data will be curated and preserved.

1.2 Structure of the document

The document is structured as follows:

- Section 2 states the data summary and the procedures to upload data to the different repositories.
- Section 3 describes the main principles for FAIR data management in TRI-HP and how it will comply with the H2020 Open Access Mandate.
- Section 4 describes the allocation of resources to make this open access to publications and data possible.
- Section 5 gives a detailed description of data security arrangements.
- Section 6 deals with ethical aspects, if any, connected to data management in TRI-HP project.
- Section 7 deals with other aspects that do not fit the previous sections.

1.3 Updates of the Data Management Plan

Projects evolve while they progress and, thus, it is not realistic to have a fully detailed DMP with all the answers and information clear in the first version, which in TRI-HP project is due in month 7. A DMP is seen as a living document, in which information is refined in subsequent updates as the project progresses. The following updates to the DMP are foreseen in TRI-HP project's Grant Agreement (814888 project number):

- D8.9. Data Management Plan DMP (update M24). Due by M24 (February 28, 2021).
- D8.10. Data Management Plan DMP (update M48). Due by M48 (February 28, 2023).

1.4 References used for this document

The following documents and websites have been used for the elaboration of this deliverable:

- H2020 Programme. Guidelines on FAIR Data Management in Horizon 2020. Version 3.0. 26 July 2016.
- Website of Norwegian Centre for Research Data: https://nsd.no/nsd/english/index.html.
- DMP WIKI NTNU: https://innsida.ntnu.no/wiki/-/wiki/English/Data+management+plan.
- CESSDA TRAINING EU: https://www.cessda.eu/Training/Training-Resources/Library/Data-Management-Expert-Guide

2 Data summary

2.1 General aspects

The objective of TRI-HP Project is to develop trigeneration integrated solutions that combine heating, cooling and electricity generation, based on heat pumps running with natural refrigerants and using multiple renewable energy sources. In order to fulfill this ambitious objective, the different partners in the consortium will work solving smaller challenges. Work in all these different aspects/topics will comprise experimental and/or simulation campaigns.

The results from these activities will be either confidential, for internal use in the project, or public and published with open access to the general public. As part of the ORDP, in TRI-HP we will make data linked to the publications available (to validate the results from the publication). Additional data not linked directly to publications will be included only if the partners involved in the specific task consider it convenient. For this purpose, NSD[1] repository has been chosen.

TRI-HP consortium foresees various types of data: results of experimental campaigns and simulations at component and system level, images/pictures/video from tests, answers from interviews, etc. The formats of these data will be also diverse.

A particular case is that of the heat pump models developed within WP 5 and the results obtained with them, which are confidential. However, the partners involved in this modelling, TECNALIA and NTNU, will use an approach based on the use of Gitlab and Sourcetree to handle and develop them safely and collaboratively.

2.2 Data susceptible to Open Access Mandate

The data used in TRI-HP project will be new data and no re-use of data is planned. The origin of these data will be different tasks, as indicated in Table 2.1. This table includes a short description of the data expected, kind of data and probable formats (using as much as possible the preferred file formats according to the NSD and shown in Table 2.2), which deliverables are associated with the task and if they are linked to any publication. It is early to define the size of the datasets, so this topic will be included in a future update. This list is preliminary and will be completed and changed with the progress of the project.

The data resulting from the activities in TRI-HP project will be useful for the following groups:

- Researchers: other researchers will have the possibility to use data for other studies, comparisons, validations, etc.
- Manufacturers: heat pump manufacturers, even competitors, will benefit from TRI-HP's results and conclusions, being a benchmark for their systems and assisting them with strategic decisions concerning their business, products, etc.
- European regulators: some of the results from TRI-HP could be useful for European regulators in order to make decisions concerning which technologies to support, new project calls to launch, etc.
- Final users: even if it is unlikely that the data from this project could be relevant for the average final user, some users could understand the benefits of installing heat pumps systems, if the outcome of the project is inline with their goals.

