Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe

Technical review report for project 3DGEO-EU

This report is part of a project that has received funding by the European Union's Horizon 2020 research and innovation programme under grant agreement number 731166.

INTRODUCTION

Technical review report is part of GeoERA's Monitoring and evaluation process for co-funded projects (*hereinafter: project*). The aim of a technical review is to assess the work carried out under the project over a certain period and provide recommendations. Such technical review evaluates the project reports and deliverables, the proper use of resources, the management of the project and the expected impact.

Technical review report consists of four sections, each representing one level of monitoring and/or evaluation of the project:

Level	Monitor / Reviewer	Input	Aim
1 – Monitoring of progress indicators	Monitoring and reporting officer (GeoZS)	MPPR* FPPR**	Monitoring of the effectiveness of implementation of selected projects with respect to finance, time and administration.
2 – Scientific review	Reviewers (GeoZS)	Submitted deliverables MPPR FPPR	Quality review of the deliverables and review of achieving scientific and professional goals.
3 – Review of the theme progress	Theme coordinators	MPPR FPPR	Review of achieving theme objectives.
4 – GeoERA Progress evaluation	Stakeholder Council member(s)	Sections 1 and 2 of this report Review meetings	Overall project progress and general recommendations.

*MPPR = Midterm Project Progress Report (see PI doc no 2)
**FPPR = Final Project Progress Report (see PI doc no 2)

Monitoring and evaluation process:

M0 = End of reporting period
M1 = Submitted (Final) Project progress Report (MPPR / FPPR)
M2 = 1 – Monitoring & 2 – Evaluation
M3 = 3 – Evaluation of the theme progress
M3 = (Final) Review Meeting & 4 – Progress evaluation

Each project will be reviewed twice: for first project period M1-M18 – Technical review report, and second project period M19-M36 – Final review report.
Technical review report is based on Horizon 2020 templates but adopted to GeoERA needs. Technical reviews of projects shall be carried out on a confidential basis.

GENERAL INFORMATION

ERA-NET Cofund Grant Agreement:	731166
ERA-NET Cofund acronym:	GeoERA
Call identifier:	H2020-LCE-2016-2017/H2020-LCE-2016-ERA
Project full title:	3D geomodeling for Europe
Project acronym:	3DGEO-EU
Project reference number:	GeoE.171.005
Project topic:	GeoEnergy
Project specific topic:	GE5-Advancements in developing and using 3D transnational geomodels
Lead partner:	BGR Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)
Project website:	http://geoera.eu/projects/3dgeo-eu/

☒ Technical review report
☐ Final review report

Period covered	01/07/2018 – 31/12/2019
Review meeting date	13.02.2020, concise 03.03.2020

Contributor:	Role:	Approved on:
Barbara Simić	Monitoring and reporting officer	27.02.2020
Maja Ilić	Monitoring and reporting officer	28.02.2020
Bogomir Celarc	Scientific reviewer	03.03.2020
Dejan Šram	Scientific reviewer	02.03.2020
Jasna Šinigoj	Scientific reviewer	11.03.2020
Matija Krivic	Scientific reviewer	10.03.2020
Serge van Gessel	Theme coordinator	16.03.2020
Glen Burridge	Stakeholder Council member	27.04.2020
Harikrishnan Tulsidas	Stakeholder Council member	01.04.2020

1 LEVEL 1 – MONITORING OF PROGRESS INDICATORS

In this section the project is monitored "remotely" on the basis of the respective reports. This part is filled in by Monitoring and reporting officer with aim to monitor the effectiveness of implementation of the selected projects with respect to finance, time and administration, based on submited MPPR and FPPR.

	Yes	Partially (comment needed)	No
PROJECT MANAGEMENT			
Has the MPPR / FPPR report been submitted on time?	☒		☐
Have there been any changes in project partnership?	☐		☒
Has the project management been performed as required?	☒		☐
Has the collaboration between partners been effective?	☒		☐
Do you identify evidence of underperforming partners, lack of commitment or change of interest of any partners?	☐ (see comment)		☒
DELIVERABLES and MILESTONES			
Have the planned deliverables for the period been submitted on time according to timeline in Project Agreement?	☐	See comment no.1	☒
Have the planned deliverables for the period been completed (from MPPR / FPPR, sheet 4)	☐	See comment no.1	☒
Have any changes to deliverables occurred (type/ dissemination level)? (from MPPR / FPPR, sheet 4 and 5)	☒	See comment no.2	☐
Have planned milestones been achieved for the reporting period? (from MPPR / FPPR, sheet 4)	☒		☐
Have the project partnership identify any difficulties achieving any of the deliverables / milestones?	☐		☒
DEVIATIONS (from MPPR / FPPR, sheet 5)			
Has the project partnership identify any deviations that will not affect projects outputs?	☒		☐
Have any deviations occur on the project, with impact on project outputs?	☐		☒
In case of deviations, have the project adopted corrective measures?	☒		☐
DISSEMINATION, COMMUNICATION			
Has the project adopted its dissemination plan?	☐		☒