[1] NSD - Norwegian Centre for Research Data is a national archive and center for research data, that aims to ensure open and easy access to research data, and to improve opportunities for empirical research through a wide range of information and support services. NSD's core value is that research data is a collective good that should be shared. For more information www.nsd.no

Table 2.1: Research data to be generated in TRI-HP project.

Task	Delivarable	Short name/description	Kind of data and formats	Publication?	Comments
Task 2.3	D2.2	Surveys on barriers towards TRI-HP systems	Statistical (.xls)	Yes	No personal data will be handled.
Task 3.3/3.4	D3.5	Test results of icephobic coatings	Test data (.xls, .csv) Images (–)	Yes	–
Task 4.2	D4.6	Test results of supercoolers	Test data (.xls, .csv) Images (–)	Yes	–
Task 4.4	D4.3	Test results of tri-partite gas cooler	Test data (.xls, .csv)	Yes	–
Task 4.6	D4.4	Test results dual-source heat exchanger	Test data (.xls, .csv) Images (–)	Yes	–
Task 4.7	D4.7	Validation TRNSYS heat exchanger models	Test data (.xls, .csv)	Yes	–
Task 5.3	D5.5	Test results heat pump prototypes	Test data (.xls, .csv)	Yes	–
Task 5.4	D5.6	Test results heat pump prototypes refined	Test data (.xls, .csv)	Yes	–
Task 5.6	D5.8	Validation TRNSYS heat-pump models	Test data (.xls, .csv)	Yes	–
Task 6.2	D6.3	Validation self-diagnosis efficiency system	Data (.xls, .csv)	Yes	–
Task 6.5	D6.5	Validation AEM system through simulations	Data (.xls, .csv)	Yes	–
Task 7.4	D7.4	System test results R290 systems	Test data (.xls, .csv)	Partially via D7.9	–
Task 7.4	D7.8	System test results R744 system	Test data (.xls, .csv)	Partially via D7.9	–
Task 7.6	D7.9	Energy performance/cost competitiveness of systems	Data (.xls, .csv)	Yes	–
Task 7.7	D7.10	Benefits TRI-HP systems in Europe	Data (.xls, .csv)	Yes	–

Table 2.2: Type of data and preferred file formats by NSD. Formats most likely to be used are bolded.

Type of data	Preferred file formats
Textual documents	**•PDF/A (.pdf)** **•MS Word (.doc, .docx)** •OpenDocument-text (.odt) •Rich text format (.rtf)
Plain text	•Unicode-text (.txt)
Spreadsheets	•PDF/A (.pdf) **•Comma- and semicolon-separated values (.csv)** **•Tab-separated values (.txt)** **•Excel file format (.xls, .xlsx)** •OpenDocument-spreadsheet (.ods)
Database	•Comma- and semicolon-separated values (.csv) •Tab-separated values (.txt) •MS Access (.mdb, .accdb) •ANSI SQL (.sql)
Tabular/statistical data	•PASW/SSPSS (.sav, .por) •STATA (.dta) •SAS (.sas) •R (.R, .Rdata, ...)
Image	**•JPEG (.jpg, .jpeg)** **•TIFF (.tif, .tiff)** •Scaleable vector graphics (.svg) **•PDF/A (.pdf)**
Video	•MPEG-2 (.mpg, .mpeg) **•MPEG-4 H264 (.mp4)** **•Lossless AVI (.avi)** •QuickTime (.mov)
Audio	•WAVE (.wav) •MP3 AAC (.mp3)
Geospatial information	•ESRI shapefiler (.shp and similar formats)

2.3 Upload instructions

2.3.1 SWITCHdrive repository

SWITCHdrive has been established by the project coordinator (SPF-HSR) as repository to allow for safe sharing of information and data among the partners in the project. A dedicated folder, *ResearchData_OpenAccess*, has been established for research data that shall be made available for the general public and will be uploaded in the NSD repository (see next sub-section). In addition, project partners are encouraged to upload their research data, including those not associated with publications and even confidential within the consortium, to the corresponding WP-folders in order to prevent any loss of valuable information/data.

2.3.2 NSD repository

It is important to plan archiving in advance, since research data that shall be made accessible (e.g. linked to publications) latest on article publication. Each partner is responsible for uploading the datasets created/collected by them. If needed, NTNU - leader of Task 8.4 on data management, will assist the partners. Partners need to create an NSD profile, ask for access to the project (contact Ángel Álvarez Pardiñas through e-mail angel.a.pardinas@ntnu.no), and upload the data to the repository. As an alternative and just in justified cases, project partners could transfer to NTNU the task of archiving their research data in the repository. In any case, these data shall be first available in the SWITCHdrive.

To create an account in NSD.

1. Access https://minside.nsd.no/.
2. Choose the log in option (Figure 2.1). Unless access with FEIDE (exclusive for Norway) or eduGAIN is possible, use Login with Google (create an account if needed).
3. If Google log in is selected, Write e-mail and password.
4. If the log in information is correct, the user will access his/her profile, which should be similar to that in Figure 2.2.
5. NTNU, as responsible of the DMP, has created a project with the name "TRI-HP. Trigeneration systems based on heat pumps with natural refrigerants and multiple renewable sources". Ask NTNU (angel.a.pardinas@ntnu.no) to share access to the project.
6. An e-mail will be sent to the user inbox with a hyperlink to open the project and add it to the user's profile.

NSD suggests the following steps to archive data.

1. Prepare data
    a) Is it the final version?
    b) Are there any personal data? This will not apply to TRI-HP project.
    c) Relevant documentation/metadata is included? Clarifications on this issue are included in section 3.1.4.
    d) Language? English (and Norwegian).
    e) Is the dataset in one of the preferred data formats (Table 2.2)?
    f) More than one file? Overview of files must be enclosed with the description of the individual files, i.e. documentation at dataset level (section 3.1.4).
    g) Is the data quantitative? Variable names and descriptions must be understandable, i.e. documentation at variable level (section 3.1.4).