Have the planned dissemination activities been completed for the reporting period? (from MPPR / FPPR, sheet 6)	☒		☐
Have the partners' disseminated project results and information adequately?	☒		☐
Is the project following dissemination plan?	☒		☐
Is the project interacting in a satisfactory manner with other GeoERA projects?	☒		☐
Is the project interacting in a satisfactory manner with national/international bodies?	☐	NA	☐

FINANCE			
To the best of your estimate, have the resources used been utilised for achieving the project? (according to MPPR / FPPR, sheet 9)	☒		☐
To the best of your estimate, have the resources used been in a manner consisted with the principle of economy, efficiency and effectiveness? *	☒		☐
Are there any major deviations in the budget consumptions from the financial plan? (zero consumption in M18; deviation from plan exceeding 20% in M36)	☐		☒
Are there any major deviations in the Person - Months consumptions from the plan? (zero consumption in M18; deviation from plan exceeding 20% in M36)	☐		☒
Are any budget modifications for the project needed? (from MPPR / FPPR, sheet 5)	☐		☒

***The principles of economy, efficiency and effectiveness**: refers to the standard of "good housekeeping" in spending public money effectively. Economy can be understood as minimising the costs of resources used for an activity (input), having regard to the appropriate quality and can be linked to efficiency, which is the relationship between the outputs and the resources used to produce them. Effectiveness is concerned with measuring the extent to which the objectives have been achieved and the relationship between the intended impact and the actual impact of an activity. Cost effectiveness means the relationship between project costs and outcomes, expressed as costs per unit of outcome achieved.

Comments (highlighting the project progress) / deviations / recommendations:

Comment no.1: In the first reporting period 13 deliverables were due:
7 deliverables were submitted in time
3 deliverables were submitted with eligible delay (amendment 1)
2 deliverables were postponed into reporting period 2 (amendment 1)
1 deliverable is in delay
Comment no.2: Changes to deliverables:
D3.1: postponed from M6 → M12
D3.2: postponed from M6 → M10
D4.2: postponed from M18 → M24
D4.3: postponed from M18 → M30
D3.4: delayed from M18 → M21

The changes have no impact on the project outputs.

Project 3DGEO-EU mainly deals with methods for harmonization of geological data and 3D geomodels across international borders, aiming to harmonize methods and workflows for cross-border harmonization.
In the first reporting period, some deviations occurred, mainly concerning deliverables postponement. The partnership recognizes the delays and are adopting the necessary corrective measures. The delays have no impact on expected project results.
Communication and dissemination plan have not been adopted as a project deliverable, so comparing activities with the plan is not possible. At the review meeting these activities have been discussed and compared to other GeoERA projects implemented dissemination and communication activities are realistic. In the Midterm Project Progress report the number of people reached is missing for almost all activities. The recommendation given to the project team at the meeting is to review the communication and dissemination plan set at the beginning of the project and update it with relevant categories and target groups. The project cooperates with other GeoERA projects in a satisfactory manner, mainly with project GIP-P, GARAH and HIKE. The project results will mainly be used by GSO's and the scientific community.
Overall financial consumption at the end of first reporting period is 50 %. One partner (LBGR) spent almost all of its budget in this period. The partner is willing to increase its in-kind budget to finance future activities.

No challenges in achieving project outcomes are recognized, the project lead provides good support to partners with implementation of project activities.

Recommendation to the project is to:

- keep track of the communication and dissemination activities and try to count or estimate the number of people reached with these activities. The same is applicable for the meetings.

Overall assessment of the project:

☐ 5 - **Overachiever** (the project has achieved all objectives and goals for the period and has even exceeded expectations)

☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals for the period)

☐ 3 - **Good progress** (the project has achieved most of its objectives and goals for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has achieved some of its objectives; however corrective action will be required)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives and/or is not at all on schedule)

Summary of dissemination activities (detailed activities are annexed to this report):

Activity	Target audience	Number of people reached
Publications	Scientific community	~100
Meetings	Scientific community	

Are the dissemination activities adequate? (link to GeoERA WP5)

☐ 5 - **Overachieved** (the projects dissemination activities have exceeded expectations)

☐ 4 - **Excellent** (the projects dissemination activities have fully achieved its expectations)

☒ 3 - **Good** (the projects dissemination activities are adequate; however, some additional activities are needed)

☐ 2 - **Acceptable** (the projects dissemination activities need corrective actions; additional activities are needed)

☐ 1 - **Unsatisfactory** (the project has failed to disseminate)

Cummulative financial statement:

	Person months	Total eligible costs	Reimbursement rate	GeoERA contribution	In-kind contribution
Plan	442,46	3.649.302	29,7%	1.083.843	2.565.459
1st period consumption	216,6	1.834.261	29,7%	544.775	1.289.485
2nd period consumtion					

2 LEVEL 2 – SCIENTIFIC REVIEW

In this section the project is reviewed ”remotely” on the basis of the respective reports. This part is filled in by reviewer with aim to review the quality of the deliverables and review of achieving scientific and professional goals. Scientific review is based on submitted deliverables and reported Impact statement in MPPR/FPPR.