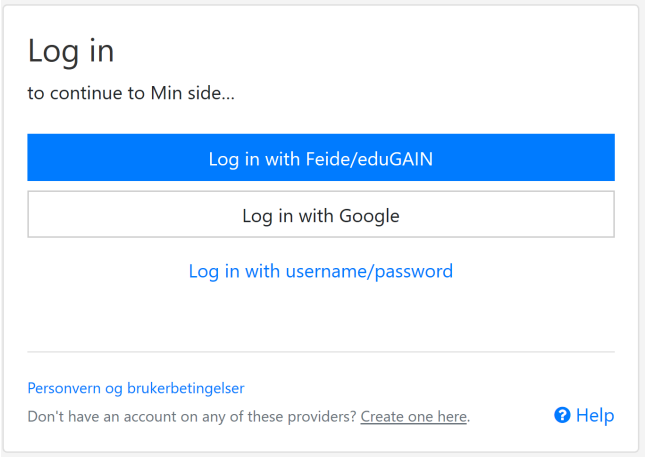

Figure 2.1: Log in alternatives to NSD

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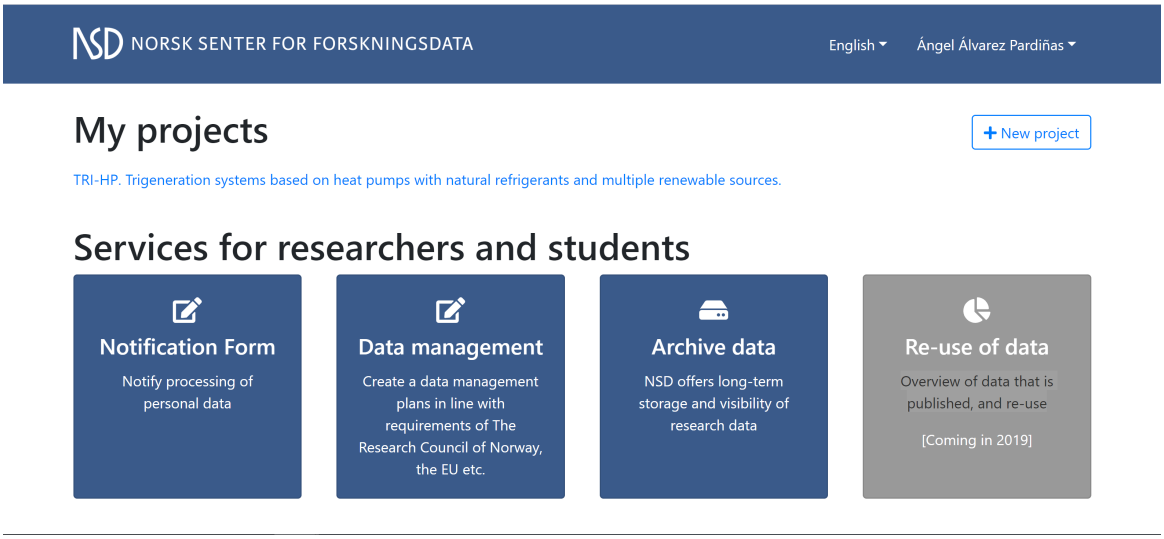

Figure 2.2: User website in NSD

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h) Are there transcribed interviews? This will not apply to TRI-HP project.

2. Deposit data files, using the NSD website created for TRI-HP project, which can be accessed as explained above. A form shall be filled out to capture the most important information about the project and data.
3. Sign archiving agreement. The user receives, within two to three working days, an e-mail confirming reception of the data and an archiving agreement. This agreement defines access conditions for the data. Once signed and returned to NSD, they start preparing the data and metadata. Confirmation is sent by NSD when the data is available.

3 FAIR DATA

TRI-HP project works according to the principles of FAIR data (Findable, Accessible, Interoperable and Reusable). The project aims to maximize access to the research data generated in the project so that it can be re-used. This applies to data intended to be public and used in publications. At the same time, there are datasets that should be kept confidential for commercial and Intellectual Property Right (IPR) reasons. Details are given in Table 2.1 in Section 2.2.

3.1 MAKING DATA FINDABLE, INCLUDING PROVISIONS FOR METADATA

3.1.1 TRI-HP and NSD repository

TRI-HP will use the TRI-HP project website created in NSD repository as the main tool to comply with the H2020 Open Access Mandate and with TRI-HP's participation in ORDP program. All scientific articles/papers and public datasets will be uploaded to this community in NSD, named according to a convention, with Digital Object Identifier (DOI) and Metadata (see subsequent subsections).

3.1.2 Naming convention

Data related to publications or deliverables will be named using the following naming conventions:
H2020_AcronymProject_DeliverableNumber_DescriptiveTextDataset_UniqueDatasetNumber_Version
H2020_AcronymProject_PublicationNumber_DescriptiveTextDataset_UniqueDatasetNumber_Version

Example: H2020_TRI-HP_D4.4_TriPartiteGasCooler_HXs1_1_v1

3.1.3 Digital Object Identifiers (DOI)

DOI's for all datasets will be reserved and assigned with the DOI functionality provided by NSD. DOI versioning will be used to assign unique identifiers to updated versions of the data records.

3.1.4 Metadata

As recommended by NSD[1], metadata should be provided at three different levels. First, at **project level**, describing the aim of the study, who is responsible for the project and the methods applied. Second, at **dataset level**, with an overview of the different files and how they relate to each other. Third, at **variable level**, in order to make data understandable to outsiders.

Project level
The metadata at project level shall include (examples/explanations are given for some categories):

- Title: H2020–TRI-HP–Deliverable/Publication–Descriptivename.
- Institution: institution responsible for the data.
- Responsible: person responsible within the institution.
- Copyright.

[1] https://nsd.no/arkivering/en/pdf/documentation-guide.pdf

- Abstract: short description of the data collected, the purpose behind these data, etc.
- Keywords: help to maximize the possibilities for re-use of the data.
- Dates of collection: Start: YYYY-MM-DD. End: YYYY-MM-DD.
- Kind of data: survey, tests (results, images), simulations, etc.
- Procedures.
- Access: who should be given access, when is data made available, etc.
- Other comments.

Dataset level
The metadata at dataset level shall include:

- Name: shall follow the following structure.
  TRI-HP_TaskNumber_Date(YY-MM-DD)_UniqueDatasetNumber_Version
- Format: .pdf, .xls, .csv, .jpg, etc.
- Size (optional).
- Date created: shall correspond to the date in the name.
- Date modified (if any).
- Short description of information in the file.

Variable level
This applies to structured and quantitative data. The names given to the variables shall be as self-explaining as possible, so that it is possible to minimize the information that needs to be given so that outsiders understand the data. Ideally, the metadata at variable level for a certain dataset could include:

- Variable group.
- Variable name.
- Description.
- Units: SI units are preferred.
- Values: range of values.

3.2 Making data openly accessible

The H2020 Open Access Mandate aims to make research data generated by H2020 projects accessible with as few restrictions as possible, but also accepts protecting sensitive data due to commercial or security reasons.

All public datasets (and associated metadata and other documentation) underlying publications will be uploaded to NSD repository and made open, free of charge, latest when the publication is available. Other datasets with dissemination level "Public" will also be made open through the same repository. Publications and related datasets will be linked through persistent DOIs. Datasets with dissemination level "Confidential" will not be shared. Information on the public datasets was included in Table 2.1 in Section 2.2

It is expected that most of the data will be accessible using usual software tools (.pdf readers, text editors, spreadsheet editors and others). In case any special software is needed, it will be detailed in the corresponding Metadata.

3.3 Making data interoperable

Data within TRI-HP project are intended to be re-used by other researchers, institutions, organizations, etc. Thus, the formats chosen for the datasets shared are widely used and in most cases accessible using open software applications. Vocabulary will be kept as standardized as possible, and further explanations will be given in case uncommon terminology is used.

3.4 Increase data re-use (through clarifying licenses)

TRI-HP project will enable third parties to access, mine, exploit, reproduce and disseminate (free of charge for any user) all public datasets. The use for the datasets is specified in the "Archiving Agreement" supplied by NSD, which is signed by the owner of the dataset after their archive. The information will be documented as "Deposit Requirement", "Citation Requirement" and "Restrictions" for further use. NSD offers the possibility to have some data not freely accessible, but these data can be order through a form, with an access later and confidentiality agreement to be signed. However, this will not be the case with the public data within TRI-HP.

3.4.1 Availability of the TRI-HP research datasets

For data published in scientific journals, the underlying data will be made available no later than by journal publication and linked to this publication. Data associated with public deliverables will be shared once the deliverable has been approved by the European Commission.

Public data will remain archived and re-usable for at least 5 to 10 years in the NSD repository[2]. NSD's perspective is to have data for "unforeseeable future".

[2]Minimum stated in the Core Trust Seal requirements

4 Allocation of resources

TRI-HP uses standard tools and free of charge repository. The costs of data management activities are limited to project management costs and will be covered by the project grant. TRI-HP publications in Open Access journals or with Open Access agreements will also be covered by the grant. The following amounts have been allocated by the different partners for this purpuse:

- SPF-HSR: 3000 €.
- TECNALIA: 3000 €.
- IREC: 3000 €.
- ISOE: 2000 €.
- NTNU: 3000 €.
- UASKA: 3000 €.

NTNU is responsible for TRI-HP's data management, which is associated with Task 8.4 from WP 8 - Dissemination and Exploitation. Task 8.4 is lead by NTNU.

5 Data security

The aspects concerning security of the research data generated/used in TRI-HP project are covered in this chapter.