Impact statement (from MPPR / FPPR, sheet 8):

A full impact statement will be provided after the end of the project for the Final Project Progress Report. Here a first short statement for the Midterm Report: The project 3DGEO-EU can generate its expected impacts after the results have been achieved in the last stages of the project in summer 2021. Especially a synthesis of best practices & optimized workflows regarding cross-border harmonization and optimization of 3D geomodels needs to be found. If the planned results will be achieved, then 3DGEO-EU can provide good advice to other Geological Survey Organisations (GSO) and the scientific community on how cross-border harmonization can be done in other regions in Europe. Helping to create coherently harmonized 3D geomodels in Europe could be considered as an important impact for sure. As the project is in general on track after the first 18 month in regard of the work plan, the signs are optimistic that the main results will be achieved as planned and therefore the hoped impacts could be generated. In addition to best practices, the establishment of cross-border harmonized 3D geomodels in the 3DGEO-EU pilot areas will enhance the state of knowledge for such regions, allowing for consistent cross-border resource assessments. Close cooperation of involved GSOs during the work process will increase mutual understanding regarding geology, concepts and applied methodologies. Furthermore, the established cross-border harmonized 3D geomodels can be the nucleus for further transnational harmonization projects in Europe. Improved visualization methods for uncertainties will help to enhance the reliability of 3D geomodels for future resource assessments in Europe. As an example of already accomplished and used results, Work Package 3 (North Sea area NL-DE-DK) has created a generalized cross-border 3D depth model of the ‘Entenschnabel’ region in the North Sea (delivered in Month 10). That geomodel is used by the GeoEnergy project GARAH for Petroleum System modeling.

Expected impact (from Project Agreement):

The cooperation of GSOs in this project to perform geomodeling work in well selected cross-border pilot areas and supported by work on method development issues will help to establish methods and workflows for cross-border harmonization of 3D geomodels, applicable to other border regions in Europe. The expected impacts can be specified as follows: • Establishment of consistent data and model base in cross-

border regions improves the state of knowledge and thus will lift up subsurface resource assessments studies in cross-border regions to a new level. • Establishment of a set of cross-border consistent geomodels in the pilot areas that can be the nucleus for further transnational harmonization projects and the establishment of a pan-European harmonized geological knowledge base. • Harmonization of stratigraphic as well as structural modeling workflows in border areas allow for a better comparability of results of cross-border assessments in the future. • Development of methodologies for semantic and geometric harmonization of data and geomodels across borders. • Improved visualization methods for uncertainties and optimized reconstruction and restoration workflows to reduce uncertainty of geomodels will help to enhance the reliability of 3D geomodels for future cross-border resource assessments at the European scale. • Advanced mapping and 3D geomodeling strategies that allow for regional to pan-European cross-border consistency and integration, thus helping to adequately inform European stakeholders and decision makers on subsurface resources. • Development of common and accepted standards and disseminate best practices for crossborder harmonization, applicable to other European countries. • Existing links to other GeoERA projects like GE1-GARAP, GE4-HIKE, GE6-GeoConnect3D will demonstrate the application of the models.

Evaluation of deliverables

Deliverables list status			
No.	Title	Status (Approve/ Reject)	Comments
D1.1	Inventory report	Approved	See below
Besides Figure 2, we recommend one picture where all 3D models are gathered in one Figure to get the overview of the size of the models (e.g. Figure 1 of this report or D.7.1. Figure 1). For the reader, not familiar in stratigraphy, it is hard to digest all the data.			
D2.1	State of the Art	Approved	See below
All figures: Missing N arrow, Table 1, 2, 4, 5, 6 (missing units in depth) be consistent in writing 1960th or 60th s. Table 2 which UTM coordinate system is used? Use some topographic maps on Figures). Authors mentioned, that there is a lot of private data – they will be used in the development of the model, but not shared with partners. It will be hard for the reviewers to be able to objectively review deliverables without examination of the input data in the final review.			
D2.3a	Harmonized 3D geomodel pilot area 1)	Approved	Late submission
D3.1	State of the art report	Approved	See below
Better overview for Figure 1 (now you can't see anything). Authors should describe, on what bases have been 9 horizons selected? Clear boundaries, unconformities, seismic horizons?			

D3.2	Generalized cross-border 3D depth model of (a part of) the Entenschnabel region	Approved	/
D3.3	Harmonized stratigraphic chart for the North Sea area NL-DE-DK	Approved	Late submission
D3.4	Lithostratigraphic/ chronostratigraphic correlation profiles through the study area		In delay
D4.1	State of the art in uncertainty visualization	Approved	/
D4.2	Report on sources of uncertainties in geomodels and how they can be handled		Postponed to period 2
D4.3	Documentation of requirements for the visualization of uncertainties in geomodels which can be used as input for EGDI		Postponed to period 2
D7.1	Technical requirements for project data and results	Approved	/
D8.2	Project Data Management Plan	Approved	See below
This deliverable provides a first version of the 3DGEO-EU Data Management Plan. It is structured according to the guidelines of the Overall GEOERA Data Management following Horizon 2020 FAIR Data and Management Plan. Since GIP-P did not yet provide recommendations and EGDI will furtherly develop, this report must be updated in the future.			
D8.3	Midterm Project Progress Report	Approved	/

Has the quality as a whole been achieved according the objectives? Has the project as a whole been making satisfactory progress?

☐ 5 - **Overachiever** (the project has achieved all objectives and goals for the period and has even exceeded expectations)

☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals for the period)

☐ 3 - **Good progress** (the project has achieved most of its objectives and goals for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has achieved some of its objectives; however corrective action will be required)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives and/or is not at all on schedule)

Comments (highlighting the project progress) / deviations / recommendations:

Opinion: GeoERA project 3DGEO-EU is divided into eight (8) work packages (WP) in which the consortia is trying to overcome the discrepancy of local national 3D models to the harmonized pan-European 3D models. Project is focusing on harmonization of

3D modelling workflows which should be useful for all organizations who are going to face with cross-bordered 3D modelling. In month 18 for midterm review, the project is on time with most deliverables (some of them were postponed). All deliverables are following the task set in the project proposal and have set the good ground for the project continuation. Based on the finalized deliverables so far there is a good prospect to finish the project on time and achieve the desired goals and impact set in the project proposal.

Remarks: Beauty of 3D models (and 2D maps) is the possibility to make a great impact on the target audience by its visualization. That's why it is recommended to make all Figures in the reports self-explanatory as much as possible. Having a 2D topographic map with the extent of the model or topographic map on the 3D models etc.

It is very important for all involved who use a 3D model, from modellers themselves to decision makers, to know the uncertainties that may affect the quality and reliability of the 3D model. That's why a tight collaboration between WP4 and GIP is very important.

3 LEVEL 3 – REVIEW OF THE THEME PROGRESS

In this section the project is reviewed ”remotely” on the basis of the respective reports. This part is filled in by Theme coordinator with aim to review the achieved scientific goals in accordance with theme objectives, on the basis of Sheet 3 in MPPR / FPPR – Project contribution to GeoERA project.

Project contribution to GeoERA project (from MPPR / FPPR, sheet 3):

3DGEO-EU is a project with a focus on testing and developing methods and workflows needed for generating harmonized coherent cross-border 3D geomodels. The work packages put a lot of effort in the first months of the project with fundamental work like covering the state-of-the-art regarding existing geomodels or data in the considered cross-border pilot areas before even starting to test or develop methods. The main results like best practices & optimized workflows and harmonized cross-border 3D geomodels that contribute to GeoERA’s aims and ambitions will be finally achieved in the last few months of the entire project. The deliverables accomplished so far represent interim results – like a few pieces of a jigsaw puzzle. Describing 3DGEO-EU’s contributions to the aims and objectives of GeoERA up to now after 18 project months is not meaningful. To stick to the metaphor above, the full jigsaw puzzle is needed to evaluate the motif. As the project and the work packages are on track in regard of the work plan, it can just be stated, that the project is on a good way to achieve the planned goals until June 2021.
The main objective of GeoERA “is to contribute to the optimal use and management of the subsurface. GeoERA will … aim to support 1) a more integrated and efficient management and 2) more responsible and publicly accepted, exploitation and use of the subsurface.” 3DGEO-EU will contribute to these objectives, as the project results will provide ways and means to harmonize underlying geological base data, which is necessary for all kind of consistent and reliable subsurface assessments and thus eventually for planning of the optimal use and management of the subsurface.
The results of 3DGEO-EU mainly aim at experts from European Geological Survey Organisations and the scientific community, thereof especially the geomodeling community, who can use the methods and best practices regarding cross-border harmonization and optimization of 3D geomodels to create coherently harmonized 3D geomodels in Europe. By this indirect way, the 3DGEO-EU results will pave a part of the road towards the future goal of creating a consistent database for pan-European assessments of subsurface resources. Therefore, in the end stakeholders, decision makers, politics and the public will also have a benefit from those technical expert results to be accomplished in 3DGEO-EU.
This project relates to the GeoEnergy Specific Research Topic (SRT) GE5 “Advancements in developing and using 3D transnational geomodels”. The results of 3DGEO-EU will contribute to some aspects of the SRT GE5 scope, for example:
- The development and evaluation of unified and substantially tested methods and workflows for cross-border harmonization of geological data and 3D geomodels holds

the potential to significantly improve the development and supply of 3D subsurface information to stakeholders and decision makers in a pan-European dimension.
- The achieved technical methods and solutions in the field of cross-border harmonization are applicable to multiple countries, regions and organisations in a wide range of geological settings and with different states of exploration. They are essentially necessary for the development, evaluation and application of regional to transnational geomodels and practical multinational case studies.
- The constructed state-of-the-art 3D geomodels in different European pilot areas can be used as examples and keystones for further transnational developments.