5.1 Active project - Utilization of SWITCHdrive repository

At the beginning of TRI-HP project, a SWITCHdrive repository was established by SPF-HSR to allow for safe sharing of information and data among the partners in the project. This repository will be active during the period in which the project is active and beyond, namely until at least one year after the project ends. Files from SWITCHdrive folder that have been deleted are not removed immediately, but moved to the folder "Deleted-files" from where they can be easily restored, if needed. Deleted files are stored in this folder for 90 days and only after that they will be permanently deleted. SWITCHdrive has a backup system that can be used to restore the whole system in case of disaster, but this cannot be claimed for individual restore requests. Thus, the HSR-SPF network drive and in addition a back-up on an external drive will be used.

Some safety facts about SWITCHdrive are that:

- all data are stored in SWITCH servers in Switzerland,
- there is full compliance with Swiss data protection regulations,
- and there is no data and metadata exchange with other Office companies.

A dedicated folder, *ResearchData_OpenAccess*, has been established for research data that shall be made available for the general public and will be uploaded in the NSD repository. In addition, project partners are encouraged to upload their research data, including those not associated with publications and even confidential for the consortium, to the corresponding WP-folders in order to prevent any loss of valuable information/data.

5.2 Repository - Data security as specified for NSD

TRI-HP project has chosen NSD's repository. All scientific publications, public deliverables, and public research datasets will be uploaded to NSD repository and made accessible for everyone.

Some facts concerning information security and maintenance are explained in NSD's website. These facts are summarised below.

- The purpose of NSD's information security is to secure the data's confidentiality, integrity and accessibility.
  - Confidentiality: data are not accessible to unauthorised persons/systems.
  - Integrity: data are not changed or destroyed by unauthorised means.
  - Accessibility: data resources are available for use when required.
- Access control: NSD keeps an updated overview of who has access to relevant Information and Communications Technology (ICT) systems.
- Training: all NSD employees/users sign the necessary declarations and are given an introduction to NSD's security guidelines and the consequences of breaching the guidelines before they are granted access to an activated user ID for NSD's ICT systems.
- Declaration of secrecy: everyone with access to personal data and/or IT systems that NSD is responsible for are required to sign the company's declaration of secrecy (new one every third year).

- Backups are made in accordance with the requirements of accessibility. Storage media for the backup are labelled to facilitate finding and recovering it. NSD keeps backup copies separate from the operating equipment/computer room in a locked and fireproof cabinet (external location). To avoid physical wear and tear on tapes/disks/storage media, incremental backups are replaced at expedient intervals. Backup cassettes are used for five weeks. After each period, a complete backup copy is transferred to a secure external location.
- NSD shall document and store all new datasets using Nesstar Publisher[1] or in the most compatible format if not possible in Nesstar. Every other year, NSD reviews the data collection to check and, if relevant, update the file formats.
- Repository lifetime: the minimum repository lifetime is 5 to 10 years, but NSD foresees repository for the "unforeseeable future".
- CoreTrustSeal: NSD is certified as a credible and reliable archive of research data and awarded CoreTrust-Seal. NSD meets requirements connected to:
  - safe operations and continuous access to archived data in a long-term perspective,
  - disciplinary and ethical standards,
  - sufficient funding and expertise,
  - information security,
  - metadata to provide retrieval and reuse,
  - workflows from data submission to data dissemination,
  - citation,
  - licensing and
  - technical infrastructure.

[1]Nesstar publisher is an advanced data management tool owned and developed by NSD

6 Ethical aspects

Currently, no ethical or legal issues that can have an impact on data sharing have been identified. Ethical aspects connected to research data generated by the project will be considered as the work proceeds.

Use and storage of e-mail addresses in TRI-HP's SWITCHdrive repository:
An e-mail address is by definition personal information and covered in GDPR[1]. The e-mail addresses of project participants are stored in the SWITCHdrive repository. Only the project participants invited have access. The e-mail address is a prerequisite to access the project's working area. By accepting the invitation to SWITCHdrive, participants consent the use and storage of their e-mail addresses. E-mail addresses will be deleted when access to the project area is no longer needed.

SPF-HSR and SWITCH (the organization handling the repository) comply with the General Data Protection Regulation.

7 Other issues

No other issues or aspects concerning data management are foreseen currently.

[1]The General Data Protection Regulation (EU) 2016/679 (GDPR)

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