Theme objectives:

Theme objectives: compliant

- Potential subsurface contributions with regards to energy resources and storage capacities;
    - The project provides an essential and generic basis to properly assess resources across borders with harmonized 3D models. Results are implemented in GARAH
- Potential risks and environmental impacts associated with subsurface use for energy applications;
    - The project provides an essential and generic basis to properly assess hazard features across borders with harmonized 3D models. Results are being implemented in HIKE
- Risks of competition and interference between different uses of subsurface space, including interactions with surface infrastructures, and rewards of synergies.
    - The project provides an essential and generic basis to properly assess interactions between subsurface activities. Aspect of uncertainty visualization is linked with GeoConnect3D

Theme scope: compliant

- Hydrocarbons including conventional/unconventional oil and gas, gas hydrates;
    - Indirect (results provide generic basis for resource assessment). Results applied in GARAH
- Energy derived from solid resources such as coal (including coal bed methane (CBM) and underground coal gasification), lignite, peat, uranium;
    - Indirect (results provide generic basis for resource assessment)
- Geothermal energy from hydrothermal and petro-thermal resources, both shallow and deep;
    - Indirect (results provide generic basis for resource assessment)

- Capacities for temporary storage of energy carriers (natural gas, hydrogen, compressed air and heat);
    - Indirect (results provide generic basis for resource assessment)
- Capacities for permanently storage of CO2 and other energy effluents.
    - Indirect (results provide generic basis for resource assessment)
- Identification and analyses of overlap and interactions between geo-energy resources and areas prone to seismic activity;
    - Indirect (results provide generic basis for hazards assessment, fault models being provided to HIKE)
- Determination and analysis of potential connections to groundwater and surface water systems;
    - Indirect (results provide generic basis for interaction assessment)
- Identification and analysis of potential interferences as well as synergies/pooling between various geo-energy resources and subsurface uses.
    - Indirect (results provide generic basis for interaction assessment)

Theme approach and methods: compliant

- Deliverables proposed by geo-energy theme projects should be compatible with a common spatial geological framework defined by the extent, depth, thickness, as well as essential properties of geological intervals containing relevant geo-energy resources and storage capacities.
    - National 3D model frameworks are integrated into cross-border standards
- Common state-of-the-art methodologies will be developed and applied with the aim to assess and quantify technically recoverable resources.
    - The harmonized cross-border Enteschnabe model (D3.2) is applied in GARAH. German 3D fault model data are being included in HIKE
- Development and demonstration of advanced 3D modelling and assessment activities may be proposed for complex geological configurations typical for specific cross-border regions under the condition that these methodologies have generic value and can be linked to the future objectives of a common spatial-assessment framework.
    - This is the core of the project. Results are presented
- The joint call will either ask for final deliverables and methodologies consistent on a transnational to pan European level, or for the demonstration and development in cross-border regions of methodologies that have generic value for future pan-European assessments.
    - The 3D modelling methods and approaches are now developed and tested in cross-border pilot areas. Wider implementation across Europe is not part of the project but should be done in future projects

- Correlation schemes of cross-border geo-energy resources;
    - Correlation schemes are part of the modelling work
- Compatible and interoperable model scales/resolutions and geometries;
    - The model development incorporates models and datasets of different origin and quality. This aspect is also essential for the uncertainty visualization being developed in the project
- Commonly agreed modelling and assessment methodologies.
    - Modelling methods are integrated across borders

Beyond state of art

- Advanced mapping and 3D modelling strategies that allow for regional to pan-European cross-border consistency and integration;
    - This is the core of the project. Results/progress presented
- Advanced and harmonized resource estimation workflows addressing uncertainty and sensitivity;
    - The projects specifically develops uncertainty visualization techniques. Results/progress presented
- State-of-the-art assessment workflows for analysis of potential geologically related surficial and subsurface effects induced by resource exploitation (e.g. subsidence, tremors, etc.);
    - Not in project scope
- Methodologies to objectively weigh interacting or mutually exclusive potential uses of space within the geoenergy theme and across the other themes on groundwater and minerals.
    - Not in project scope

Project-2-Project:

The 3DGEO-EU project delivers results to GARAH and HIKE and collaborates with GeoConnect3D on uncertainty visualization

Has the project as a whole achieved the objectives and expected impact of the theme?

☐ 5 - **Overachiever** (the project has achieved greater impact on project theme and/or other themes than expected)

☐ 4 - **Excellent progress** (the project has fully achieved its objectives and goals towards the theme as expected)

☒ 3 - **Good progress** (the project has achieved most of its impact towards the theme for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has minor impact; corrective action will be required)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives and/or is not at all on schedule and/or has no impact on the theme; corrective actions are required)

Comments / deviations / recommendations:

3DGEO-EU progresses in line with the project objectives and thereby follows the theme scope/objectives and GeoERA principles in general as mentioned in the call description.

Additionally the review analyses how the project performs beyond the project scope and raises the overall profile of the Energy Theme and GeoERA as a whole, i.e.:

- Developing and actively implementing standards and methods for panEU harmonization in the GSO community that are of value to the Energy Theme and/or GeoERA in general (i.e. beyond the project scope)
- Successfully introducing and implementing innovative and novel methods and standards in stakeholder/science communities leading to wider recognition of the Energy Theme and/or GeoERA
- Stimulating synergies between projects and themes
- Raising the overall impact and recognition of the Energy theme and/or GeoERA though active engagement of stakeholder and science communities
- Opening opportunities for future research and spin-offs including EP-GSE (i.e. possibilities for sustained development of results after project lifetime)

The 3DGEO-EU project is rated as 'good' for the following reasons:

1) The project actively develops and implements standards and strategies for harmonizing 3D geological models across (country) borders and visualizing model uncertainties. In that sense it has the potential to set new standards for the GSO community in general. Benefits are already demonstrated through direct exchange of 3D model data with the GARAH project.
2) Although the project has synergies and interactions with other GeoERA projects (GARAH, HIKE), the current activities are still mostly focused on the project internally. It is recommended to increase external stakeholder engagement and involvement. How to stimulate further external recognition

of 3DGEO-EU activities and thereby demonstrate the added value and benefits of performing these activities in the context of the Energy Theme and GeoERA in general?

3DGEO-EU focuses on specific pilot areas. One of the key challenges will be how to implement the results and experiences across Europe. How can the pilot results improve assessments in general and how can we raise interest from relevant stakeholders (i.e. recognition of harmonized 3D modelling relevance in the broader Energy Theme and GeoERA context)? It is recommended that 3DGEO-EU interacts with other projects in GeoERA to discussand investigate potential synergies and opportunities for future spin-offs.

4 LEVEL 4 – GEOERA PROGRESS EVALUATION

In this section the project is reviewed on the Review meetings, where projects present their overall progress and achievements. This section relates to particular project, broader impact of GeoERA as a whole on policies will be covered at the Final Review meeting with questionnaire and interview with Evaluator.

Based on technical review summaries provided by Sections 1 – 3 of this report, and project presentation on the (Final) Review meeting:

Has the project as a whole been making satisfactory progress according to your own understanding and expectations of the GeoERA project?

☐ 5 - **Overachiever** (the project has exceeded expectations)
☒ 4 - **Excellent progress** (as expected)
☐ 3 - **Good progress** (minor recommendations given below)
☐ 2 - **Acceptable progress** (below expectations; minor corrective action will be required)
☐ 1 - **Unsatisfactory progress** (the project has failed; corrective actions are required)

Overall comments for the project (overall recommendations, modifications, corrective actions, or re-tuning the objectives to optimize the impact or keep up with the State of the Art, re-focusing, or a simple praise)

Stakeholder one feedback:
3DGEO-EU is a crucial project that can provide valuable inputs for the optimal utilization of the European sub-surface. Presentation of data in 3D allows various stakeholders to visualize the data quickly and plan for the viable utilization that can help in tackling challenges such as climate change, and progress towards a circular economy.

Pilot studies: WP 1-3 are related to 3 pilot projects. The outputs from these pilot projects will be useful in understanding the cross-border issues in harmonizing the data. The studies have highlighted the data issues in cross border 3D modelling. Some of the data are in different resolutions, quality and details, so the project can have issues in joining all the data, especially in the cross-border regions. The difference in data quality is due to the availability of data produced in different periods (some are from the seventies or eighties). The older the data is, acquisition technologies and resolution differ.
In some cases, only limited data, such as gravity data, was available. The project has issues in accruing some data from different stakeholders due to data ownership issues. Due to ownership issues, the project output can only provide processed data, not the raw data itself.

Methodology: WP4-6 have developed unique, innovative methodologies in 3D modelling. The focus is on representing uncertainties, faults, and optimizing reconstructions. This work also has highlighted the potential for using the subsurface in addressing future challenges, e.g. green economy, deep geo-energy, hydrogen or CO2 storage. The synthesis of all this into one framework will be a challenge, which the project will be addressing in the next phase.

The project has interacted with other projects such as GARAH, HIKE and GIP-P. Overall the project has performed exceptionally well, and all the project members are congratulated for the sincere and dedicated work.

Recommendations:

1. The project has done an excellent job in highlighting critical issues in cross border harmonizing of data. The use of gravity data in 3D modelling, where expensive seismic data was not available is worth highlighting.
2. It is recommended that projects like this should have access to all the available data from all stakeholders, including governments and companies. As the outputs are highly valuable for strategic decision making in Europe, there should be no impediments for the projects in accessing all available data. The project reports should suggest the required high-level policy directives to make all data freely available for GeoERA project in particular, and Horizon 2020/Europe projects in general. However, the project need not publish the raw data, but only the processed data to the public.
3. Synthesizing 3D methodology will be a challenge, but the outputs will be a productive contribution not only for the objectives of the project, but to science in general, and the results should be published in a reputed journal such as Science or Nature.
4. The methodologies have highlighted the use of 3D models to support decision-making for the green economy. These aspects should be highlighted when communicating and disseminating the results.

Stakeholder two feedback

General Comments

What leapt out most to me in reading the reports and participating in the meeting were:

1. How much work we still need to do as a profession to systematically build a 3D (….let alone dynamic, 4D) geological model of Europe. GeoERA and 3DGEO-EU are very welcome and significant initiatives in the direction, but many more will be needed in the forthcoming decades.
2. The co-operation that is occurring between GSO's is not systematised at a European level outside of EU projects in a continental-scale plan yet. In the

meantime, it is clearly a step-by-step approach being used, to build up capabilities, prove the work's value and prioritise focus on useful study areas.

3. The sheer size of the GeoERA programme and the impact it seeks. It is not only attempting to tackle the technical puzzle of fitting the various elements of the continent together, but also concerning itself in how to translate this for a wider audience, which is very positive.
4. The powerful intention in 3DGEO-EU to get away from tri- and quadrangle meshes that can not only give a false impression of precision in 3D geological models, but also can lead the non-specialist to view the creation of these objects as an engineering exercise rather than a geoscientific one (a dangerous impression).
5. The centrality of depicting the uncertainty associated with the output 3D models from the project. Such transparency and feedback to the fundamental confidence in the inputs can go a long way to persuade observers to put faith in our recommendations and promote a more fruitful dialogue with stakeholders, whether decision-makers or public at large.
6. The historical legacy of Europe's numerous countries and their respective inward focus on geological mapping by its own GSO that projects like 3DGEO-EU is now looking to rectify and the material and human benefits that will bring.

Evident Challenges

- Finding the will and funding to pursue / extend this effort from pilot areas to the entire continent and demonstrate utility at the comprehensive scale.
- Differing completeness of 3D models between GSO's, scales and areas. There is also the associated question of the varied requirements of different end-users.
- Historic siloed workings of GSO's, even on the European continental mainland, as regards cross-border geological mapping. Data acquisition often stops at or before the borders.
- The paradox of the greatest gaps in data coverage often occurring in border regions, especially in high mountains or lack of trans-border coverage, leading to "edge effects".
- Consequent issue, in some cases, of trying to distinguish these "edge effects" from the geological features that frequently form the basis of national borders.
- Getting the different public and private sector actors to co-operate together for mutual benefit in terms of model verification, knowledge/lesson sharing and, ultimately, communicating the power of these models.
- Highlighting to the public these are not engineering structures as such, but science-based descriptions of the world around/beneath them.
- Convincing stakeholders of the knock-on value of the models for teaching, public understanding, geotourism.

- The need for careful parameterisation and thinking about data formats, volume rendering, software products and versions, etc as move towards the 3D visualisation realm.
- The risk of inappropriate upscaling or filtering as such models move into the hands of other professionals, especially our engineering colleagues.
- Finding a common basis on which to build best practice and guidance on how to collate the various elements of the 3D(4D?) European geological model. How will this guidance, once written, be best distributed and incorporated into future work?
- Ensuring the legacy of the GeoERA 3D modelling outputs in a usable and securely-stored and referenced knowledge-base. What comes next? Need for anticipatory timeline for future EU funding.
- The need to find a way to have a 4D approach to updates made by individual partners and to provide them to a common repository that can act as a single point-of-reference for a common European vision of its geology.
- Provision of systematic updates of changes or plans for extensions to mapping by GSO or other contributory parties.

Questions

- Are there any issues with cut-offs/clipping of attributes relevant to resource estimation across GSO models?
- Has there been any contact with the UK's Oil & Gas Authority over harmonising the WP3 NL-DE-DK super-model with their integration efforts? Similar question for Norway's Petroleum Directorate (NPD).
- What are the prospects of releasing raw data in light of the EU initiatives? Are the legal issues in some countries considered simply too difficult to resolve?
- Has there been any attempt to distinguish human in the uncertainty assessments, e.g. entrenched availability or confirmation bias? Overconfidence?
- Is there any thought to how GSO's could more systematically work together outside of EU projects, i.e. how they can best notify each other of impinging/nearby mapping work that is ongoing or anticipated?
- What will be the best way to publish the best practice workflows? Offer as software-embeddable templates? Plug-ins? Other clever methods?
- Is there any work/project aiming towards a standardised European Stratigraphic Column? Beyond that, a "resource attributes" catalogue?
- Should the project be thinking more deeply about a succession plan for its outputs? Is there a "wish list" of what they want to preserve, where and how?
- Could a simple forward-looking plan be devised for what the consortium would like to work on next in this venture to 3D model the continent? Rank the next key geographic areas?
- How many more 3DGEO-EU's will it take to deliver the impact the profession or stakeholders seek? Can future proposals be linked to the Green Deal or other strategic concerns?

- Having learnt from Connect3d of the success of their blog, where each partner produces two a year with very public-facing content, is this something that could be considered for 3DGEO-EU?
- Can EFG help with dissemination of 3DGEO-EU's results via our communication channels and those of our national associations?

Annex 1: Review meeting list of participants

Name	Function	Beneficiary
Tessa Witteman	GeoERA coordinator	Netherlands Organisation for Applied Scientific Research
Barbara Simić	Monitoring and Reporting Officer	Geological Survey of Slovenia
Maja Ilić	Monitoring and Reporting Officer	Geological Survey of Slovenia
Matija Krivic	Scientific reviewer	Geological Survey of Slovenia
Bogomir Celarc	Scientific reviewer	Geological Survey of Slovenia
Dejan Šram	Scientific reviewer	Geological Survey of Slovenia
Serge van Gessel	GeoEnergy Theme coordinator	Netherlands Organisation for Applied Scientific Research
Glen Burridge	Stekaholder council member	European Federation of Geologists
Stefan Knopf	Project manager	Federal Institute for Geosciences and Natural Resources, Germany
Melanie Witthöft	Project member	State Office for Mining, Energy and Geology Lower Saxony
Christoph Jahnke	Project member	State Office for Mining, Geology and Raw Materials Brandenburg
Hans Doornenbal	Project member	The Netherlands Organisation for applied scientific research
Fabian Jähne-Klingberg	Project member	Federal Institute for Geosciences and Natural Resources, Germany
Björn Zehner	Project member	Federal Institute for Geosciences and Natural Resources, Germany
Emilio L. Pueyo	Project member	Geological Survey of Spain
Lars Schimpf	Project member	State Office for Geology and Mining Saxony-Anhalt

Annex 1: Review meeting list of participants

Concise Review meeting 03.03.2020		
Harikrishnan Tulsidas	Stakeholder council member	UN Economic Commission for Europe

Annex 2: Communication and dissemination activities

Please select activity	Subcategory	Date	Target audience	Number of people reached	Short name of project participant	Author(s)
MEETINGS	Internal project meeting	04.07.2018	SCIENTIFIC COMMUNITY		all 3DGEO-EU partners	
MEETINGS	Internal project meeting	11.09.2018	SCIENTIFIC COMMUNITY		LBEG, TNO	
MEETINGS	Meeting with other GeoERA projects	11.-13.09.2018	SCIENTIFIC COMMUNITY		BGR, GEUS, TNO	
MEETINGS	Internal project meeting	25.09.2018	SCIENTIFIC COMMUNITY		IGME	
MEETINGS	Meeting with other GeoERA projects	24.-15.10.2018	SCIENTIFIC COMMUNITY		LAGB, BGR (meeting with GIP-P)	
MEETINGS	Internal project meeting	04.-05.02.2019	SCIENTIFIC COMMUNITY		LBEG, TNO	
MEETINGS	Meeting with other GeoERA projects	11.-12.03.2019	SCIENTIFIC COMMUNITY		BGR, GEUS, IGME, LAGB, LBGR, LUNG, PGI, TNO	
MEETINGS	Internal project meeting	12.03.2019	SCIENTIFIC COMMUNITY		BGR, GEUS, IGME, LAGB, LBGR, LUNG, PGI, TNO	
MEETINGS	Internal project meeting	27.-29.05.2019	SCIENTIFIC COMMUNITY		BGR, GEUS, TNO	
MEETINGS	Internal project meeting	09.-10.07.2019	SCIENTIFIC COMMUNITY		LBGR, LUNG, PGI	
MEETINGS	Internal project meeting	18.-19.09.2019	SCIENTIFIC COMMUNITY		BGR, GEUS, TNO	
MEETINGS	Internal project meeting	22.-23.10.2019	SCIENTIFIC COMMUNITY		BGR, GEUS, IGME, LAGB, LBEG, LBGR, LUNG, PGI, TNO	
MEETINGS	Internal project meeting	22.-23.10.2019	SCIENTIFIC COMMUNITY		BGR, GEUS, TNO	
MEETINGS	Meeting with other GeoERA projects	23.10.2019	SCIENTIFIC COMMUNITY		BGR, GEUS, IGME, LAGB, LBEG, LBGR, LUNG, PGI, TNO	
MEETINGS	Internal project meeting	24.10.2019	SCIENTIFIC COMMUNITY		LBEG, TNO	

Annex 2: Communication and dissemination activities

MEETINGS	Internal project meeting	19.11.2019	SCIENTIFIC COMMUNITY		BGR, TNO	
MEETINGS	Internal project meeting	04.12.2019	SCIENTIFIC COMMUNITY		BGR, GEUS	
PUBLICATIONS	PROJECT SPECIFIC PUBLICATION (please specify: leaflet, poster, catalogue, …)	02.-08.09.2018	SCIENTIFIC COMMUNITY		BGR	Björn Zehner
PUBLICATIONS	PROJECT SPECIFIC PUBLICATION (please specify: leaflet, poster, catalogue, …)	21.-24.05.2019	SCIENTIFIC COMMUNITY		TNO	Hans Doornenbal
PUBLICATIONS	PROJECT SPECIFIC PUBLICATION (please specify: leaflet, poster, catalogue, …)	21.-24.05.2019	SCIENTIFIC COMMUNITY		BGR	Björn Zehner
PUBLICATIONS	PROJECT SPECIFIC PUBLICATION (please specify: leaflet, poster, catalogue, …)	21.-24.05.2019	SCIENTIFIC COMMUNITY	ca. 100	CGS	Staněk, F., Franěk, J., Jelínek, J.
PUBLICATIONS	PROJECT SPECIFIC PUBLICATION (please specify: leaflet, poster, catalogue, …)	11.-14.06.2019	SCIENTIFIC COMMUNITY		LBEG	Melanie Witthöft
PUBLICATIONS	PROJECT SPECIFIC PUBLICATION (please specify: leaflet, poster, catalogue, …)	10.-13.09.2019	SCIENTIFIC COMMUNITY		BGR	Björn Zehner
PUBLICATIONS	PROJECT SPECIFIC PUBLICATION (please specify: leaflet, poster, catalogue, …)	22.-25.09.2019	SCIENTIFIC COMMUNITY		BGR	Björn Zehner